A Critical Evaluation of Emile Cheysson's Contributions to Economic Analysis.

Robert Francis Hebert
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A CRITICAL EVALUATION OF ÉMILE CHEYSSON'S
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A Dissertation
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
in
The Department of Economics

by

Robert F. Hebert
B.S., Louisiana State University, 1965
M.S., Louisiana State University, 1966
August, 1970
"Economists . . . achieve immortality by accident, if at all."

LORD KEYNES
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ABSTRACT

The mathematical investigation of certain economic problems undertaken by the nineteenth-century French engineer, Émile Cheysson, has attracted little attention by twentieth-century economists. The importance of Cheysson's performance was, however, recognized by several of his contemporaries outside of France. Their acknowledgements, as well as later ones, centered on a lecture of Cheysson's entitled "La Statistique géométrique," which was later published in a French journal of engineering. Neoclassical appraisals of this work tended to emphasize the importance of the mathematical method in economic analysis; whereas, at least one contemporary evaluation has focused on Cheysson's particular contributions. Neither have introduced excerpts from original sources, however, and those evaluations that have been forthcoming have been seriously incomplete. The purpose of this research has been to examine Cheysson's contributions critically, and in detail, by resorting to his economic writings directly. This method, in turn, has sponsored the translation of a number of Cheysson's important economic tracts.

In "La Statistique géométrique," Cheysson took a significant step forward in the development of econometrics. He attempted to apply Cournot's mathematical principles of profit maximization in a concrete, statistical case, and he developed statistical revenue and cost curves in the process. In the selection of statistical data for this application Cheysson revealed an awareness of some of the major problems involved in identifying statistical economic relationships. Thus, while working with rudimentary tools of analysis, Cheysson showed some degree of sophistication in his "econometric" performance.
Cheysson enlisted the aid of geometry and statistics to solve many important problems in the economics of the firm. He was among the first, for example, to investigate the effects of freight-rate reductions upon the spatial boundaries of economic markets and the degree of competition between firms as well as between transport enterprises. He was the first to offer a mathematical explanation of the Ricardian proposition that artificially high wage levels bring about technological unemployment. He was the first to attempt a simple explanation of "product equilibrium" in the case where a firm is free to vary the quality of its output. Moreover, he employed a concept not unlike Keynes' "marginal efficiency of capital" in determining the economic desirability of fixed investments, and his description of stable equilibrium in a labor market is strongly evocative of the kind of dynamic models later referred to as "cobweb." All of this Cheysson did in a single lecture marked by original thought of considerable import.

In his other writings Cheysson was more of a disciple than an originator of great ideas. He spent much of his physical and intellectual energies seeking to carry out the social reforms of Frédéric LePlay, and espousing the merits of the empirical approach to social science. In one of his lesser articles, however, Cheysson developed an economic framework which might have served as an early blueprint for studies in industrial organization. But apparently little was made of Cheysson's suggestion.

On purely analytical grounds, Cheysson had few peers in France during the neoclassical period. It is significant that the person Léon Walras first turned to in order to have his ideas promulgated in France was Cheysson. Cheysson's reluctance, on methodological grounds, to join Walras' "mathematical school" accounts in no small measure for his subsequent neglect by other economic theorists. Yet his imaginative application
mathematics and statistics to certain micro-economic problems demands another hearing, even if it comes at this late date.
CHAPTER I

INTRODUCTION

Purpose and Scope of Study

In the history of economics as in the history of life, the participants in the drama are either victims or heroes. And since recorded history is the sum total of man's experiences based only upon the recorder's reaction to the events he has witnessed, it is not surprising to find more victims than heroes among its pages. The history of ideas in general, and the history of economic analysis in particular, is replete with "victims" of historical consequences, i.e., those "neglected" economists, the number of which is periodically affirmed by the new discovery of an earlier proponent of this or that particular aspect of economic theory.¹ In one respect the search for analytical ancestors can be a never-ending one. But such historical safaris are not without interest or importance. To uncritically accept the conventional wisdom that "there is nothing new under the sun," strikes this writer as naive; to be satisfied with the implication that the progress of knowledge will eventually lead to the rediscovery of useful and valid techniques foreshadowed earlier, unforgiveable. Anyone genuinely interested in progress must also be interested in the continuity of progress, and is therefore apt to look askance at barriers which tend to interrupt that continuity. Thus, while there is little merit in exposing neglected economists who deserve to be neglected, failure

¹Even the most respectable economists frequently indulge in such pastimes, e.g., Jacob Viner, E. R. A. Seligman, and George Stigler.
to recognize and adopt significant contributions to the progress of economics as a scientific discipline is of more than passing interest. Attempts to recognize important, but hitherto neglected, contributions to economic analysis should therefore be a legitimate occupation of historians of economic thought. In the same spirit of intellectual endeavor, this study embarks upon a critical investigation of certain analytical contributions which are found in the writings of Émile Cheysson, a French engineer and economist who stands today as one of the intellectual heirs of Cournot and a non-adventitious precursor of much of what has become the modern theory of the firm.

Jean-Jacques Émile Cheysson was a man of many talents, not a few of which trespassed the boundaries of economics. By formal training he was an engineer. By choice and temperament he was an economist, statistician, and social philosopher as well. Born in 1836, his published works and professional activities spanned a half-century, and he remained physically and intellectually active until his death in 1910, the same year, incidentally, in which Léon Walras—Cheysson's senior by only two years—also died. During his lifetime, Cheysson received considerable recognition by his French contemporaries, though less as an economist than as a social reformer and student of Frédéric LePlay.

Today Cheysson stands as somewhat of an historical oddity. His reputation as an economist, at least in English-speaking countries, rests primarily upon the brief exposure he has received in the works of three prominent writers. In his own country he is regarded mainly as an innovator who combined geometry with statistics in economic analysis.

The scant attention which Cheysson has received in Anglo-American economic literature has acquainted few students of the history of economic analysis with his name or the nature of his contributions. Among standard histories of economic thought in the English language, only L. H. Haney mentions Cheysson, but he does so only in passing. Even in France, Cheysson has apparently received little attention as an economist and

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5This fact was brought home to this writer during his attendance at a 1968 seminar in the history of economic thought at Duke University. While a sizable contingency of the most respected students of the history of economic thought were in attendance, only two exhibited any familiarity with the name of Cheysson, and no one was in a position to discuss his analytical contributions to economics.

"applied theorist."^ It is not surprising, therefore, that Cheysson's impact on Anglo-American economic literature has been virtually nil. Nowhere has Cheysson, the economist, received full-scale treatment in book or article form. Nevertheless, because a few modern writers have recognized the originality of Cheysson's contributions to economic analysis, no attempt will be made in this study to "discover" Cheysson. Insofar as such matters are important, that honor belongs to Hans Staehle. In 1942, Staehle praised Cheysson's foresight and analytical expertise and attributed to him the development, as early as 1886, if not before, of "a scientific program which sounds very much like [Ragnar] Frisch's introductory address at the first meeting of the Econometric Society at Lausanne in 1931."^8 The bulk of Staehle's article was devoted to recent contributions to statistical cost functions, however, and he mentioned Cheysson only in passing.

In his compendious History of Economic Analysis, Joseph Schumpeter expressed gratitude to Dr. Staehle for "having pointed out [the] amazing


assemblage of tools and ideas" contained in Cheysson's writings that he "should otherwise have overlooked."\textsuperscript{9} Despite Schumpeter's praise of Cheysson, however, his \textit{History} contains a mere glimpse of what to expect from Cheysson's writings.

It should be noted that William Jaffé, whose scholarly labors in connection with the collection and publication of Léon Walras' correspondence exposed him to Cheysson's writings, also lauded Cheysson's "powerful originality."\textsuperscript{10} But as for the rest, Cheysson's name and works remain obscure. According to Schumpeter, such neglect:

\textit{... is readily understandable only if we realize what it is historians of economics usually look for, namely, on the one hand, a man's views on the practical issues of his day and, on the other hand, the way in which he handles the theoretical tools that are common currency in his day. New ideas, unless carefully elaborated, painstakingly defended, and 'pushed' \textit{simply will not tell}.\textsuperscript{11}}

As an ardent disciple of LePlay--the social and religious reformer--and as a member of numerous scholarly and civic organizations, Cheysson rarely failed to speak out, at frequent meetings and conventions, on matters of social and labor reform. He was no less an ardent defender of capitalism against the threat of Marxian socialism in nineteenth century France. His views on the practical issues of his day were clearly and frequently defined. Moreover, on theoretical grounds, despite a tenacious bias against abstract deduction, which eventually cooled his relationship with Walras, Cheysson exhibited a remarkable ability to apply economic tools to the solution of commercial and industrial problems.

\textsuperscript{9} Schumpeter, \textit{op. cit.}, p. 842 n.

\textsuperscript{10} \textit{Correspondence}, II, p. 53 n.

\textsuperscript{11} Schumpeter, \textit{op. cit.}, p. 464.
The question, then, of why Cheysson remains obscure in spite of fitting Schumpeter's description of "what historians of economics usually look for" is one to which this study addresses itself. Part of the answer undoubtedly lies in the fact that Cheysson's writings have enjoyed a very limited modern audience, since no English translations of his works exist; another part lies in Cheysson's tendency to relegate his analytical contributions to secondary importance in his tireless quest for moral and social reform. Too often, poor elaboration of new ideas was also in evidence in Cheysson's writings.

Schumpeter boldly asserts that Cheysson's treatment of economic decision-making was undertaken "in the true spirit of econometrics." In evaluating Cheysson's contributions, this claim will be examined thoroughly, but no attempt will be made to present a history of econometric theory, or of any theory for that matter. While such an undertaking strikes this writer as both provocative and rewarding, it is beyond the scope of this study. An attempt will be made, however, to point out Cheysson's unique contributions in this area, if any, and to bring his major ideas up to date.

Those economists who have recognized and praised Cheysson's accomplishments in economics have unanimously cited a lecture entitled "La Statistique géométrique," which first appeared in its entirety in a French engineering journal, *Le Génie civil*, in 1887. It is here that Cheysson's

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13 Apparently there has been no recent, comprehensive attempt along these lines, although H. T. Davis injects some historical flavor into the development of econometric concepts in his *Theory of Econometrics* [Bloomington, Ind.: Principia Press, 1941]. One other work should be mentioned for its attempt to trace the historical development of a closely related field: R. D. Theocharis, *Early Developments in Mathematical Economics* (London: Macmillan & Co., 1961). Neither work mentions Cheysson.
major contributions to economic analysis are concentrated and most clearly set forth. The wide range of economic problems taken up in this lecture suggest the desirability of a detailed investigation of the tools and ideas assembled therein. A major goal of this research is to perform this investigation while simultaneously attempting to "discover" and examine Cheysson's other writings in order to uncover materials which may be relevant to clarification or elaboration of the analytical contributions found in the above lecture. Consequently, the main thrust of this dissertation involves a review of the essential points in Cheysson's analytical program, an examination of those points in the light of previous and subsequent theoretical developments, and an attempt to analyze the extent to which Cheysson's contributions have enriched the analytical structure of economics. Since this reconstruction of Cheysson's views involved not only extensive translation of original tracts from French to English but some "filling in" of gaps in the printed argument at certain stages, it is not necessarily a "correct" version of his views. A considerable amount of interpretation as well as summarization is characteristic of this study.

To Cheysson, economics was both science and art. Quoting Nassau Senior approvingly, Cheysson wrote that "political economy establishes: as science, the laws which regulate the production and distribution of wealth; and as art, the institutions and customs which facilitate this production and favor public prosperity."\(^{14}\) Although most of Cheysson's energies were

\(^{14}\)Émile Cheysson, "Leçon d'ouverture de Cours d'économie politique de M. Émile Cheysson à l'École libre des Sciences politiques," *Journal des Économistes*, 4th Ser., XX (Dec. 15, 1882), p. 358. This article and several others by Cheysson have been translated into English by Eleanor Evans and edited by R. F. Hebert. The (unpublished) collection of these articles has been entitled, "Selected Writings of Émile Cheysson," and is available only in the Louisiana State University Library at Baton Rouge. All future references to Cheysson's translated works will be to this collection, cited hereafter as, "Selected Writings." References to works which have not been translated will be to their original sources.
devoted to the latter aspect of economics, he was perfectly capable of
writing a scientific treatise establishing important mathematical relationships on the nature of production and distribution. And it is this area
of Cheysson's thought that constitutes the major interest of this study.
There may be a necessary relationship between social thought and economic thought, but the study or explanation of that relationship is not the pro-
vince of this research. This does not mean that Cheysson's social thought
is of no concern, or that it should be ignored; rather, it means that re-
gardless of his social and political convictions, Cheysson's venture into
economic analysis, however brief, will be no less brilliant, provided the
richness and clarity of his contributions can be firmly established. To
establish as much is the primary object of this study.

One reason for not spending too much time on the moral and social
thought of Cheysson is that it is virtually indistinguishable from the
social doctrine of LePlay, who has received considerable treatment else-
where. A major distinction between master and disciple should be empha-
sized, however. According to Schumpeter, LePlay had no taste for economic
analysis, as such, and despised the misunderstood bits of it that he knew.

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15 Cf., C. C. Zimmerman and M. E. Frampton, Family and Society (New
York: D. Van Nostrand Co., 1935); Luigi Einaudi, "The Doctrine of Original
Sin and the Theory of the Elite in the Writings of Frédéric LePlay," in
Essays in European Economic Thought, trans. & ed. Louise Sommer (New York:
D. Van Nostrand Co., 1960), pp. 162-217; Paul Farmer, "The Social Theory of
Frédéric LePlay," in Teachers of History: Essays in Honor of Laurence
Bradford Packard, ed. H. S. Hughes (New York: Cornell University Press,
1954), pp. 58-78; and Henry Higgs, "Frédéric LePlay," Quarterly Journal of
Economics, IV (July, 1890), pp. 408-433.

16 Schumpeter, op. cit., p. 523. Schumpeter adds, however, that "he
deserves a place in the history of economic analysis because of his method
of studying family budgets that may some day help to bring into existence a
theory of consumption worthy of the name."
Cheysson not only enjoyed a grasp of economic principles but was capable of using his knowledge of economics and statistics to establish, among other things, an "econometric" program, and to erect an economic defense against the burgeoning socialist tendencies of nineteenth-century France. 17

In short, it is Émile Cheysson, the economist and tool-user, who forms the core of this study. Although much of the preparatory research has been devoted to Cheysson's social and political thought in order to place him in the proper setting; or with a view to catching some glint of economic theory or policy previously ignored; major emphasis will be placed on his contributions to economic analysis. A conscious attempt will be made to place Cheysson in the mainstream of the history of economic analysis by discussing and evaluating, on their own merits, his contributions to economic theory and/or policy, as evidenced by his writings.

The plan of this study includes six chapters. The second chapter briefly traces the state of economics in nineteenth-century France, particularly the last three decades, and attempts to find Cheysson's niche in the then-prevailing milieu. Chapter II also investigates LePlay's influence on Cheysson and the latter's conception of the economic order. The third, fourth and fifth chapters are devoted to Cheysson's contributions to economic analysis, which are treated topically. Chapter III examines Cheysson's program of "geometric statistics" and seeks to evaluate it in relation to what is called "econometrics." The fourth chapter explores Cheysson's contributions to transportation economics and to spatial economics; the fifth,  

his contributions to the theory of production and investment. The sixth and final chapter evaluates Cheysson's contributions to economic analysis in broader perspective than has been possible heretofore, and attempts to find Cheysson's proper place in the history of economic analysis.

Bibliographical Orientation

Cheysson's original writings constitute the starting point of this research. From there other source materials have been utilized, but they necessarily revolved around Cheysson's own writings, which were indeed prolific. A complete bibliography of Cheysson's publications, including articles, lectures, reports, and observations presented at various meetings, was found to contain no less than 546 entries. A closer examination, however, revealed considerable duplication insofar as a given entry may have been published in more than one place, sometimes under a slightly different title. Cheysson's publications also reflected his wide range of interests, and many entries found in a complete bibliography of his writings are not immediately relevant to the study at hand.

A glance at the various titles in Cheysson's bibliography shows that he spread his talents in many directions. He not only qualifies as "an economist of eminence," to coin Schumpeter's description of Cheysson; he was an engineer by trade, a statistician, and a publicist. In the area of social reform, his publications were devoted to such diverse topics as: the necessity and availability of low-cost housing for workers, insurance against industrial accidents and old age, the disruptive effects of alcoholism

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18 This bibliography is a part of the first volume of Émile Cheysson: Oeuvres Choisies (2 vols.; Paris: A. Rousseau, 1911), pp. 73-107.
and tuberculosis, the role of the wife at home, the necessity of freedom from Sunday work obligations, matters of social hygiene, and so on. Several articles were devoted to technical engineering procedures or to statistical studies on particular topics which today have purely historical interest, e.g., birth rates and mortality rates, shipping statistics as between different carriers, navigation of certain rivers, etc.

For the most part, these works have either been visited briefly or passed over. There were primarily two reasons for doing so. The first concerns the nature of their content; the second, their accessibility. As a prominent member of a school composed of followers of LePlay who considered themselves "social economists" rather than economic theorists, Cheysson advocated and wrote about social reforms which are as much, if not more, the province of applied sociology as applied economics. That he should be occupied with social questions is neither surprising nor unusual, since he lived and wrote at a time when the distinction between economics and the various other branches of social science was less finely drawn. As one writer has observed, teleological and normative considerations were much more openly a part of the subject matter of economics in the nineteenth century than they are today. The debate over whether this fact has hindered or helped the progress of economics simply does not concern us here. Many, though not all of Cheysson's writings on social and economic reforms have been examined with a view to understanding the totality of his thought and his conception of the economic and social order. But this has never been the primary purpose of this research. For the most part, Cheysson's ideas on these matters are deemed more important

to the history of sociology, or to the history of economic thought than to the history of economic analysis, which interests us here. With regard to purely technical or statistical studies, though not all were accessible, those which were examined, however interesting from the standpoint of historical aperçus to be derived, were found to be lacking in theoretical significance.

Anything which suggested economic content and was available in one way or another has been examined with a view to uncovering analytical contributions. Together, these considerations limited the scope of Cheysson's publications which were found to have a bearing on this study. His major economic writings appeared throughout the 1880's and 1890's in various journals, among them: *La Réforme Sociale*, *Le Génie civil*, *Journal des Économistes*, *Bulletin de l'Institut international de Statistique*, *Journal de la Société de Statistique*, and *Revue parlementaire et politique*.

Prior to this study, none of Cheysson's works had been translated into the English language. Consequently, it was necessary to translate several of his economic tracts. A selected bibliography containing what the author regards as the more significant of Cheysson's publications

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20 The distinction between the history of economic thought and the history of economic analysis accepted by this writer is Schumpeter's. He defines economic thought as "the sum total of all the opinions and desires concerning economic subjects, especially concerning public policy bearing on these subjects, that, at any given time and place, float in the public mind"; while economic analysis, "however much disturbed it may have been by the interests and attitudes of the market place, displays a characteristic property which is completely absent from the historical development of economic thought." The latter represents "and effort to improve our conceptual apparatus," and thus is conducive to scientific progress, whereas the former is not. [Schumpeter, op. cit., pp. 38-40].

21 The author wishes to acknowledge the generous assistance of the L. S. U. Foundation and the L. S. U. College of Business Administration in making the translations for this study possible.
comprises Appendix I of this dissertation. Those works which have been translated for this study are indicated in the general bibliography and in footnote references throughout the text.

After Cheysson's death in 1910, a number of his different works were collected by his friends and disciples and published under the title, Émile Cheysson: Oeuvres Choisies. This collection was published in 1911, in two volumes, and apparently the intent of the editors was to portray, by selection of articles included in the two-volume work, the full range of Cheysson's many and varied interests. In general, this collection of Cheysson's writings should not be considered a complete review of his economic thought, since several important articles did not find their way into the Oeuvres Choisies. This writer experienced little difficulty in tracing a large number of Cheysson's writings to the journals in which they originally appeared, and where translations were made, these original sources were used. The biography and bibliography contained in Cheysson's Oeuvres Choisies have been indispensable, however. The former was heavily relied upon in the preparation of the biographical sketch in this chapter, and the latter formed the starting point for the research of this study. Copies of the Oeuvres Choisies are generally scarce in this country, but may be obtained from the Kress Library at Harvard University, or the Cornell University Library.

There is a paucity of secondary sources on Cheysson, especially in English. With the exception of Léon Walras, who for six years enjoyed an intermittent correspondence with Cheysson from his Swiss home-in-exile, and the Italian, Maffeo Pantaleoni, who bestowed footnote recognition on
Cheysson in his *Pure Economics*, few leading economic theorists outside of France seemed aware of Cheysson's work.

In France, attention must be called to two biographies written by individuals who knew and admired Cheysson. The one found in the first volume of *Oeuvres Choisies* was partially drafted by Cheysson, himself, and completed after his death with the aid of various notes and documents he left behind. The second, a memorial article, was written on the occasion of Cheysson's death by Clément Colson, a friend of Cheysson's and an important economist in his own right. This last article appeared in the proceedings of the French Academy of Moral and Political Sciences, which had extended membership to Cheysson in 1901. A eulogy by Émile Boutroux pronounced on the occasion of Cheysson's funeral also contains some interesting material.

The greatest problem in connection with the primary research of this study has been one of translation. With the exception of a few minor bits

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and pieces, the bulk of the work has been left to professionals, although this writer remains responsible for final editing. Occasionally it has been necessary or desirable to repeat certain quotations in the original French, but such quotations have been kept to a minimum.

Biographical Sketch

Jean-Jacques Émile Cheysson was born at Nîmes, France, on May 18, 1836. His family boasted a proud heritage of distinguished public servants in the legal and military professions, but the French Revolution had left them ruined. Nevertheless, Cheysson distinguished himself as a student in the secondary schools of Nîmes, and after two years of preparatory instruction at the Jauffret Institute in Paris, he was accepted to the École Polytechnique in 1854. Two years later he began his technical training in engineering and mathematics at the École des Ponts et Chaussées.

It is a curious coincidence that on the same date thirty-two years earlier, the French engineer and economist, Jules Dupuit, was born. This coincidence is noted here because several parallels exist in the lives of the two men: both were engineers by training, both were drawn to economics by practice of their profession, both contributed to economic analysis, and both received only slight attention by later economists. Underscoring the fact that Cheysson, too, was an engineer in the public service, Schumpeter remarked that "in this respect he continued a French tradition that is adorned by the name of Dupuit and is now more alive than ever." [Schumpeter, loc. cit., pp. 841-842]. For the most recent and complete treatment of Dupuit, see R. B. Ekelund, Jr., "A Critical Evaluation of Jules Dupuit's Contributions to Economic Theory and Policy" (unpublished Ph.D. dissertation, Dept. of Economics, Louisiana State University, 1967).

Created in 1794 as a post-revolutionary institute of higher technical education, the École Polytechnique was "devoted mainly to the applied sciences—in contrast to the École Normale, created at the same time and devoted to theory . . . . [It] commanded from the very beginning a teaching staff probably more illustrious than any other institution in Europe has had before or since." The new École Polytechnic was the embodiment of an idea held by G. Monge, the founder of descriptive geometry, in which "all classes of engineers would receive their training in the subjects held in common at a single, great school." [F. A. Hayek, The Counter-Revolution of Science (London: The Free Press, 1955), p. 111].
In 1859, Cheysson made his debut as engineer at Reims, where "he was put in charge of different services, of roads, of navigation, and of agricultural improvements, which had previously been dormant, but which he rapidly developed."28 Having been made a member of the Reims Academy upon his arrival in that city, Cheysson frequently took the opportunity to present papers before its members. Here he was first exposed to the kinds of social questions which were to command so much of his efforts in later years. Among other things, he worked on a plan to prevent pollution of the Vesles River with the chemist, Marieton.

The speed and efficiency with which Cheysson dispatched his tasks, including the construction of a thirty-kilometer railway between Reims and Chalons in little more than a year, soon brought Cheysson's name to the attention of Amédée Bommart, the Inspector-General of France's public works. In 1864, when Frédéric LePlay was recruiting personnel for the 1867 Paris Exhibition, Bommart named Cheysson as LePlay's collaborator. Cheysson could not fail to be impressed by the redoubtable LePlay, and there followed a teacher-disciple relationship which exercised a decisive influence upon the former's life and thought. The 1867 Exhibition was a success, and for his services, Cheysson was decorated by the French Legion of Honor.

From 1868 to 1870, Cheysson had various responsibilities, including that of attaché to the Secretariat of the *Annals des Ponts et Chaussées*; control of navigation on the Marne River; and direction of the interstation railway system. He became professor of administrative procedure at the École des Ponts et Chaussées in 1868.

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The outbreak of the Franco-Prussian War in 1870 found Cheysson charged with the maintenance of Paris' food supply. Turning his engineering genius to the matter at hand, Cheysson successfully increased bread production during the siege of Paris by converting train stations to flour mills, utilizing locomotive engines as a power source. Only when wheat supplies were eventually exhausted did Paris capitulate.

Following the armistice of February, 1871, Cheysson agreed to accept a position as factory director at the Creusot foundry of Eugene Schneider. Schneider had met Cheysson at the Paris Exhibition in 1867, and had offered him a position as early as 1869, but Cheysson was not disposed to accept it at that time. However, "the war and especially the [Paris] Commune had changed Cheysson's earlier dispositions . . . ." On August 12, 1871, he took up his new post.

As always, Cheysson performed his new duties with effectiveness and dispatch. The significance of his tenure at Creusot, however, centered upon his relationship with Schneider. "For the second time in his life, Cheysson had the rare good fortune to work under a man of great vision." As LePlay was the great reformer in the eyes of his disciples, Schneider was le grand patron in the eyes of his employees. For Cheysson, therefore, Creusot was at once a social and economic laboratory. Under the influence of Schneider, Cheysson came to appreciate that beneficence of economic patronage and cooperation between employer and employees which LePlay had preached. But more important for the development of economic analysis,

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29 Cheysson later described the trials of war production in "Le Pain du Siège," which is included in the first volume of his Oeuvres Choisies, pp. 115-151.


31 Ibid., p. 24.
Cheysson began to work out, independently, a system for the solution of micro-economic problems which anticipated things to come. One of his biographers recorded that before 1871, "as engineer of bridges and highways he had been occupied with the operation of roads, railways and canals, but not mining, metallurgy or the production of machinery. It was a whole new world for him." Fortunately for economics, this "new world" turned Cheysson's attention to many economic relationships and problems in the firm.

Schneider's sudden death in 1874 was a severe blow to Cheysson. When, a little later, his wife's already delicate health began to deteriorate in the smoke-filled atmosphere of Creusot, Cheysson decided it was futile to remain. He submitted his resignation the same year and left Creusot to return to Paris.

Upon his return to the Corps of Bridges and Highways in 1874, Cheysson was coldly received. As a "penance" for his industrial escapade he was given the unenviable position of subordinate engineer in charge of the Seine, at Vernon, where he again served under Krantz, his friend and former chief during the war. In 1877, however, he was called into the Ministry of Public Works as the new Director of Maps and Plans, a position in which he could indulge his taste for economic studies. His chief duties in this position involved the construction of national and regional maps and the collection and presentation of various transport statistics. While attached to the Ministry, Cheysson edited twelve volumes of the

32Ibid., p. 23.
Bulletin de Statistique et de Legislation comparées and thirteen volumes of the Albums de Statistique graphique.  

According to Clément Colson, Cheysson's statistics regarding the operation of the French railroads and his method of presenting them were extremely useful in illustrating the absurdity of government reclamation schemes which proposed equal treatment for all lines. Comparisons of revenue and cost data for each line revealed which were economical and could be extended so as to profit both the companies and the state, and which lines should have been restricted because they already placed excessive burdens upon taxpayers.

Regrettably, these volumes were not accessible. It seems, however, that Cheysson's performance in connection with them was more of an exercise in applied statistics than an analytical performance [See Cheysson's "Note sur l'Album de Statistique graphique de 1879," Annales des Ponts et Chaussées. Mémoirs et Documents, 5th Ser., XVIII (October, 1879), pp. 261-264]. Colson gives this impression in his biography of Cheysson [loc. cit., p. 162]. The overall importance of Cheysson's editorship of these volumes should not be overlooked, however. Particularly in the Albums, Cheysson began to illustrate the fruitfulness of an analytical approach which interprets masses of complex statistical data by means of relatively simple geometric diagrams—an approach which later led to the construction of a general analytical method, which Cheysson called "geometric statistics".

In order to stimulate railway construction in France after 1842, the French government set up certain subsidies and guarantee arrangements whereby it would make up the deficits of unprofitable companies in addition to guaranteeing interest payments on all companies' bonded indebtedness. Since some companies could not operate profitably, especially after a new wave of railway construction in 1871, the State did come to own several lines. For a while it was a question of whether or not the State should own all the lines, but the government shied away from the huge financial transactions this would involve. In 1883 a new arrangement was made under which the guarantees continued in force but profits were to be shared by the companies and the State [See L. C. A. Knowles, Economic Development in the Nineteenth Century (London: George Routledge & Sons, 1936), pp. 212-214.]
Of Cheysson, the statistician, Colson notes that "in these matters, he was always the apostle of the most rigorous and exact methods; in his numerous pamphlets and lectures he continually recommended and employed statistical data."\(^{36}\) He was a member of the Paris Statistical Society and the International Statistical Institute, having served as president of the former in 1881.

Cheysson's most impressive analytical work, "La Statistique géométrique," first appeared in print in 1887, although the same ideas had been presented before the Société de Statistique de Paris in 1885 and before the Bordeaux Conference on Technical Education in 1886. The year 1887 also saw the end of the Bulletin de Statistique et de Legislation comparées, and a re-direction of Cheysson's activities. Free from many technical duties after 1887, Cheysson progressively turned his attention to social questions, with which he came into more frequent contact. He remained with the Corps of Bridges and Highways, however, gradually rising to the rank of Inspector-General, first class, in 1898. In 1902, while still in the public service, Cheysson was named Director of the École des Ponts et Chaussées.

The rest of Cheysson's multi-faceted career need not unnecessarily detain us. He had been appointed professor of political economy at the École libres des Sciences politiques in 1882; and in 1885 he accepted a chair in political economy at the École des Mines. He held both academic positions concurrently for many years. In 1890, Cheysson published a statistical analysis of 100 family budgets collected by Le Play and his

\(^{36}\)Colson, loc. cit., p. 166.
followers, which achieved for the author a certain measure of fame, particularly the following year when it earned him the Montyon Statistical Prize, awarded annually by the Academy of Sciences of the French Institute.

A complete list of Cheysson's activities almost defies description. He was a man of such diverse interests and tireless energies that his presence and direction touched many areas. He was elected president of the French Geography Society in 1896; became a member of the prestigious Academy of Moral and Political Sciences of the French Institute in 1901; and was chosen president of the French Agricultural Society in 1903, particularly for his efforts in combating the phylloxera, or vine blight, which threatened the future of French viniculture. In addition to representing France at many national and international conferences, Cheysson was one of the founders of the Musée Social, a Commander in the French Legion of Honor, one of the most ardent supporters of the Alliance for Social Hygiene, and three times president of the Société Internationale des Études Pratiques d'Économie Sociale, which had been founded by LePlay in 1856. He died in the Swiss Alps, at Leysin, in 1910.

Cheysson's formal training in economics remains somewhat of a mystery. He was familiar with the writings of the inconspicuous Henri Baudrillart, and indeed, probably studied under him at the École des Ponts et Chaussées; but the analytical economics taught in France in the 1850's consisted of little more than J. B. Say and Frédéric Bastiat. References to the latter and to Sismondi are frequent throughout Cheysson's early economic writings. An outline of the course in industrial economy which

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Cheysson taught at the Ecole des Mines reveals some familiarity, and disagreement, with Ricardo's theory of rent and Malthus' theory of wages. He was probably acquainted with Adam Smith only through Say. Some minor references to Wilhelm Roscher dot Cheysson's writings, indicating an awareness of the German Historical School. Also mentioned on several occasions is the Italian, Pellegrino Rossi, who taught at the Collège de France.

From a methodological standpoint, Le Play's influence on Cheysson is unmistakable. Beyond LePlay, of course, lies the whole French positivist tradition of Condorcet, Saint-Simon, and Comte. Among other contemporaries, Cheysson was perhaps tangentially influenced by Paul Leroy-Beaulieu, who is cited often, Émile Levasseur, Hippolyte and Frédéric Passy, Clément Juglar, Joseph Garnier, Alfred Jourdan, Émile de Laveleye, Alfred Neymarck, Paul Cauwès, and Alfred de Foville, all of whom rate mention in one place or another. But as far as the purely scientific aspects of economics, Cheysson apparently received little exposure to nineteenth-century economic theorists, either in France or abroad, at least before 1885.

At first blush, the questionmark of Cheysson's economic lineage is augmented by the fact that despite his command of certain economic tools developed by Cournot and others, he admits not having read their works

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39According to LePlay, the method of inquiry which held the most promise for the scientific advancement of social science was the "monograph," or family budget study, which consists in the painstakingly intensive investigation of a limited number of individual cases, each considered in the totality of its moral, social, and cultural environment.

40It is curious that among Cheysson's writings examined by this writer the only reference to John Stuart Mill is to Mill's Logic rather than his Principles.
until after he had developed his analytical system and presented it before
the Société de Statistique de Paris, in 1885.\textsuperscript{41} Closer analysis reveals,
however, that Cheysson's application of certain analytical tools to the
solution of economic problems without knowledge of preceding theoretical
contributions is not overly surprising. The contributions of another
French engineer, Jules Dupuit, are based on a similar claim.\textsuperscript{42} In many
respects, Dupuit's theoretical work advanced that of Cournot, even though
Dupuit was unaware of Cournot's work. Instead, he was led to the formulation
certain economic tools through the demand of the engineering pro-
profession. In similar fashion, Cheysson, by his own testimony, developed
a number of mathematical models in order to solve certain problems which
rose from the exigencies of his profession.

Cheysson's ignorance of important theoretical advances developed in
the nineteenth century is less than shocking in view of the state of formal
economic instruction in France prior to 1878. Until that year, political
economy was taught only in the highest technical and cultural schools,
such as the École des Ponts et Chaussées, the Conservatoire des Arts et
Métiers, and the Collège de France. All of the instructors in these
schools were members of that orthodox group of economists who belonged to
the French Institute and professed the liberalism of Smith and Say.\textsuperscript{43}
Their failure to accept and to build upon the theoretical contributions of

\textsuperscript{41}Letter of Émile Cheysson to Léon Walras, May 26, 1886, in Correspondence, II, pp. 128-129. A translation of the Walras-Cheysson correspondence is appended to "Selected Writings," supra, n. 17.

\textsuperscript{42}Ekelund, \textit{op. cit.}, p. 19.

\textsuperscript{43}See Henri St-Marc, \textit{Étude sur l'Enseignement de l'Économie politique dans les Universités d'Allemagne et d'Autriche} (Paris: Larose et Forceil, 1892), p. 121; and \textit{infra}, Ch. II.
the "unorthodox" Cournot, Dupuit, and Walras is indicative of the kind of stagnation and indifference which characterized so much of French economics in the nineteenth century. As Schumpeter has observed, "they simply did not care for the purely scientific aspects of our subject." In view of these facts, it is not surprising that most of the plaudits for peak performances in France have gone to mathematicians (e.g., Cournot, Aupetit) or to engineers (e.g., Isnard, Dupuit), rather than professional economists, with the exception of Walras, who was certainly no member of the economic orthodoxy in France.

Thus Cheysson's most significant theoretical contributions emerged in an environment hostile to the analytical aspects of economics, and this accounts somewhat for the misguided attention accorded Cheysson in his lifetime. Perhaps Cheysson would prefer to be remembered as a social reformer rather than as an economic theorist. He admittedly despised the "abstract speculations" of the deductive method. But this does not diminish the significance of his analytical contributions nor does it justify the insufficient attention he has so far received at the hands of other economists. It is hoped that this research will contribute to an understanding and recognition of those contributions.

44Schumpeter, op. cit., p. 841.
The State of Economics in Nineteenth-Century France

It is extraordinary that a country which has traditionally spawned literary, artistic and scientific giants could, at the same time, have treated its gifted children so badly. In economics, Schumpeter is reputed to have said that of the world's four greatest economists, three were French. He might have added that two of the three were either ignored or treated shamefully by their countrymen during their lifetimes. Peak achievements in French theoretical economics, after the Revolution, were always effected in spite of a predominant intellectual atmosphere antagonistic to innovation. This is certainly true of Cournot, Dupuit, and Walras. It is also true of Cheysson, who, unlike the others, never swam completely outside the mainstream of French orthodoxy, but nevertheless, ventured beyond the shallows, and in so doing, made significant contributions to the development of economic theory, particularly in the applied fields.

The entire nineteenth century represents an interesting period in the history of economic ideas, not only for the richness of individual

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1 See P. A. Samuelson, "Economists and the History of Ideas," American Economic Review, LII, No. 1 (March, 1962), pp. 3-4. The three were: Quesnay, Cournot, and Walras. Presumably, Alfred Marshall was the fourth.

2 Cournot was simply ignored prior to his resurrection at the hands of Jevons and Walras. The latter was, of course, denied a teaching position in France and forced to seek less hostile surroundings for the dissemination of his ideas.
contributions, but for the emergence of major trends as well. Roughly speaking, the beginning of the century marked the acceptance and dissemination of classical liberalism throughout Europe and the United States; its end marked the genesis of neo-classicism and the rise of marginal utility theory. In between, Marx and the Utopian Socialists were at work.

Cheysson represents somewhat of a transitional figure in this pattern. Though not as extreme as some, he was a liberal in the classical sense, and violently opposed to socialism. But at the same time, he showed, on a theoretical level, some of the innovational spirit associated with neo-classical economics. For example, he made mathematics a vital part of his economic analysis even though it was not fashionable to do so in France.

An understanding of the intellectual environment in which Cheysson developed his ideas is essential to a realistic assessment of his impact (or lack of it) on economics. Therefore, this chapter reviews that environment as a preamble to the critical evaluation of Cheysson's ideas which follows.

The Performance of Classical Liberalism

Although the nineteenth century saw the spirit of individual liberty which inspired the French Revolution rapidly deteriorate in the French political arena, the same spirit persevered in the creed of economic liberalism which descended from Adam Smith. From the French standpoint, the foremost spokesman of classical liberalism in the early 1800's was J. B.

3For which a large part of the responsibility must go to J. B. Say, the French popularizer of Adam Smith (but not merely so), whose Traité d'économie politique (1803) enjoyed tremendous textbook success on the continent and especially in the United States.
Say, France's first academic teacher of economics, initially at the Conservatoire National des Arts et Métiers (1819), and later at the Collège de France (1830). The combination of France's predisposition to individual freedom and Say's early supremacy in the formal instruction of economics looms large in the development of French economics throughout the nineteenth century.

The tradition begun by Say remained strong for more than a hundred years, so much so that classical liberalism attracted more followers and persevered longer in France than in any other country on the continent. Say was succeeded in his chair at the College de France by the Italian, Pellegrino Rossi; Rossi by Michel Chevalier, the well-known free-trader and sometime Saint-Simonian; Chevalier by his son-in-law, Paul Leroy-Beaulieu, editor of the Économiste Français and contemporary of Cheysson. Haney's denials to the contrary, these men formed the core of a "school," in the Schumpeterian sense, and while they contributed little of significance to economic theory, the succession from Say to Leroy-Beaulieu is important because it was "a succession in spirit and doctrine." As the

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4 According to Schumpeter, "The Collège de France is neither a college nor a graduate school in the American sense, though somewhat more like the latter than the former. Appointment to a chair is an honor that spells recognition of the appointee's leading position rather than the opportunity for inspiring and directing research. Lectures are addressed to a wide public and sometimes are (or were) frequented by le monde." [op. cit., p. 496 n.

5 In this respect, Lamontagne was certainly correct in noting that "we must go back to Say if we want a full explanation of the trend which economic theory has followed in ... [France]." [Maurice Lamontagne, "Some French Contributions to Economic Theory," Canadian Journal of Economics and Political Science, XIII (November, 1947), p. 523].

6 Haney, loc. cit., p. 846.

7 Schumpeter, op. cit., p. 497.
succession continued, however, the doctrine became more dogmatic,particularly after 1850. Reflecting the influence of Dunoyer and Bastiat, the French liberals of the latter half of the nineteenth century became decidedly more optimistic, and rejected those parts of English classicism which were basically pessimistic, such as Ricardian rent theory, Malthusian population theory, and the wages-fund doctrine. While the "succession in spirit and doctrine" which began with Say was little interrupted, the majority of French economists after 1850 remained liberal only in the laissez-faire sense, so much so that laissez-faire became a rational principle rather than a rule of art. Moreover, the increasing popularity of socialist doctrines among the workers of France provided an additional raison d'être for the "optimistic" school and a powerful cohesive influence upon its members.

Exclusiveness of French Economics after 1850

Under this form of self-imposed orthodoxy, the "optimists" soon attained a position of hegemony which failed to meet any serious opposition, on the non-socialist front, prior to 1870. Significantly, but not surprisingly, they controlled the Journal des Économistes, founded in 1842; the new dictionary of political economy and the publishing house of Guilllaumin; the central professional organization in Paris (i.e., the Société d'Économie Politique); the Collège de France; and other institutions, "as well as most of the publicity—so much so that their political or scientific opponents began to suffer from a persecution complex."\(^8\)


In two important respects the success of the Paris Group, or optimistic school, was due to peculiarly French reasons. In the first place, the French educational system, since the time of Napoleon, has always been unique, and among institutions with university status, economics had no place prior to 1878. Such instruction as did exist took place outside of the university system, in the Collège de France, for example, which neither educated disciples nor attracted regular students; or in the technical schools. Among the latter there were chairs of political economy at the École des Ponts et Chaussées, the École des Mines, the Conservatoire des Arts et des Métiers, the École des hautes Études commerciales, and the École libre des Sciences politiques. The latter was somewhat more important than the others but was founded as late as 1872. Before 1878, all of these chairs were staffed by members of the economic orthodoxy, thus giving the Paris Group an effective monopoly of formal academic instruction in economics.

In the second place, as the home of France's intellectual elite, the Paris Institute was a major factor in the direction of all of the sciences, including economics. Essentially, the Institute was a central organization composed of different academies in various fields of science. Political economy was included in the Academy of Moral and Political Sciences, which, in the nineteenth century, represented a kind of "closed shop," insofar as no unorthodox members were allowed to threaten the dominant position of the Paris Group within the Academy. Membership in the Institute was elective, and new members were carefully received only upon the death of a former

10 In 1878 a serious threat to the exclusiveness of the Paris Group began to mount following the inclusion of economics instruction in the Faculties of Law of the university system. [See Charles Gide, "The Economic Schools and the Teaching of Political Economy in France," Political Science Quarterly, V, No. 4 (December, 1890), pp. 630-634].
member. The official duty of the Institute was apparently that of promoting and encouraging scholarly achievements, and to that end, it sponsored numerous competitive essays and researches. So prestigious was recognition by the Institute that, with few exceptions, all of France's most brilliant young minds turned their efforts in this direction. Thus, the Paris Group was able to maintain the exclusiveness of French economics and to shape economic thought, "directly by the subjects assigned for competitive prize essays and indirectly by the somewhat one-sided views which govern final awards, so that the very solutions looked for in advance [were] evoked."\textsuperscript{11} From this standpoint, the Institute, despite its prestige, its lofty ideals, and its eminent membership, did much to retard the development of French economics in the nineteenth century. The economists of the Institute showed no taste for the analytical aspects of economics. Many, if not most, of them were successful men of affairs, and "owing partly to the practical turn of their minds and their too exclusive concentration upon economic policy, they lacked interest in purely scientific questions and were in consequence almost wholly sterile as regards analytic achievement."\textsuperscript{12} Moreover, the group's doctrine seemed to be inspired, "less by a truly scientific spirit than by a predetermination to justify the existing order of things."\textsuperscript{13}

The predominance of members of the economic orthodoxy in the educational system cannot singlehandedly account for the uninterrupted continuity of the optimistic school, for several students of the technical

\textsuperscript{11}Cossa, \textit{op. cit.}, p. 369.

\textsuperscript{12}Schumpeter, \textit{op. cit.}, p. 497.

schools made notable theoretical contributions to economics. Scholarly achievements which did not receive the sanction of the Institute, however, simply were not accepted. As Gide has pointed out, those French economists who dared venture beyond the economic orthodoxy into the realm of pure theory were ignored. With few exceptions, these "heretics" remained virtually unknown in their native land, receiving "tardy recognition only when at last discovered by foreigners."^15

Despite his membership in the Institute and his sympathy for the politics of the Paris Group, Cheysson moved on a somewhat higher plane and turned in a creditable performance as regards analytic achievement. There remains, however, a real question as to whether further investigations into theoretical economics by Cheysson were not stifled by French orthodoxy and the Institute.

Politics of the Paris Group

We must pause, however briefly, to discuss the politics of the optimistic school, for it was political rather than theoretical considerations that so dominated their thought and their utterances. It has already been mentioned that they were laissez-faire in the extreme sense. In part this was because of a rising trend of socialism in Europe and especially in France, but more fundamentally because of a continued belief in natural law and the conviction that social evils were the result of interference

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14 Dupuit was a student at the École des Ponts et Chaussées; Walras, at the École des Mines.

15 Gide, Political Science Quarterly, V (1890), p. 607. Among those mentioned by Gide in this respect are Condillac, Dupuit and Cournot.
or non-conformity with the natural order. All digressions from a very rigid orthodoxy were viewed as socialist-inspired. Thus they were opposed to state intervention of any kind. Anti-statistes in the ultra sense, they were staunch defenders of the status quo, which meant they were constantly refuting socialist doctrines and combatting myriad plans for social reform.

Among the more distinguished names in the group which controlled the Société d'Économie Politique were: Paul Leroy-Beaulieu, J. G. Courcelle-Seneuil, Léon Say, Maurice Block, Émile Levasseur, Yves Guyot, Gustave de Molinari, Frédéric Passy, Henri Baudrillart, and Alfred Neymarck.

Beginnings of Dissent: LePlay and his School

The various socialist schools in France, England and Germany were obviously juxtaposed to the ultra-liberal French school, but despite France's vigorous impulse to socialism in the first half of the nineteenth century.

16 "The laws which govern capital, wages, the distribution of wealth are as good as they are inevitable. They gradually raise the level of mankind." [Paul Leroy-Beaulieu, Précis d'Économie politique].

"We assert that it is enough to observe them (these natural laws), levelling the natural obstacles that impede their action and, above all, refraining from putting artificial obstacles in their way, for the condition of mankind to be as good as is consistent with the advancement of his knowledge and his industry. Our gospel may therefore be summed up in these four words: 'laisser faire, laisser passer'." [Gustave de Molinari, The Natural Laws of Political Economy].

Both passages are cited by Gide in Political Economy, pp. 19-20 n.

17 See Gide's account of the intellectual stagnation which characterized the society's meetings [Political Science Quarterly, V (1890), pp. 622 et passim].

18 Haney erroneously advances Cheysson's name among the members of this group, while Schumpeter affirms that although Cheysson "sympathized with the politics of the group," he was "no member of its inner circle and hence, very significantly, mentioned but rarely." [Haney, op. cit., p. 849; Schumpeter, op. cit., p. 841].
century, socialism never gained the upper hand in that country, and the second half of the century witnessed Germany's particular contributions to the development of the socialist doctrine. To be sure, the optimistic school was compelled to refute the socialist menace, which was somewhat revived in France after the war of 1870 and the Paris Commune. But the first significant reaction against the optimistic school came from outside the socialist ranks. It was begun by Frédéric LePlay, around 1855, the year in which LePlay published his work entitled, Les Ouvriers européens.19 The movement begun by LePlay was significant in the sense that it engendered a genuine school of followers, an official journal (La Réforme sociale), and a professional association (the Société Internationale des Études Pratiques d'Économie Sociale), all of which rivalled, to some extent, the like organs of the established orthodoxy.

While remaining aloof from the optimistic orthodoxy in several vitally important points, LePlay's school was never hostile to the Paris Group. Rather, the two schools were always on good terms. LePlay's Les Ouvriers européens was even crowned by the Institute. Like the liberal school, LePlay was opposed to state intervention. He also defended the rights and ownership of capital, and the wages system, although he would modify the latter so as to increase initiative while simultaneously recognizing the duties of the employer to increase the workers' well-being and encourage "social peace." According to St-Marc, it was the romantic and patriarchal ideas of this school; its belief in the goodness of employers

19 Les Ouvriers européens was a collection of thirty-six detailed family monographs, or budget studies, compiled from LePlay's personal observation.
and employees, and the perpetual guardianship of the capitalists which earned the sympathies of the orthodox economists.  

On the other hand, LePlay's school of social reform was not fundamentally optimistic. It denied the beneficence of individualism, the existing economic organization, and the "false dogmas of 1789." Starting from the Christian doctrine of original sin, it placed no confidence in man's natural instincts, and it expected him "to be kept in the right path, if not by the state, at least by the family, by the ruling classes or by religion." The school's self-appointed task, therefore, was the re-establishment of these various authorities, particularly that of the head of the family and of the employer, or patron. The object of its researches was applied economics rather than pure theory, i.e., questions of wealth, morals, legislation and government were considered inseparable. In the words of one member: "Human societies should aim not so much at the creation of wealth as such, but rather at increasing the well-being of mankind. Well-being includes daily bread, but it does not exclude social peace." Finally, LePlay and his followers rejected the deductive method in favor of factual observation. The school practiced the inductive method in a very original and picturesque manner, invented by

20St-Marc, op. cit., p. 121.

21Specifically, the doctrines of the original perfection of mankind and the belief that peace and happiness are the spontaneous and effortless outcome of every free society. Rousseau was the obvious villain here.


LePlay himself, namely, by various monographs, or budget studies, of working-class families.  

The dissent initiated by LePlay took a more aggressive turn at the hands of a new school even more Catholic than LePlay's—the Christian socialists. Led by Cardinal Manning and the Count de Mun, the Christian socialists launched a vigorous onslaught against the anti-étatistes, condemning them as responsible for France's social evils, insisting upon state intervention for the protection of the working classes, and preaching the gospel of corporate organization in the economic world, and provincialism in the political. Unlike LePlay's social reformists, the Christian socialists denied the beneficence of private capital, thus incurring the full wrath of the Paris Group. Despite the intransigence of the Christian socialists, they were nevertheless unsuccessful in dislodging the ultra-liberals, although they may have succeeded somewhat in rendering the doctrines of the latter school "antiquated and unfashionable.

Finally, a different, and in the long-run more effective kind of dissent began to gain ground after 1878, as a "new breed" of jurist-economists

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24 An example of a LePlay family monograph is included as an appendix to Henry Higgs' article, "Frédéric LePlay," Quarterly Journal of Economics, IV (July, 1890), pp. 467-484. For structural information on the LePlay monographic method, see C. A. Ellwood, "Instruction in the Observation of Social Facts According to the LePlay Method of Monographs," American Journal of Sociology, II, No. 5 (March, 1897), pp. 662-679. Cheysson's contributions to this area of research, as well as the merits of the monographic method, are discussed below.


26 Ibid., p. 628. Of France in the latter part of the nineteenth century, Gide observes, "there are a certain number of revolutionists, and a crowd of radicals, but hardly any socialists, although the radicals deck themselves willingly with this title as a feather in their caps ... . Although it be merely a matter of show, this new fashion contributes also to render the doctrines of the liberal school antiquated and unfashionable."
in France achieved a platform from which to air their ideas on the nature of the economic order.

As indicated above, economics had no place in the regular plan of university instruction prior to 1878, a fact which contributed to the sustained hegemony of the optimistic school. But the members of that school considered this deficiency lamentable, and seeking to install themselves or their kind in the universities so as to attract more adherents, particularly from the younger generation, they succeeded in having chairs of political economy created in each of the thirteen law faculties of the university system. Due to a peculiarity in the university statutes, however, which allowed only lawyers to fill such chairs (and which was completely overlooked by the dominant school), almost all of the new academic positions went to persons outside of their ranks. Thus the result obtained was quite opposite that intended. As Charles Gide has pointed out, lawyers are "... not apt to relish the doctrine of laissez faire."27

As a result, a deliberate, if somewhat slow, frontal attack upon the dominant school of French orthodoxy became visible around 1880. The final and complete outcome of this development may yet be in doubt. It should be noted, however, that with few exceptions, this "new breed" of French economists has revealed little more proclivity or taste for pure economics than their antagonists, while the distinctly French contributions to the progress of economics in the twentieth century appear to be in the applied fields (e.g., particularly their attempts at marginal cost pricing in public utilities, etc.).

27 Political Science Quarterly, V (1890), p. 631. Gide filled one of the newly-created chairs at the University of Paris.

Among this "new breed" of economists who, among other things, founded the *Revue d'Économie Politique* in 1887, were Paul Cauwès, Charles Gide, editor of the *Revue* during its first forty-six years, Alfred Jourdan, and Edmond Villey. Later followers in the same tradition include Charles Rist, who collaborated with Gide on the ever-popular *History of Economic Doctrines*, Adolph Landry, and Albert Aftalion.

**The Social Economy of Cheysson and LePlay**

Cheysson properly belongs to LePlay's school, although he had friends and admirers in many camps. Those factors which distinguished LePlay from the Paris Group were also revealed in Cheysson's writings, especially the predominance of moral and religious considerations in the economic order; a distrust of evolutionary processes and natural progress, along with hostility toward the "false dogmas" of the revolution; emphasis upon organization and stability in the family and the workshop, and the preservation of patrimony.

As far as the purely analytical aspects of economics, however, Cheysson rose above LePlay; he reveals a taste and a talent for dealing with economic problems which is lacking in LePlay, although the latter was certainly competent in his own right, viz., analyzing the economic and social foundations of society.

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29 For purposes of identification, LePlay's school shall henceforth be referred to frequently as the Sociological School. The followers of LePlay thought in terms of "social economy," or sociology, and considered political economy to be but one branch of the moral sciences. Hence they might be called social economists, or sociologists, though some, like Cheysson, were much more. By contrast, members of the orthodox, or optimistic school, like the Physiocrats before them, called themselves simply, "the economists."
Methodology, Family, and Society

LePlay's influence is everywhere in evidence throughout Cheysson's writings. The latter's methodology, his conception of society, the importance of the family, and his zeal for social reform begin with LePlay. Yet Cheysson was more than the ardent disciple and popularizer of LePlay he is made out to be. He was much more interested than LePlay in the analytical aspects of economics, particularly from the managerial standpoint, and his performance in this respect betrays a talent and a method which anticipated later developments in micro-economic theory.

LePlay has received less attention from economists than from sociologists, and perhaps rightly so, despite the fact that LePlay's fundamental premise for studying family behavior was economic. That premise, accepted by his followers, is that all activities of the family are eventually recorded as income or expense, so that the family budget is the "complete summary of the existence of a family." Based upon the same premise, LePlay developed a genuinely unique method for studying family behavior: the family monograph, or budget study, constructed from empirical data collected by on-the-spot observation of the budget activities of working-class families.

From LePlay's standpoint, the significance of the family monograph was as much, if not more, sociological than economic; moreover, it was perceived as a dynamic rather than a static method. It is "... not confined

30. LePlay's contributions to sociology have been most capably analyzed and assessed by Pitirim Sorokin [Contemporary Sociological Theories (New York: D. Van Nostrand, 1936)]. Also, cf., Zimmerman and Frémiot, op. cit., which contains, in addition to an excellent treatment of LePlay's thought and method, an abridged translation of the first volume of LePlay's Les Ouvriers européens, translated by Samuel Dupertuis.

to portraying . . . [family existence] like a snapshot, so to speak, but it portrays the family in a living, moving state; it reveals all its workings; penetrates the depths of family morality, prejudices and customs; at the same time it brings to light the institutions and general events affecting each family, the consequences for them and their reactions to these events and institutions." The choice of the family as the object of investigation was obvious to LePlay, since he considered the family the basic social unit of any society. The justification for such studies remained a genuine quest for those factors which contribute to the social and economic well-being of society.

Impressed by cyclical swings in the economic and social prosperity of different nations, LePlay applied his analytical method in an attempt to explain the causes of such phenomena. The answer was sought in the structure of society, and in addition to the family, particular emphasis was attached to employment, social mores, labor unions, and the relationships between individuals and government; between worker and employer. To LePlay and his school organization and stability in and among these

32 Ibid.

33 Limitations of time and space preclude an exhaustive analysis of LePlay's sociological preconceptions and contributions. For an excellent treatment of LePlay along these lines, see the two works of Zimmerman, supra, n. 30, from which this section draws heavily. Sorokin, who profoundly influenced Zimmerman, says the following of LePlay: "The name of Frédéric LePlay deserves to be put among the few names of the most prominent masters of social science. He and his pupils have created a really scientific method of the study and analysis of social phenomena; they elaborated one of the best systems of social science; and finally, they formulated several important sociological generalizations. In all these contributions LePlay and his continuators have displayed a conspicuous scientific insight, a brilliant talent for scientific analysis and synthesis, and an originality of thought. As a result, they compose a real school in sociology with very definite methods and principles." [Sorokin, op. cit., p. 63].
components of the social structure provided the key to social welfare; they were therefore devoted to the discovery and reinforcement of the ties existing between the several components.\textsuperscript{34}

With regard to scientific method, the inductive approach was favored as the only realistic and dependable alternative. As indicated above, the monographs collected by the sociological school were minutely detailed and very exhaustive.\textsuperscript{35} Emphasis was placed upon arranging the mass of facts in uniform fashion so that statistical comparisons could be made between families. LePlay did not attempt such comparisons, however. Most of his life was spent in numerous travels through France and abroad, on which he collected family data, and in written discourses on the nature and efficacy of his method. The first attempts at a statistical comparison of the results of such studies was made by Ernst Engel, a student of LePlay, in 1857, when he published his famous law.\textsuperscript{36} Cheysson's and Toqué's analysis in the \textit{Bulletin de l'Institut international de Statistique} followed in 1890.

However, LePlay did draw some interesting conclusions on the nature of the most stable family organization. He observed three major types of families, but the type which he found to be the most stable was what he called the \textit{famille-souche}, or stem family. The stem family consisted of a primarily rural, parent household (the stem) which preserved the organic

\textsuperscript{34}Zimmerman and Frampton, \textit{op. cit.}, pp. 85-86.

\textsuperscript{35}The reader interested in obtaining more information in this respect is referred to Henry Higgs' article and appendix, \textit{loc. cit.}, pp. 408-433. The appendix, which contains the monograph of a British cutler and his family, is on pp. 467-484. Cf. C. A. Ellwood, \textit{loc. cit.} Less accessible, perhaps, but not less significant, is the collection of 100 such monographs by Cheysson and A. Toqué, \textit{loc. cit.}

\textsuperscript{36}Ernst Engel, "Die Productions-und Consumptionsverhältnisse des Konigreichs Sachsen," \textit{Zeitschrift des Statistischen Bureaus des K. Sachsische}, Ministerium des Innern, Nos. 8 & 9 (Sonntag, November 22, 1857).
basis of society, and a number of individual members (the branches) who sometimes leave the parent household for industrial establishments and urban surroundings where high but fluctuating money wages are paid. In the midst of massive industrial developments and sweeping transformations in nineteenth-century France, the *famille-souche* was considered most adaptable to an industrial society. The successful branches contribute to the advancement of society by their rapid adjustment to new opportunities, by the development of industrial areas, and by the increase in new methods of production. At the same time, the parent household provides a haven of safety for those members who cannot adapt to their new contractual relationships. Aside from its benefits of stability, therefore, the *famille-souche* reduces the necessity of public assistance for the unemployed, and is therefore consistent with the non-interventionist sympathies of the LePlay school.

Within this framework, anything which threatens the authority or continuity of the family organization threatens social stability and social welfare, thus making the removal of disruptive influences the object of social and economic reform. With this in mind, many of Cheysson's polemics in favor of testamentary liberty, and against alcoholism, tuberculosis,

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37 Zimmerman and Frampton, *op. cit.*, p. 47. It should be noted that the concept of the stem family was not a hypothetical construct, although the term *famille-souche* originated with LePlay. Cheysson and LePlay had observed this kind of family structure among the Melouga family in the French region of Lavedan [See Cheysson, "La Famille-Souche du Lavedan," in *Émile Cheysson: Oeuvres Choisies*, I, pp. 267-318].

38 Zimmerman and Frampton, *loc. cit.*

39 The provision of the Napoleonic Code which required inheritances to be divided equally among all living children was regarded by LePlay and his followers as an infringement of paternal authority and a source of family and industrial instability. See Cheysson's affirmation of this view in "L'Influence des Lois successorales et Expansion de la Race," *La Réforme Sociale*, 5th Ser., VI (Dec. 16, 1903), p. 889.
slums, female and child labor, industrial accidents, etc., take on additional meaning, though they are of little interest to the history of economic analysis.

The Nature of Economic Production and Relationships Between Factors

LePlay recognized, of course, that the object of production was to increase human welfare in the broadest sense. But he never sacrificed moral considerations to economic ones; in fact, "he balanced the economic and social in the same sentences." LePlay and his followers emphasized that a fundamental factor in society is the need for "daily bread," but he would be the last to say that the social welfare depended exclusively upon the quest for economic livelihood. Unlike Marx, therefore, LePlay (and his followers) did not accept economic determinism as a total explanation of man's life.

Cheysson's writings indicate a similar willingness to accept Marx's emphasis on the importance of the economic foundations of society, but at the same time, hostility towards the idea that the economic means of securing a living determine the entire processes of the social organization. Rather, he conceived industry as a logical extension of the family, or at least an analogous organic association. The industrial family is the workshop, wherein the employer, or patron, is the obvious head and the workers,

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40 Zimmerman and Frampton, op. cit., p. 46.

41 "The essential needs of man are two: knowledge of the moral law and possession of the daily bread. The satisfaction of these two needs is guaranteed to those societies which follow the essential constitution and customs from which they derive." [F. LePlay, Les Ouvriers européens (2nd ed.; Tours, 1879), I, p. 446].

42 Zimmerman and Frampton, loc. cit.
the dutiful children; with mutual respect and mutual responsibilities required of each other. Moreover, the relative factors, capital and labor, are viewed as brothers rather than as antagonists. On more than one occasion, Cheysson attempted to show that capital increases the productivity of labor, thus raising its remuneration in real terms.

As an engineer, Cheysson was naturally led to questions of economic efficiency and its importance in the production process. The influence of LePlay and his own experience, especially as director of factories at Creusot, convinced him that industrial efficiency at the micro level and material prosperity at the macro level must be predicated upon "social peace" and stability in the workshop. In one place he observes that:

In order to grasp the essence of these differences in productivity, one need only consider two different work crews of the same industry, but not the same morale. In one, the workers are bitter, discontent... they 'restrain' themselves, especially if... [there] is a rush order; if necessary, they will leave out a part to harm the company. In the second workshop, on the contrary, peace reigns; the workers, far from hating the boss, have confidence in him and are interested in the prosperity of his business... They show a 'love for their work,' and they supervise one another to avoid any waste and poor workmanship; they are stable and maintain a permanent rapport with their supervisors.


45 "Each day sees new inventions which render labor more productive and bring about higher wages... The increase in wages during the course of this century has been clearly established by numerous supporting statistics... [Furthermore] statistics confirm that the increase in wages has appreciably surpassed the rise in the cost of living... Not only have the workers' money wages gone up... his standard of living has also increased." [Cheysson, "The Income Crisis and the Age of Labor," in "Selected Writings," pp. 264 et passim].

LePlay had also stressed the need for stability in industrial relationships, but had confined his researches primarily to the study of family behavior. Cheysson, on the other hand, turned his attention more in the direction of the causes of industrial peace and stability, as well as material prosperity. In this, as in so many other things, he received inspiration from LePlay. Cheysson's own contribution to the study of economic phenomena lay in his adaptation of the monographic technique to the workshop, or basic unit of production. As long as small industry prevailed in the early part of the nineteenth century, the home and workshop were essentially one, so that LePlay's family monographs, in a sense, did double duty by analyzing social and economic phenomena at the same time. With the advent of large-scale industry in the latter half of the century, however, Cheysson noted "an increasingly sharp separation between home and workshop," so that the economic phenomena manifested in the latter would go unnoticed if one confined his scientific studies to the home and family. Thus Cheysson proposed a workshop monograph to accomplish for economics what the family monograph had done for sociology.

The minor innovation involved in developing a workshop monograph was a logical extension of the monographic method and was not highly original on Cheysson's part, since LePlay had already laid the groundwork for such studies. Nevertheless, it was significant, because in developing the "workshop monograph," Cheysson laid much of the foundation for future studies in industrial organization. His outline of the content of a "workshop monograph" is remarkably comprehensive, both as to commercial organization

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48Ibid., p. 221. The same article contains Cheysson's suggestions for the form and content of the workshop monograph.
and the organization of labor. But apparently Cheysson's contribution ended here, since there is no evidence that he actually performed any industry studies of the kind he recommended.

Many of Cheysson's economic writings investigated the roles of the various factors of production, particularly the interplay of capital, labor and entrepreneur. In his ideas on labor, for example, Cheysson mirrored the utilitarian creed of Bentham and Mill. He showed none of the scientific rigor or analytical embellishments of Jevons' pleasure-pain calculus, but nevertheless recognized, as did Jevons, that "At the root of all human actions, when analyzed, there is found the desire to escape pain or to procure satisfaction." According to Cheysson, satisfaction proceeds from need through the human effort of work, and in the labor so expended, he found both moral and material consequences.

Moreover, he found this to be a universal law, "to which everyone must submit. In so doing, labor provides the engine of progress, for "... if you suppress it all movement stops: you have a society of ascetics, of fakirs, of theives ... . Pain and suffering (of which work is a form) is like a guard-rail at the edge of a precipice; thus need plays a wholesome role by forcing us to work in order to procure pleasure."  

Cheysson preferred the term "patron" to the more familiar "entrepreneur," primarily because of the moral and economic responsibilities to the workers incurred by the former and the overall importance of patronage in the LePlay framework. Nevertheless, Cheysson recognized the "patron" as a risk-taker and innovator [See "Capital and Labor," loc. cit., p. 143].

Cheysson, "Opening Lesson of the Course in Political Economy given by Émile Cheysson at the School of Political Science," in "Selected Writings," p. 15.

"By imposing upon man a burden from which he would prefer to escape, labor . . . [constitutes] an excellent molder of character and an effective means of moral growth." [Cheysson, "Labor and Sismondi's 'Winch','" in "Selected Writings," pp. 67-68].

Cheysson, "Opening Lesson . . . ," p. 16.
Labor pursued for its own sake was eschewed, however, and Cheysson welcomed labor-saving technological advances, for although they produce temporary disequilibria, they increase economic and social welfare in the long-run. Moreover, he found no "fatal antagonism" between moral and material progress.\textsuperscript{53}

With the increase of material progress, however, the essential problem remained "that of maintaining peace in social relations, which becomes increasingly more difficult with the complexity of societies and the instability which stems from it." Yet Cheysson considered this problem far from insoluble, "... provided that the development of moral forces keeps pace with the development of material progress."\textsuperscript{54}

Within the workshop, capital as well as labor is a necessary ingredient to social peace and economic progress. To Cheysson, capital consisted of "all that can serve consumption and production," including money, houses, factories, tools, and inventories.\textsuperscript{55} He divided capital into three categories: provisions, raw materials, and tools; and showed that in the form of provisions capital makes it possible for man to devote himself to different tasks rather than spend his every moment seeking an economic livelihood. In this form, capital "... has been the true emancipator of the human spirit; because it released us from the tyranny of immediate need; permitted us to elevate ourselves to the contemplation of beauty,

\textsuperscript{53}"An enlightened nation doesn't necessarily sacrifice a part of its members to misery, no more than all primitive races are happy by the mere fact that they are primitive. One can, without being harsh to a segment of mankind, applaud the conquests of the telegraph, the steam-plow, and the railroads." \textit{[Ibid., p. 23].}

\textsuperscript{54}\textit{Ibid.}

truth, and goodness; . . . it can [not] be accused of being oppressive with regard to labor, since to supress this form of capital would be to revert to barbarism and to be crushed by the incessant pressures of earning one's daily bread.\textsuperscript{56} The same holds for the second category, raw materials, which Cheysson considers "inoffensive," even to the socialists.

Finally, with respect to machinery, Cheysson refuted the socialist arguments against this form of capital, calling those economists "backward" who would suppress technological innovations because of their unemployment effects. He pointed out, instead, that in the long-run the introduction of machinery more often "employ[s] more hands, thanks to the boost given to consumption by the lowering of prices, which in turn, is effected by the introduction of equipment."\textsuperscript{57} Furthermore, Cheysson recognized, in a fashion, the existence of certain economies of scale. He pointed out that in small industries and sole proprietorships where machinery plays a minor role, workers are frequently subjected to seasonal unemployment and the "fluctuations of the market," whereas "such fluctuations are somewhat buffered by a huge mechanical apparatus in a large industrial firm."\textsuperscript{58}

Most of Cheysson's exposition on the nature of capital were enshrouded in polemics against socialism, where his methodological preconceptions came to the fore. He was not interested in the "abstract speculations" of the socialists, but in what was actually happening. What he found in nineteenth-century France was an increasing stock of capital and a labor supply which

\begin{itemize}
\item \textsuperscript{56} Ibid., pp. 135-136.
\item \textsuperscript{57} Ibid., p. 139.
\item \textsuperscript{58} Ibid., p. 140.
\end{itemize}
did not increase proportionately, so that the demand for labor relative to capital increased, and so did wages. 59

The final essential ingredient of social peace in the workshop was the patron. In this respect, Cheysson recognized the desirability and practical necessity of profits as the return to risk and innovation. Moreover, he seemed to recognize the concept of opportunity costs where the patron, or capitalist, is concerned, and the importance of incentives to produce and save. 60 What stands out among Cheysson's writings and those of other writers of the sociological school is the emphasis upon the moral and economic responsibilities of the patron to his workers. One such responsibility is that of assuring permanent employment to the workers, since unemployment tends to disrupt the family and the workshop. The suggestion is made that this assurance of permanent employment to the workers is in the patron's own self-interest, since it assures that harmony in the industrial establishment upon which productivity depends. Therefore, the burden of maintaining a "guaranteed" annual wage and permanent employment should fall upon the private, not the public sector, in Cheysson's opinion.

The Nature of Economic and Social Reform

Ideologically, Cheysson placed himself and the Societe d'Economie Sociale squarely between the laissez faire ultras of the Societe d'Economie Sociale.

59 "The statistics confirm that the annual increase of capital in relation to the static number of workers increases the number of dollars that chase after manual labor and inevitably result in higher wages." [Cheysson, "Capital and Labor," loc. cit., p. 145].

60 "It is necessary for interest rates and profits to remain important enough to be an incentive to produce and save. To reduce them below a certain level would be harmful to capital formation, business initiative, and the demand for labor." [Ibid., p. 144].
Politique and the Marxian socialists. He was not willing to accept the evils of pauperism and the sufferings of the worker, as were the former, but his remedies were different from the Marxian ones. Like LePlay, Cheysson emphasized recognition of responsibilities among workers and patrons, and the removal of artificial barriers to the encouragement of private initiative. But while LePlay concentrated on the family and its relationship to society, Cheysson was more impressed with the economic transformations being wrought by industrialization, and he went somewhat farther than LePlay in clarifying the nature of economic reforms. These reforms did not include the formation of labor unions—which had received a considerable impetus from Marxianism, but which appeared to Cheysson to signal the end of the wage system, which he sought to preserve—but they did include cooperative associations of consumption and production, savings and insurance institutions, mutual aid societies, building societies, measures to prevent industrial accidents, and various pension systems, subsidies to workers, piece-work and profit-sharing schemes.

61 See Cheysson, "Les Ouvriers et la Réforme," Société Internationale des Études Pratiques d'Économie sociale, Bulletins, V (March 25, 1877), p. 659. In the discussion which followed Cheysson's paper, Joseph Garnier of the Société d'Économie Politique, expressed some reservations about Cheysson's position. Citing the lack of hostility to the concept of individual liberty on the part of the Société d'Économie Sociale, Garnier expressed the view that despite some differences in method and in conclusions between the latter and the Société d'Économie Politique, they were really sister societies. Cheysson was more correct, however, in insisting on the distinct identities of the two, as Gide has confirmed [Gide, Political Science Quarterly, V (1890), pp. 625-626].

62 In what appears one of his earliest general statements on the nature of economic reform, Cheysson remarked: "As the most ardent friends of the worker, we want to alleviate his physical and moral suffering, safeguard his dignity, assure his well-being, establish his family, and facilitate his ascension in the social hierarchy." ["Les Ouvriers et la Réforme," loc. cit., p. 626].
Cheysson was not blind to market imperfections, and he frequently sought to rectify social and economic injustices. But toward this end he repeatedly proclaimed that private initiative produced the best results. For its part, the State has primarily two duties to fulfill: first, as representative and head of the nation it should remove artificial barriers to existing incentives and supply new ones. Second, as an employer of civil servants, the State has duties to fulfill with respect to its own employees, viz., assuring the permanence of their employment. In this respect the State should give good example to the patrons and should honor those patrons who do likewise. Moreover, as the holder of public power it should actively strive to discover new employment opportunities. Beyond that the State should encourage the reform movement and subsidize the cooperative societies of consumption, production, and savings.

Such was Cheysson’s interpretation of the economic and social order. Not unlike more prominent economists of his own day, and later, Cheysson was genuinely concerned with the question of social reform, which to him, was a question of economics and morals as well. Later, in attempting to place Cheysson in general perspective, we may have occasion to return to these ideas again. But although they are a necessary part of the fabric of Cheysson’s ideas, they do not constitute the primary interest of this study. Cheysson’s peak performance as an economist has yet to be examined.

63"Too many patrons, reassured by the imported English theories, believe that it is perfectly legitimate to follow the law of 'supply and demand' to the letter; in favorable times they increase production, increasing their personnel in proportion; then when a crisis comes, they unscrupulously lay off those workers who are no longer needed . . . [but] a good number of first class workshops are able to assure their members the benefits of permanent employment by virtue of their prosperity and material progress . . . the patrons who direct these workshops do not wish to build a fortune upon the misery and degradation of their collaborators." [Ibid., pp. 650-651].

64Ibid., pp. 652 et passim; 633.
CHAPTER III

GEOMETRIC STATISTICS: THE CASE FOR ECONOMETRICS

Cheysson's major contributions to economic analysis are concentrated in a conférence of his entitled, "La Statistique géométrique" (i.e., Geometric Statistics), which was presented on two separate occasions, in 1885 and 1886. The former occasion was the 25th anniversary of the Société de Statistique de Paris; the second was an address to the Congress of Technical, Industrial and Commercial Training at Bordeaux. Its verbal argument was repeated in an engineering journal, Le Génie civil, in two installments, on January 29 and February 5, 1887; and later republished, with minor changes, in Émile Cheysson: Oeuvres Choisies, a posthumous collection of Cheysson's lectures and article, which appeared in 1911.¹ A brief resume of the initial presentation of "La Statistique géométrique" appeared in Le Génie civil on August 28, 1886.

The somewhat forbidding title of Cheysson's lecture probably did little to enhance its popularity, yet it remains significant for several reasons. Not the least of these is the fact that although "La Statistique

¹Evidence of earlier contributions to the theory and determination of railway rates is contained in a report presented by Cheysson to the Société de Statistique de Paris on March 9, 1881: ["La Statistique graphique et les Tarifs de Chemin de Fer," Journal de la Société de Statistique de Paris, XXII (1881), pp. 116-121]. Regrettably, the Journal did not see fit to reproduce the analytical diagrams utilized by Cheysson in his study and explanation of tariff questions, nor could they be located elsewhere. [See, "Graphical Statistics and Railway Rates," in "Selected Writings," op. cit., pp. 3-11]. It is possible that Cheysson's more mature views on the question of railway rates were assimilated into his later lecture on geometric statistics.
"géométrique" was not a general treatise, it nevertheless proposed a general method of analysis. Furthermore, the method proposed has a distinctly modern flavor, and from a programmatic standpoint, it represents an original contribution to economic analysis.

The plan of this chapter is to investigate and assess Cheysson's method as set forth in the above lecture; to compare it with earlier contributions, and later ones, in order to determine the significance of Cheysson's contributions to economic analysis; and to underline Cheysson's understanding of theoretical tools as well as any shortcomings of his procedure. The following two chapters will explore his contributions in specific areas of economic decision-making.

Nature and Scope of Cheysson's Method

From the very outset of his lecture, Cheysson revealed a desire to place managerial decision-making on a more precise and scientific basis. Noting the plethora of economic problems which daily confront manufacturer, businessman, farmer and financier, Cheysson pointed out that in the usual course of affairs, "... interests will be served as best they may by sense and by instinct; that is to say, somehow or other, decisions will be made for better or worse. In general, they will be worse rather than better, and those who are mistaken will pay heavily for their error."2 His objective was to reveal a method which "has the precise purpose of indicating the best solution, in many cases with certainty, and of putting into

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the hands of the businessman a guideline which will prevent him from being misled into a labyrinth of obscure facts."³

At the base of this method was statistics. As an experienced statistician, Cheysson was convinced that the solution to many economic problems was implicitly contained in statistical data. The problem was to devise a method which would extract those solutions, "as metal is extracted from its ore."⁴ To this end, Cheysson enlisted the aid of geometry. Today graphical analysis has become such a vital part of economic theory and exposition that economists find it commonplace. Yet the use of geometric techniques to illustrate economic relationships gained popularity rather slowly, and only after 1870. Then as now, it was common classroom practice to suggest numerical applications for simple geometric models. But Cheysson was not interested in mere graphic representation of numerical data. According to him, "graphical statistics" was useful, but in confining itself to visual representation, it "adds nothing to fact other than clarity, refinement, and contrast."⁵

Likewise, geometric statistics did not represent mere graphical interpolation, "which consists in hazarding an assumption regarding the continuity of a curve's slope and hypothetically extending the curve beyond its known elements."⁶ Cheysson concluded that graphical interpolation had "a conjectural side which is disquieting and can be misleading."⁷

³Ibid.
⁴Ibid., p. 166.
⁵Ibid., p. 165.
⁶Ibid.
⁷Ibid., p. 166.
Geometric statistics, he asserted:

... holds the middle road between graphical statistics and interpolation. It uses their advantages while avoiding their inconveniences; it is as dependable as the former and as dynamic as the latter. It goes beyond known facts instead of confining itself to translation and reproduction. It proposes to uncover unknown elements, but in this search it leaves nothing to chance nor hypothesis.\(^8\)

The method Cheysson suggests for approaching economic problems can be summarized in the following fashion: Geometry provides a theoretical framework for expressing economic relationships. But unless these relationships are tested by statistical data, they remain in the category of what Cheysson called "abstract speculations." Thus, mathematico-economic relationships must be "fitted" to statistical data in each case, if "real" solutions to "real" problems are to be obtained. The marriage of economic theory to geometry and to statistical analysis is an essential ingredient of geometric statistics. This scientific alliance of economics, geometry and statistics is what prompted Staehle and Schumpeter to praise Cheysson's "econometric program." It might have been said of Cheysson, as Schumpeter said of the Italian, Pietro Verri, that "he knew how to weave fact-finding and theory into a coherent tissue."\(^9\)

The term "econometrics" is relatively modern. It was introduced in 1930 by Ragnar Frisch, one of the founders of the International Econometric Society and first editor of *Econometrica*. According to Frisch, it is the unification of economic theory, statistics, and mathematics that constitutes econometrics.\(^10\) In 1931, Frisch lamented the dearth of "intimate

\(^8\)Ibid.


and continuous collaboration between the observer and the theoretician" in economics\(^{11}\) and noted that the main concern of the Econometric Society was:

. . . to advance as much as possible those forces which permit the collaboration between the observer and the theoretician in economics. We prefer to formulate the laws of political economy in such a way that we can expect to accurately express and effectively determine (whether today or tomorrow) their numerical nature by an appeal to statistical procedures.\(^ {12} \)

Perhaps Cheysson was ahead of his time, when, in describing his own method of geometric statistics forty-five years earlier, he observed:

Observation is basic to the method and is used to determine the primary direction of existing relationships . . . . But upon these fundamental graphical curves . . . we shall then construct others which can be deduced in a mathematical fashion, that is to say, with complete rigor.

The system is thus partly statistical, partly geometrical. It borrows data from observation, translates the data by means of graphical statistics, and sets the data to work by means of geometry. Thus it is . . . a powerful means of elaborating empirical data and realizing through sound reasoning the same advantages as algebra, whose operations lead to more direct conclusions.\(^ {13} \)

Today there seems to be less agreement about what constitutes econometrics and what econometricians do, but the combination of economic theory, geometry and statistics remains an essential ingredient of so-called "econometric" studies.

In presenting his analytical system, Cheysson revealed a preference for geometry instead of algebra, although he recognized their necessary interdependence. By 1887, of course, mathematical economics had gained

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\(^{12}\)Ibid., pp. 175-176.

considerable ground. Jevons had been extremely vocal in his praise of the mathematical method as early as 1862, although his Theory of Political Economy had to wait until 1871. In 1874, Walras' Elements appeared, marking the formal beginning of a life-long crusade on the part of its author to spread the mathematico-economic method throughout the world. Cournot, of course, anticipated the neoclassical emphasis on mathematics as early as 1838, but was only resurrected later at the hands of Jevons and Walras. Jevons' bibliography of mathematico-economic writings includes several other notable contributions prior to 1887.

Cheysson's reasons for choosing a geometric approach are lucidly stated in a footnote to "La Statistique géométrique":

All problems which are going to be reviewed later on can be dealt with through mathematical analysis as well as by geometry. In this case, statistical curves are replaced by analytical functions expressing them and the desired solutions are then determined by calculation. But geometrical analysis presents the advantages of being more easily accessible to those without special preparation and of immediately interpreting the statistical data without requiring an idea of their analytical laws or functions. To establish required calculations of those laws or functions is often very laborious and can lead to at least difficult, if not insolvable integration expressions. Finally, the graphical procedure permits us to follow, step by step, the operations which lead to the solution: it points them out to the eyes as well as to the mind, whereas the ... [mathematical] process leads the calculator to the solution blind-folded.


15 The nature and scope of Walras' crusade in this regard has only recently become evident by William Jaffé's masterful edition of Walras' correspondence. It is noteworthy that Walras made a special effort to enlist Cheysson in this cause. Cheysson's response will be discussed below.

16 See Appendix V to Jevons' Theory of Political Economy, pp. 322-342.
Abruptly, almost brutally, under a veil of formulas and manipulations which hide the many different stages en route, one reaches the solution without having been forced to fathom its gradual formation.  

At the same time, Cheysson frequently expressed the curvilinear relationships of his models in mathematical functions. These notations were, however, confined to footnote rank, a practice which Marshall also followed in his Principles three years later.

One rather poignant distinction between Cheysson and other neoclassical writers concerns the scope and applicability of mathematics to economic analysis. Cheysson's reaction to the neo-classical revolution was basically conservative. He admitted a "personal penchant" for applying mathematics to certain economic questions, but only to those problems which deal with "a concrete class of well-defined objects, such as prices, quantities, and currency." Regarding the practical application of mathematics to human behavior, Cheysson shared a popular reservation of his day. In a letter to Hâton de la Goupillière, French Inspector-General of Mines, Cheysson wrote:

As a matter of principle, I place very little credence in endeavors which aim at enclosing human activity within algebraic formulas. In such cases, mathematics leads to apparently precise conclusions, while in fact, the inevitable neglect of certain data renders them suspect. It is for me an ingenious exercise in mental gymnastics rather than an effective guideline in the maelstrom where moral forces (which escape calculation) occupy the main role. Therein lies a special dynamic, the laws of which depend upon experience and not upon mathematics.

\[ \text{17"Geometric Statistics," p. 167.} \]
\[ \text{18Ibid., p. 168.} \]
\[ \text{19Letter of Émile Cheysson to Hâton de la Goupillière, July 10, 1885, in Correspondence, II, p. 62.} \]
Elsewhere, Cheysson observed that "it certainly would be . . . vain . . . to put all problems involving man's 'fluctuating and diverse nature' into mathematical equations. In such problems most elements which intervene in the final result do not lend themselves to either weight or measurement . . . and hence, escape the grasp of mathematics." This view explains why Cheysson was careful to apply quantitative methods only to those variables which he thought were measurable, and why he had no taste for the utility doctrine.

Insofar as Cheysson's method represented a combination of empirical observation and a priori reasoning, he considered it above the criticisms commonly levelled against the use of pure mathematics to solve economic problems. He openly asserted that geometric statistics:

is neither a mathematical abstraction nor a simple curiosity of the mind . . . . It will withstand reproaches usually made against the use of pure mathematics to solve economic problems, e.g., the criticism that economic questions are too complex to be enclosed within a single formula.21

Cheysson's consistent attempt to enlist the aid of statistics in applying the maximization principle to economic decision-making, primarily at the micro level, is the hallmark of "La Statistique géométrique." The areas touched by his contributions in this regard include the theory and measurement of statistical demand and statistical cost curves, profit maximization under increasing and decreasing cost conditions, the determination of market boundaries, transportation rates, wages, total sales as a function of wages, rational choice of sources of raw materials, of product quality, of investment securities, and more; although, by his

21Ibid., pp. 162; 167.
own admission, this list is "very far from having exhausted the number of applications involved in this method."\(^{22}\)

Nineteenth-Century Forerunners of the Modern Theory of the Firm

Cheysson's contributions to economic analysis were primarily in the area of micro-economics. The modern theory of the firm is generally considered to have begun with Cournot, although von Thünen may also vie for the same honor in several important respects. The fact remains, however, that the most significant contributions to the theory of the firm prior to 1870 failed entirely to percolate, until the impetus was provided by Jevons, Walras, Marshall and other leading theorists in the last decades of the nineteenth century.\(^{23}\) Throughout these developments France, by her own choosing, remained aloof and unresponsive to the new doctrine.

**Cournot and Cheysson on Demand and Profit Maximization**

"La Statistique géométrique" appears to have been written in much the same spirit as Cournot's *Recherches sur les Principes mathématiques de la Théorie des Richesses*. It shares the empirical approach to demand taken by Cournot and even advances beyond Cournot in statistical application


\(^{23}\) Schumpeter reports that prior to 1870, "the sponsors of supply and demand . . . with the unnoticed exception of Cournot . . . [Charles] Ellet and [Dionysius] Lardner, even experienced difficulty in setting on its feet the very supply-demand apparatus, the claims of which to a place in economic theory they tried to assert . . . . The concepts, so familiar to every beginner of our own days, of demand *schedules*, or curves . . . and of supply *schedules*, or curves . . . proved unbelievably hard to discover and to distinguish from the concepts--quantity demanded and quantity supplied." [Schumpeter, op. cit., p. 62].
and suggestions. The basic theme of both works is application of the maximization principle. For Cournot, this is achieved at the margin, and his argument, mathematically speaking, is in marginal terms. Cheysson wrote as though he clearly understood the nature and importance of decisions at the margin, but he also recognized the advantages of totalism used correctly, and he couched his arguments in "total" and "net" relationships rather than marginal ones. Both eschewed considerations of the origin of value, exchange, etc., and concentrated on maximizing value (in money terms) obtained from trade or production.

In matters of pure exposition and scientific completeness, Cheysson's performance in the area of demand and profit maximization is less impressive than Cournot's. But in one important sense, Cheysson had a grander vision— to make economic theory more relevant through practical application. In this endeavor, Cheysson thought that he was striking out into new territory on his own. In his 1885 lecture on geometric statistics, he declared that in representing the concepts of value and wealth he was "departing from the classical images presented by Turgot and J. B. Say." And indeed he did, only he was unaware that Cournot had preceded him in this regard.

24 In Chapter IV of his Researches, Cournot stated: "We shall undertake to explain neither the origin of property nor that of exchange or division of labour . . . . We shall invoke but a single axiom . . . , a single hypothesis, i.e., that each one seeks to derive the greatest possible value from his goods or his labour . . . . To deduce the rational consequences of this principle, we shall endeavor to establish better than has been the case the elements of the data which observation alone can furnish." [Cournot, op. cit., p. 44].

Cheysson maintained that the major problem facing commerce and industry was the selection of that price for output which maximized profits. The solution to this problem, he thought, could be easily reached by a combination of geometry and statistics. "If we possessed two curves, that of markets and that of production costs," he noted, "and [if we] refer to them, we will be safe from making miscalculations, and we shall know in each particular case the most advantageous position to take." Like Cournot, Cheysson made consumption of an object a function of its market price. By observing the amount consumed at each price and plotting those points on a two-dimensional graph, Cheysson traced out his "markets" curve (i.e., courbe des débouchés) as shown in Figure 3-1. As was the practice before Marshall, "price" was placed on the horizontal axis and "quantity" on the vertical axis.

The "markets" curve is an average revenue curve with empirical foundations. In describing the nature of this curve, Cheysson observed that:

... it differs for each good produced and assumes the most varied forms. If the market is in inverse ratio to the price, it is found by an 'equilateral hyperbola' [sic]; if the reduction of markets is proportional to that of price it becomes a straight line. But these are theoretical cases which can differ markedly from practical ones. Thus it is necessary to study each particular curve for each individual product.

Continuing his discussion of the "markets" curve, Cheysson touched upon the concept of price-elasticity of demand without, of course, using that term. He remarked:

If one is dealing with a product whose consumption is limited, reduction of the price has no significant influence on the market. The example of coffins is a classic case to illustrate this category of goods. Yet, ... one finds

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27Ibid.
Figure 3-1
CHEYSSON’S "MARKETS" CURVE
some other service, like that of transportation, which receives a very lively impulse following the reduction of a tariff. The curve in this case rises very sharply for moderate prices and then drops suddenly as the price increases, until it cuts the horizontal axis (i.e., until the price exceeds a certain limit and thereby becomes prohibitive). Thus, a market's curve exists for each particular case. It may be fairly difficult to determine, but this difficulty will not detract from its reality, nor its statistical nature. Our curve is not purely theoretical nor does it proceed from abstract geometry. It is practical, furnished by observation, and reveals the facts which it interprets, directly.28

Through graphical construction, Cheysson then proceeded to derive a total gross revenue function from the average revenue curve. Figure 3-2 reveals how this is accomplished. Cheysson noted that the gross revenue curve, OAP, starts from zero when the price is zero, rises to a maximum for some combination of price and output, then returns to zero for the prohibitive price. Furthermore, "it goes through equal values, two by two, in rising and falling through a maximum at summit A."29 Each point on the gross revenue curve represents the total receipts derived from the sales price on the horizontal axis directly below the point in question. Thus, in Figure 3-2, "HD . . . represents the revenues derived from sales price, OH, for the market, HE."30

Following the logical progression from average revenue to total revenue, Cheysson set about developing a net revenue, or profit function, which he derived by subtracting total costs from gross receipts at each level of output. But before doing so, he dwelt momentarily on the subject of production costs. He noted, for example, that:

29 Ibid., p. 173.
30 Ibid.
Figure 3-2

GROSS REVENUE DERIVED FROM AVERAGE REVENUE
These costs may be proportional to gross revenue or they may increase less rapidly or more rapidly than gross revenue. In average terms, they are constant in the first case, decreasing in the second case, and increasing in the third case.31

In the "Résumé," written in third person, Cheysson reported how, with geometric diagrams as an interpretive aid, he analyzed each of these cases under the respective headings of "constant returns," "increasing returns," and "decreasing returns."32 Later, Cheysson presented statistical average and total cost curves for the Austrian railway network, based upon data compiled by Wilhelm von Nördling, a former Director-General of Austrian railways. Nördling's researches, published in the Annales des Ponts et Chaussées in 1886, constitute a "pioneer" effort, and repay examination even at this late date. Nördling correctly diagnosed the cost structure of the railroad industry as one of decreasing marginal costs, and his attempt to identify marginal costs, both empirically and geometrically, met with considerable success. He was aware of the problem involved in measuring railway output, which consists of both passenger and goods traffic; and after detailed justification, he adopted the French convention of giving equal weight to a ton-kilometer of goods traffic and a passenger-kilometer of travel. Among his reasons for doing so were a comparison of the relative costs involved and the reliability of statistics required for this method.33 Nördling then chose from among the various


32Ibid.

railway systems operating in Austria at that time, those in which the scale of plant remained as nearly constant as possible for at least two years (not necessarily consecutive), while at the same time, large variations in the volume of traffic occurred. From the cost information available in the given years, Nördling determined the total number of ton-kilometers supplied during the year and the total costs, exclusive of interest on funded debt, per kilometer.

Cheysson's graphic representation of Nördling's cost data is reproduced below as Figure 3-3. In this instance, Cheysson's procedure is consistent with traditional practice which considers costs a function of output. But in moving to a practical application of the concepts he had described, Cheysson saw the need to represent total costs in a different fashion. Figure 3-4 represents Cheysson's statistical application of the profit-maximization principle in the Austrian railway case. The heavy, dark lines of the revenue and cost functions were fitted to available statistics and the dashed segments represent the parts of the various functions extrapolated from the statistical data. The gross revenue curve is derived from the average revenue curve via the method outlined above. Cheysson proclaimed that his revenue functions were based on "official reports" of the railway system, but gave no explicit citation as to his source of data. In Figure 3-4, the curve labelled, "total costs of production," demands attention because it is not a total costs curve in the traditional sense. That is, it does not show any relationship between costs and output. Instead, it shows a relationship between costs and price per

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34 As Hans Staehle has pointed out, this practice compares favorably with the procedure utilized by Joel Dean in The Relation of Cost to Output for a Leather Belt Shop (New York: National Bureau of Economic Research, 1941). [See Staehle, loc. cit., p. 325].
Figure 3-3

TOTAL AND AVERAGE COSTS
OF AUSTRIAN RAILWAY SYSTEM IN 1886
Figure 3-4

PROFIT MAXIMIZATION IN A STATISTICAL CASE
unit of output, while simultaneously embodying the same data as the total cost curve in Figure 3-3. Cheysson's reason for handling total costs in this unfamiliar fashion is obvious, since this allows the graphical determination of the net revenue function in Figure 3-4, and it is this last function which provides the key to the profit-maximizing solution. He was quick to point out that the optimum combination of tariff and output was the one which maximized net receipts. According to Cheysson, this result is achieved in Figure 3-4 at a tariff of 3.2 centimes and traffic of 2.6 million tons.

According to Cheysson, if we let F represent costs of production; D, demand (i.e., quantity demanded); and P, the sales price, then knowing the two curves, F/D and D/P, will allow us to deduce the curve, F/P. "Thus the costs of production curve, F/P, and the demand curve, D/P, are reduced to the same denominator, i.e., the same abscissa." [See "Geometric Statistics," p. 175]. In tracing the "cost" curve in Figure 3-4, therefore, one must first determine the volume of output offered at a given price, then find the corresponding cost of producing that level of output.

The reader's attention is directed to the fact that although the principle which Cheysson sought to establish is clear, there is a discrepancy in Figure 3-4 which might otherwise pass unnoticed. In his explanation, Cheysson maintained that a tariff of 3.2 centimes (pt. R) is the one which maximizes net revenue. But that price cannot support a traffic of 2.6 million ton-kilometers because the latter is not represented by a point on the demand curve at the given price. It is possible that 2.6 million is the maximum traffic consistent with the price of 3.2 centimes, as statistically derived, but that the net revenue curve was inadvertently drawn so that its maximum is reached before 50,000 fr. (left axis) instead of at that figure, where the demand curve and the net revenue curve would then intersect opposite the quantity of 2.6 million ton-kilometers. As the diagram stands, however, 3 centimes is the optimum tariff, not 3.2 centimes. Unfortunately, Cheysson's verbal explanation does not reveal whether the error is his or whether it occurred in publication. Insofar as the Cournot point of equilibrium lies on the hypothetical portion of the demand curve, it is likely that the error is one of graphic elocution rather than the result of faulty reasoning. At any rate, the error does not detract significantly from Cheysson's argument. It is noted here only for the sake of accuracy. So far as this writer could discern, no mention of this discrepancy was ever made by Walras, who had read Cheysson, or by anyone else.
Given the stated functions, the solution is reached by locating the highest point on the net revenue curve, then by reading the optimum price directly below this point on the price axis. From the same point on the net revenue curve, an imaginary line can be drawn upwards to the markets curve, then across, horizontally, to the optimum traffic on the right axis. The representation of "output" on the right axis and "revenues and costs" on the left axis in the same diagram is somewhat clumsy by modern standards, but is the method used by Cheysson.

On the theory of profit maximization, Cheysson reached the same conclusion as Cournot, who had observed that "whatever may be the abundance of the source of production, the producer will always stop when the increase in expense exceeds the increase in receipts." In the railroad case, Cheysson concluded that once the most profitable tariff is reached, "it would . . . no longer be advantageous to further reduce the price in order to increase traffic, as costs would subsequently increase more rapidly than gross revenues, and henceforth, reduce profits." But in concentrating on net revenue, Cheysson's analysis of profit maximization was more akin to Dupuit's, or to Marshall's, who also utilized the net revenue approach. Unlike Dupuit, however, Cheysson's net revenue schedule is net of total expenses minus interest on funded debt. And the "normal profit" concept is absent from Cheysson's treatment of costs, so that his "net receipts" are not monopoly profits in the Marshallian sense.

Minus its statistical trappings, Figure 3-4 might be regarded as merely a graphic representation of the mathematical principles developed

37Cournot, op. cit., p. 59.
by Cournot in Chapter V of his *Researches*. It was not the first such offering. Dionysius Lardner presented a less complicated graphical model of profit-maximization in 1850, and J. de la Gournerie offered a similar model in 1880. Significantly, both writers were railway economists and both analyzed profit maximization in the case of railroads only. Despite the special cost structure of the railroad industry, none of these writers, including Cheysson, addressed themselves to the larger question of whether or not a railroad should maximize profits. They simply took it for granted that they would.

Cheysson appears not to have read Lardner, but he did read de la Gournerie, and he cited him in the proper place. But what made Cheysson's approach to the profit-maximizing problem unique was his explicit attempt to enlist statistical revenue and cost functions in the service of economic theory. Furthermore, this attempt came at a time when, in Schumpeter's words, "a specifically econometric program--mathematical theory plus statistical figures--was struggling toward conscious formulation . . . but, with some important exceptions," notably this one, "did not quite make it all the same."^41

In vision and programmatic approach, Cheysson's analytical work was indeed marked by the "spirit" of econometrics. What Cournot accomplished many years earlier, Cheysson later attempted to put into practice, both geometrically and statistically. In doing so, he used statistical revenue and cost functions, and in this respect, pointed the way for future


econometric studies. If his treatment of certain variables was less sophisticated than that found in modern econometric studies, it does not detract from the importance or originality of his approach. It merely indicates that economics had to wait for statistics to "catch up" rather than the other way around.

On the other hand, if it is to be said that Cheysson made any specific contribution to econometrics beyond establishing the framework and motivation for econometric studies, then his technique of fitting curves to concrete statistics must bear closer scrutiny. But before proceeding to evaluate this technique in more detail, it is worthwhile to pause momentarily to consider Cheysson's claim to independent discovery of his analytical method and to review briefly those writers who were considered by him to be "pioneers" in this field. Then Cheysson's contributions, if any, might be viewed in a more proper perspective than would otherwise be the case.

The Question of Priority

Cheysson had apparently worked out his theory of the firm independently and in rudimentary form as early as 1871, while at Creusot as factory director. 

"Jevons' Theory of Political Economy appeared the same year, and although Jevons is cited in the first installment of the 1887 version of "La Statistique géométrique," Cheysson implies, in a letter to Walras, that he was unaware of Jevons' work prior to the initial presentation of his analytical program before the Société de Statistique de

42 Letter of Émile Cheysson to Léon Walras, May 26, 1886, in Correspondence, II, p. 128.
Paris on June 18, 1885. On the other hand, Cheysson reports how he applied the maximization principle to good advantage in solving certain industrial problems at Creusot. And in 1887 he reaffirmed that the method of geometric statistics came to him "... as an inspiration, more than fifteen years ago, through the demands of the engineering profession."

Cheysson credits Walras with introducing him to Cournot's work and inspiring him to seek out other analytical contributions similar to his own. Since the correspondence between Cheysson and Walras began on July 16, 1885, Cheysson's efforts in this direction must have occurred between that date and May 26, 1886, at which time Cheysson wrote Walras of his having referred to Cournot and several other writers. In Cheysson's first letter to Walras, on July 19, 1885, he reported that he had known Walras' name and several of [his] works for quite some time, though apparently, the Éléments d'Économie Politique Pure was not among those works.

All that remains of the 1885 version of Cheysson's lecture at the Société de Statistique is a very brief summary (résumé) which was published the following year in two separate places. In the "Résumé," Cheysson presented revenue and cost functions similar to those of Fig. 3-4

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43 Ibid. Cheysson was at Creusot from 1871-1874.


45 Cheysson to Walras, May 26, 1886, Correspondence, II, p. 128.

46 Letter of Émile Cheysson to Léon Walras, July 19, 1885, in Correspondence, II, p. 63. Cheysson did not mention any works by title, but by this time most of Walras' major writings had appeared.

47 Cf., letter of Léon Walras to Émile Cheysson, January 20, 1886, in Correspondence, II, p. 98.

48 Le Génie civil, IX, No. 18 (Aug. 28, 1886), pp. 283-285; and Journal de la Société de Statistique de Paris, 1860-1885 (Paris: Berger-
though not for any concrete statistical case. Moreover, only four diagrams were included in the "Résumé," while the full rendition of "La Statistique géométrique" included sixteen diagrams of major importance. The fact that the "Résumé" does not acknowledge earlier works appears to support Cheysson's claim to independent discovery. This omission proved to be a source of considerable embarrassment to Cheysson, however.

In May of 1886, having only the "Résumé" before him, and unaware of the circumstances surrounding its publication, Walras severely attacked Cheysson for failing to acknowledge Cournot's priority—as well as his own—in the area of demand and profit maximization. Somewhat chagrined at Walras' sudden hostility, Cheysson countered:

I have been mulling over the subject of my last paper, which I entitled "La Statistique géométrique" for twelve years now... Since... [Creusot] I have continued to pursue my reflections in this direction and when I gave my lecture last year on the occasion of the 25th anniversary of the Société de Statistique, I did not know—I must shamefully admit—what Cournot had done in this field and what you yourself had done.

Thanks to Mr. Hâton de la Goupillière, I was put into contact with you. I am indebted to him for this good fortune. You sent me your works; I referred to Cournot's; I met other authors... and I realized that therein was all sorts of material examined from all aspects.

Levrault, 1886), pp. 135-140. The publication of the Résumé was somewhat of a compromise between Cheysson and the Société de Statistique de Paris. The latter wished to publish Cheysson's manuscript in its entirety and asserted a claim to it by virtue of its inclusion in the program of June 18, 1885. However, Cheysson was reluctant to do so since he had been exposed to other pioneers in the field of mathematical economics in the interim period and he wished to acknowledge them as well as otherwise update his manuscript. "Finally," Cheysson wrote, "for the sake of peace and tranquillity, I consented to give a brief summary of my work, which was quite extensive, and a footnote on the first page was added by the committee indicating that this was merely an outline of an article or even a book which the author was preparing." [See, Cheysson to Walras, May 26, 1886, Correspondence, II, p. 128].

49 Walras to Cheysson, May 24, 1886, Correspondence, II, p. 126.
Thus I was wrong in thinking that what I had discovered by myself through my own personal reflection, had not already been discovered by others before me under different forms and for different applications. But concerning the scientific customs and manners to which you adhere so strongly, the past has proved to all those who know me, and the future will prove to you, the extent to which I have been and will remain respectful of the titles of those who have preceded me . . . . 50

Certainly Walras' zeal in matters of scientific courtesy was commendable, but in fairness to Cheysson, there is considerable justification, in addition to his own testimony, for his claim to independent discovery. The general neglect of Cournot's works in the nineteenth century, particularly in France, has been well-documented. Moreover, like Dupuit before him, Cheysson was an engineer by training, and a good one, fully endowed with the engineer's talent for solving practical problems and his taste for applied theory as opposed to pure theory. Engineers are, by temperament, led to rely on their own skills in solving practical problems. Perhaps for this reason, they have frequently been in the vanguard of initial progress in theoretical economics, and in no other country is this tradition stronger than in France. Cheysson is merely another in a long line of cases in point. By his own admission, it was qua engineer (at Creusot) that he developed his analytical method. Significantly, his lecture on geometric statistics was first published in an engineering journal.

It is also a fact that Cheysson's formal training in economics fully reflected the orthodox point of view, and while he apparently overcame the Philistine aversion to economic theory of the orthodox economists, he nevertheless was constantly diverted from "the more disinterested and

50 Cheysson to Walras, May 26, 1886, Correspondence, II, p. 128.

abstract speculations of pure economics" by "the reality and gravity of
problems of applied economics." Moreover, prior to the beginning of his
career as a professional economist in 1882, Cheysson's energies and atten-
tion were more likely to be directed toward technical matters rather
than questions of pure economics. Then too, he simply was not the scholar
that Walras was.

Finally, although Jevons and Walras had been at work for some time
prior to 1885, at which time Cheysson began to familiarize himself with
their major works, their new theories remained anathema to the French or-
thodoxy, and unlike Jevons or Walras, Cheysson continued to function in
an atmosphere openly hostile to the new doctrine. Under these condi-
tions, Cheysson would not be led to a study of "unorthodox" theories as
a matter of course.

In this respect, it is important to note what problems concerned
Jevons and Walras, as well as Dupuit and Gossen, and precisely what as-
pects of their analysis proved offensive to the French traditionalists of
the Société d'Économie Politique. The culprit was not the concept of
utility per se, since the French tradition begun by Condillac and Say
has consistently assigned a role to utility in describing the concept of
value. Nor was it the use of mathematics alone, since the nineteenth
century produced a group of French writers who employed mathematical me-
thods in the analysis of various economic questions without incurring the
hostility of the French orthodoxy. In this category are several works

52Letter of Émile Cheysson to Léon Walras, April 24, 1891, in Correspondence, II, p. 444.

53This observation holds even though Say never understood the role
of utility in the determination of value; in fact, he clearly repeated
Smith's water-diamond paradox.
which preceded Cheysson's, including those of Esméard du Mazet, Mathieu Wolkoff, Courcelle-Seneuil, du Mesnil-Marigny, G. Fauveau, H. Lefèvre, E. Fontaneau, A. Achard, J. Marchand, Léon Pochet and Émile Dormoy. This group was by no means cohesive, nor were their writings of equal importance, but the number of works produced during this period is an indirect admission of the efficacy of mathematics, however simple, in the treatment of economic relationships.

On the whole, it is true that these writers were not enthusiastically embraced by the inner circle of the French orthodoxy, but at the same time, a certain atmosphere of peaceful co-existence prevailed. In some cases, the authors mentioned were members of the Société d'Économie Politique, and several of the earlier writings were apparently inoffensive enough to be included in the tightly-controlled Journal des Économistes. But none of these writers chose the paths of Dupuit or Walras, viz., an attempt to quantify the psychological (i.e., utility) considerations underlying the question of value. Instead, they placed more restrictions on the extent of mathematics and seemed to share the popular prejudice that social phenomena, like biological and physiological phenomena, cannot be neatly enclosed within mathematical formulas.⁵⁴

⁵⁴This opinion found ample expression in an article by Charles Letort, a member of the Société d'Économie Politique who was frequently in evidence at its meetings [See, "De l'Application des Mathématiques à l'Étude de l'Économie politique," L'Économiste Français, III, No. 44 (Oct. 31, 1874), pp. 540-541. Cited by Jaffé in Correspondence, I, pp. 458 n.; 529 n.] Letort tended to view the works of Jevons and Walras as a continuation of a trend established by Canard, Thünen, Cournot, Dupuit and others. He considered Walras' work, particularly, of the highest interest from a speculative and scientific viewpoint, but he doubted the usefulness of rigorous mathematical deductions in practice. His article is included in Jevons' bibliography of mathematico-economic tracts in the Theory of Political Economy. Whether Cheysson read Letort's article is not known.
Cheysson also shared this opinion. Undoubtedly, what he admired and found useful in the works of the "utility school" was its use of mathematically-economic reasoning, rather than the utility precepts upon which their respective theories were built. In this, therefore, Cheysson remained more loyal to the Cournot tradition than to the "mathematical school" which eventually rallied around Walras.

These considerations, coupled with Cheysson's own testimony, strongly advance his case for independent discovery of certain economic principles. Yet, as mentioned earlier, the establishment of this claim is not of primary importance; it is in Cheysson's application of those principles to specific problems that his real contributions to economic analysis lie.

The Mathematical Foundation of Geometric Statistics

In view of Walras' censure of the "Résumé," Cheysson took advantage of the first opportunity to set the record straight. That opportunity came upon the occasion of the initial publication of "La Statistique géométrique" in extenso, in 1887. Therein Cheysson wrote:

... in order to give everyone his just desserts, it is my duty to add that in later studying the works of economists I have noted that in several of its parts this method comes into contact with the theories issued in France by Mssrs. Cournot, du Mesnil-Marigny, Dupuit, Wolkoff, Fauveau, and de la Gournérie; in England by Mssrs. Stanley-Jevons, Whewell, Tozer, and Macleod; in Switzerland by Mr. Léon Walras; in Germany by Mssrs. Gossen, de Thünen, Rau, Brentano and Launhardt; in Italy by Mssrs. Boccardo, Errera and Zambelli; [in the U. S. by Mr. Hadley, etc.].

55 "Geometric Statistics," pp. 162-163. The words placed in brackets were added in the version of "La Statistique géométrique" reprinted in Emile Cheysson: Oeuvres Choisies, I. Some of those mentioned, including Cournot, Dupuit, Jevons, Walras, Gossen and Thünen, need no introduction. The others might, particularly the French and Italians, because of the extensive number of individuals involved, however, the usual footnote apparatus is deemed inappropriate. For this reason, a brief sketch of each of
Cheysson's *amende honorable* failed to appease Walras, however, who revealed considerable indignation over the apparent insult to Cournot of being ranked *matter-of-factly* with eighteen other "predecessors" (including himself).\(^56\) To a certain extent, Walras' indignation was warranted, though he obviously belabored the point unnecessarily. Cheysson's claim to independent discovery of his analytical method is accepted here, although in his construction of the *statistical* demand curve in Figure 3-4 he was almost certainly influenced by Cournot to some extent. His intellectual debt to others is less easy to trace, but a brief review of those writers mentioned above is informative in this regard.

It is not the aim of this study to evaluate Cheysson's performance in detailed comparison to all of the writers he cited as predecessors. Even if this were desirable, it would be extremely difficult, owing to the scarcity and inaccessibility of many of the lesser-known works. However, Cheysson's failure to assign any hierarchy of priority necessitates some general comparison of his own contribution with those offered by his contemporaries, or those who preceded him, since not all of the writers cited contributed to economic analysis in equal measure or along the same lines.\(^57\)

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\(^56\) Letter of Léon Walras to Wilhem Launhardt, February 26, 1887, in *Correspondence*, II, p. 197. The relationship between Walras and Cheysson, such as it was, became noticeably strained after the publication of the "Résumé" in 1886. After 1887, the correspondence between them stopped entirely, with one exception—a single exchange of letters in 1891.

\(^57\) The more significant works and their authors have received due attention at the hands of others, but it is perhaps significant that the names of de la Gournerie, du Mesnil-Marigny, Fauveaux, Wolkoff, Tozer, Errera and Zambelli are not included in Schumpeter's highly-regarded *History of Economic Analysis*. 
Errera and Zambelli provide cases in point. According to Jaffé, the respective articles which warranted their inclusion in Jevons' bibliography of mathematico-economic writings contain nothing more than résumés of Walras' theory of exchange, "interlarded with laudatory remarks." Likewise, Boccardo was mainly instrumental in reviving Cournot's works, especially in Italy.

Among the Germans, attention is directed to Schumpeter's assessment of von Thünen: "He was the first to use the calculus as a form of economic reasoning. Nobody, before or after, ever understood so profoundly the true relation between 'theory' and 'facts'." Launhardt's contributions in the area of transportation and location theory paralleled Cheysson's own accomplishments in these areas, and will be examined below. Cheysson's interest in Rau was evidently spurred by the latter's frequent application of theoretical principles to concrete cases, and his "incidental" acknowledgement of the value of mathematics by the introduction of symbolic or graphical statements. Brentano's writings—particularly those containing his contributions to the relationship between wages and hours on the one hand and worker productivity on the other, as well as several of his economic and social reforms—are more evocative of Cheysson's other

58Jaffé, Correspondence, I, p. 410 n.

59Ibid., II, p. 760 n.

60Schumpeter, op. cit., p. 466.


writings than his "La Statistique géometrique," though Brentano's statistical studies may warrant his mention here.\(^{63}\)

While most of Macleod's works were devoted to the theory of money and credit, he had anticipated Jevons on the subject of negative value, and according to Jevons, "all the writings of Mr. Henry Dunning Macleod exhibit a strong tendency to mathematical treatment."\(^{64}\) This plus the fact that Chevalier had adopted Macleod's textbook at the College de France probably attracted Cheysson's attention. Similarly, the mathematical treatment of certain economic propositions by Whewell and Tozer in the Cambridge Philosophical Society's Transactions evidently recommended themselves to Cheysson.

Nothing more need be said of Cournot, who as Walras suggested, tops the list of "pioneers" where Cheysson's analytical performance is concerned. Like Dupuit and Gossen after him, Cournot was simply ignored for a long time. It remained for Walras to direct Cheysson's attention to their works in 1886. Jules du Mesnil-Marigny, member of the Société d'Économie Politique and former student of the École Polytechnique, had included mathematical notes in his Catechisme de l'Économie Politique basée sur des Principes rationnels, but according to Jevons, he was "otherwise diverted from a true theory . . . [and] built upon the sand."\(^{65}\) As for Wolkoff, his appearance among Cheysson's list of "pioneers" is notable only insofar as he was a disciple of von Thünen, and in expounding some of the latter's

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\(^{63}\) Brentano was a statistician in the government service and worked under Ernst Engel, a former student of LePlay; which perhaps accounts for Cheysson's interest in Brentano's work.

\(^{64}\) Jevons, op. cit., p. xxvii.

\(^{65}\) Ibid., p. xxv.
theories, he employed mathematical methods. Likewise, Fauveau made several contributions to the mathematical theory of value and of taxation in the Journal des Économistes. De la Gournerie influenced Cheysson's approach to profit maximization under monopoly conditions, and shared billing with Cheysson in Pantaleoni's Pure Economics.

All of the names in Cheysson's list (with the exception of Hadley's, which was added later) appear in Jevons' bibliography of mathematico-economic writings, thus underlining the common thread of mathematical exposition employed by each of them, in varying degrees of sophistication and completeness. Despite Cheysson's deference to other writers, however, he considered his method of geometric statistics something apart from previous achievements. Immediately following the passage in which Cheysson acknowledged forerunners in the mathematical method, he added:

> In general, these authors, some of whom are eminent, based their points of view on speculative analysis for the exposition and dissection of economic categories, such as exchange, value, or money; rather than aiming at practical applications and solutions to industrial problems. But they rightfully deserve earnest respect and it is just to salute them as the precursors who have cleared the way for the commercial transformation of our method.

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67 Fauveau's works are listed in Jevons' bibliography in the Theory of Political Economy.

68 Pantaleoni, op. cit., p. 156 n.

Thus, Cheysson mentions their names only in passing. But even so, the mathematical foundations of his method have been clearly established, and we can now turn to an assessment of his econometric performance.

Evaluation of Cheysson's Statistical Model

The Spirit of Inquiry

According to Robert H. Strotz, "the salient feature [of econometrics] is the explicit use of mathematics and statistical inference. Nonmathematical theorizing and purely descriptive statistics are not part of econometrics." Following Henry Schultz, Strotz attributes the first "significant combination of mathematical theory and statistical estimation" to Henry Ludwell Moore, "during the early part of the twentieth century." While deference is usually given to earlier forerunners, Cheysson's position in the history of econometrics is almost universally overlooked. Yet Cheysson's performance is a significant link in a line of thought begun by Sir William Petty in the seventeenth century and culminating in the works of Moore, Schultz, and others in our own.

In order to dispel any doubt that statistical inference, and not simply description, was essential to Cheysson's analysis, certain passages from "La Statistique géométrique" are offered as testimony. Cheysson said of Geometric Statistics that:


71 Ibid., p. 351.

72 The exceptions of H. Staehle and J. A. Schumpeter, both elected-fellows of the International Econometric Society, have been noted in Chapter I.
It goes beyond known facts, instead of confining itself to translation and reproduction. It proposes to uncover unknown elements, but in this search it leaves nothing to chance nor hypothesis. Raw facts, suitably placed in a work, furnish solutions which are implicitly contained within themselves; this method extracts those solutions as one extracts a metal from its ore.

Observation is basic to the method and is used to determine the primary direction of existing relationships; and in that respect we are fully in the area of graphical statistics. But upon these fundamental curves, as upon a solid foundation, we shall then construct others which can be deduced in a mathematical fashion, that is to say, with complete rigor.73

Upon comparing Cheysson's description of geometric statistics with Strotz's description of econometrics, it once again becomes obvious that the modern spirit, if not the actual techniques, of econometrics formed an integral part of Cheysson's analytical approach to economic problems.

Nature of the Data

Statistical functions used in economic analysis must be interpreted in view of the nature of the data used and the method of analysis employed. In this respect, Cheysson's choice of Nördling's cost data was fortunate, not only because Nördling's performance was an admirable one for his time but also because his article is readily accessible in English. On the demand side, it should be emphasized that although Cheysson had independently worked out the geometric solution to profit maximization before 1886, he did not attempt a statistical application of the same solution until that year, subsequent to his reading of Cournot. Moreover, in pressing on to a statistical application of Cournot's analysis, Cheysson obviously felt that he was removing Cournot's performance from mere "abstract speculation."74


The key to the success of Cheysson's statistical model therefore lies in the respective contributions of Nördling and Cournot, since they provided the starting point for Cheysson's "statistical" curves.\footnote{Cheysson's curves were "statistical" in the sense that they were based on actual, numerical observations, adjusted in various ways discussed below. There was no attempt on Cheysson's part to substitute other "statistics" (i.e., first-order differences, link-relatives, trend ratios, etc.) for the original observations.}

In his independent study of railway costs, Nördling met and overcame the familiar problems which face modern writers on the subject of statistical cost functions. For example, he confronted the problem of diversified outputs and the problem of possible changes in technology and the size of equipment. He successfully isolated the net changes in the rate of output from among the many factors that influence costs and he made the necessary separation of costs into those which depend on the passage of time and those which depend upon utilization. Moreover, he used annual, average costs per kilometer for each line, expressed in terms of constant monetary units. Thus Nördling was keenly aware of the changes relevant variables undergo in time, and he took measures to adjust available data for these changes in his method of analysis. Nördling's work was purely empirical, however. He attempted no theory of costs. By contrast, Cheysson's contribution consisted in inserting statistical functions, such as Nördling's, into the theoretical structure of profit maximization, and in doing so, he accepted Nördling's contribution on its own merits. In view of Nördling's performance this fact should not be taken lightly in an overall assessment of Cheysson's "econometrics."

Apart from the cost side of Figure 3-4, the nature of Cheysson's data and the method of analysis he used to derive the statistical demand...
curve are greatly obscured. Thus it is difficult to tell whether Cheysson fared badly or magnificently in identifying a statistical demand curve of practical importance. There is sufficient evidence neither to indict, nor to praise him on unequivocal grounds. For this reason, any explanation of the statistical nature of Cheysson's "markets" curve—in this particular case, at least—is not fully removed from the area of speculation. Cheysson, himself, offered little help to his readers in this regard. He gave only a vague reference to "official statistics" as the source of his revenue data and offered no explanation as to how, or if, the official statistics were adjusted for the passage of time, changes in demand, and so forth. We know from Lardner's testimony that European railroads, from their earliest history, kept detailed reports as to classes and volume of traffic and related tariffs and receipts.\footnote{Lardner, \textit{op. cit.}, p. 246. Here Lardner presented a tabular classification of receipts, expenses, and profits for the Belgian railways in 1844. He also computed average receipts per unit of traffic for each classification.} Furthermore, Nördling's researches should have alerted Cheysson to major problems that would have to be faced in the identification of statistical revenue data. But how Cheysson followed through his construction of the "markets" curve in Figure 3-4 we simply do not know. All that has survived is the end result. And that result is certainly not a demand curve in the traditional sense.

\textbf{Cheysson and the Statistical Law of Demand}

Twentieth-century purveyors of statistical demand relationships have often differentiated their demand curves from those of traditional economic theory. H. L. Moore, for example, held that the statistical "law of demand"
at which he arrived is a dynamic law, whereas the demand curve of economic theory is a static law. Cheysson made a similar claim on behalf of geometric statistics. In a letter to Hâton de la Goupilliére, he wrote:

"this method does not use statistics in a passive way, but actively; the analysis is no longer static but dynamic. Statistics no longer merely record and describe facts but uses them to anticipate laws and predict trends."

"Static," as used in this context refers to a particular point in time, whereas "dynamic" refers to phenomena experienced over time. These terms are often ambiguous, however, and mask the true distinction between statistical and theoretical demand curves. In Cheysson's case, the "markets" curve of Figure 3-4 represents a relationship between various prices and corresponding amounts of output sold; i.e., it is an ex poste relationship. Thus Walras was correct in identifying Cheysson's "courbe des débouchés" with Cournot's "courbe du débit," or sales curve. In the actual construction of statistical demand curves, however, certain refinements are required in order to get satisfactory results. Cournot recognized this when he wrote:

"... the price of an article may vary notably in the course of a year, and, strictly speaking, the law of demand may also vary in the same interval, if the country experiences a movement of progress or decadence. For greater accuracy, therefore, in the expression F(p), p must be held to denote the annual average price, and the curve which represents function F to be in itself an average of all the curves which would represent this function at different times of the year."
According to E. J. Working, "a statistical law of demand represents a condition under which the relationships between factors may be considered to have remained the same, or, to put it more accurately, a condition which is an average of the relationships during the period studied." Working also shows that this last characteristic makes the "static vs. dynamic" distinction meaningless in many cases. Since the process of curve fitting corresponds to averaging, the fitted curve may be considered to depict the average relationship between price and quantity. But this amounts to the same thing as representing the relationship at a point of time which is typical for the period studied. Thus what started as "dynamic" ends up as "static." Nevertheless, both Cournot's demand relationship and that described by Cheysson seem to fit Working's definition.

Cheysson studied the relationship between price and output for the Austrian railway system. His "markets" curve shows average prices charged for average output supplied, the averages being taken for a number of different lines within the system in a year when the relationships between technology, scale size, and output remained constant. Despite serious aggregation problems among the different lines in a railway system, and even though he did not reveal precisely how he derived the average revenue data in Figure 3-4, there is little doubt about Cheysson's purpose and direction—-he attempted to construct a statistical demand curve which in its basic composition conforms to Working's definition of what statistical demand curves are. Moreover, Cheysson's demand curve was dynamic, at least in the sense that it embodied statistical data observed over time. The traditional demand curve of economic theory represents a schedule of price-

82 Ibid., p. 232.
quantity relationships which hold only for a given moment of time, and are hence static by our definition. On the other hand, a statistical demand curve is composed of price-quantity relationships over time, i.e., the original data consists, in effect, of observations of points at which the (static) supply and demand curves have intersected. Although the data may be reduced to static conditions, it nevertheless originates in the market. And the market is dynamic; "consequently our data are of changing conditions and must be considered as the result of shifting demand and supply schedules." 83

Both Cournot and Cheysson were concerned with the relationship between market price and quantities sold over time; that is, both derived statistical rather than theoretical demand curves. In this respect, Cheysson was much more in the Cournot tradition than was Marshall, or Dupuit, both of whom derived static, theoretical demand curves based on utility considerations. 84

Once it is admitted that a statistical demand (or supply) curve is a locus of theoretical supply-demand equilibria, then another problem unfolds—namely, the problem of identifying the locus of points as a demand or a supply relationship. Depending on whether shifts in demand are correlated with supply shifts and whether the shifts in one curve are greater or less relative to shifts in the other, efforts to derive a statistical relationship between price and quantities sold will result in

83 Ibid., p. 218.

curve fits which may be either upward-sloping or downward-sloping. If the former obtains, we may wish to conclude that our statistical relationship is one of supply rather than demand. In the latter case we may conclude the opposite. This is the classical "identification problem" encountered by investigators of statistical market relationships. It is not fair to criticize Cournot for overlooking this problem, however, since the static, theoretical law of demand had not been developed when he wrote his *Researches*. Moreover, in Cheysson's case, although Dupuit had developed a theoretical demand curve, Cheysson, when he discovered it, considered Dupuit's demand curve only an "abstract speculation" devoid of any practical significance. It is likely, therefore, that were Cheysson aware of the identification problem, he would have considered it no problem at all, since he would have no truck with theoretical demand curves in the first place.

But when Cheysson included Cournot with other "speculative" writers, he erred badly, as Walras seemed to be trying to tell him. Despite the obscure nature of the data used by Cheysson to construct the statistical demand curve in Figure 3-4, it seems fair to conclude, with Walras, that Cheysson's "markets" curve and Cournot's "sales" curve are identical. In fact, the only difference between Cournot and Cheysson on this score was that Cheysson attempted an application of statistical demand in a concrete case. Although there is some evidence that Cheysson may have met and overcame several significant problems in the construction of statistical demand curves, his contribution in this area, if any, must be held in abeyance until such time as all questions regarding the nature of his revenue

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85 For considerable elaboration on the nature of the identification problem, see Working, *loc. cit.*
data in the railroad case can be resolved. This study has not been able to accomplish as much. Therefore, Cheysson's real contribution to econometrics at this point lies in the nature of his programmatic approach to economic analysis. When he combined statistical cost and revenue functions in a single model of profit-maximization, Cheysson took a significant step forward in the theory of applied econometrics.
CHAPTER IV
CHEYSSON'S CONTRIBUTIONS TO RAILWAY RATE
THEORY AND SPATIAL ECONOMICS

As long as the transportation of goods over geographic distances involves an economic cost which increases the delivered price of such goods at their market destinations, ¹ the economics of transportation will continue to form an integral part of the economics of location and vice versa. The tendency, in fact, has been to consider one aspect of theory a logical extension of the other, while preserving some specialization between the two fields of inquiry. ² There is no doubt that Cheysson recognized the inter-relationship between transportation and location theory, for his investigation into the economics of transportation, particularly railway transportation, led him to certain analytical conclusions regarding the effects of competing modes of transport upon the nature of industrial location and the size of competitive market areas. The objective of this chapter is to explore and evaluate Cheysson's contributions in this area, with particular reference to similar achievements by his contemporaries and those writers who were to follow.

¹Traditional location analysis abstracts from the existence of "freight absorption" policies on the part of various shippers.

The Historical Development of the Law of Market Areas in Relation to Transport Costs

Historically, the theory of industrial location has developed along two major lines, both of which assume that profit maximization is the prime locational motive. The distinction between these two approaches had been appropriately defined in the following fashion:

The first approach, which is largely of German origin, emphasizes the search for the least-cost site by abstracting from demand. It assumes competitive pricing, different costs among locations and a given buying center. In conformance with its purely competitive framework, an unlimited demand for the output of any firm exists at the prevailing price, and all sellers have access to the buying center. [In] the second approach . . . buyers are conceived to be scattered over an area rather than confined to a given consuming point. The cost of procuring and processing raw materials is assumed to be the same everywhere, and each seller charges an identical net-mill price, leaving delivered price to vary with the distance between consumers and suppliers. Sellers, by dispersing, thus gain control over buyers situated near their plants. In this analysis, demand for the output of a firm is accepted as a variable factor governed by the location of competitors. [This] . . . approach differs from the least-cost theory because it emphasizes the control over specific buyers that is offered by locations in a space economy. 3

There is no basic difference in the philosophy of the two approaches; yet the distinction is useful for categorizing historical developments. For example, the transition from the former approach (which emphasizes pure competition and a single consumption point) to the latter approach (which stresses the natural advantages of plant location and the necessity of defining market boundaries over a given area) was largely a result of the re-orientation of economic thought towards imperfect competition.

French economists since Cournot--particularly the writers on railway economics and public works--have been, on the whole, less preoccupied with the

3Greenhut, op. cit., pp. 84-85.
tenets of pure competition than their counterparts in other countries. Cheysson continued the tradition begun by Cournot in this regard. His analysis of spatial problems and transportation questions, by concentrating on the natural advantage of shippers served by low-cost carriers and emphasizing the seller's control over specific market areas, is therefore consistent with the later reorientation of economic thought described above.

**Early Progress in Spatial Economics**

In its general form, the theory of location is a distinctly twentieth-century phenomenon. Progress in this field was extremely slow during the eighteenth century, although several writers—notably Sir William Petty, Richard Cantillon, and Adam Smith—discussed the locational differentials of land rent. In the early part of the nineteenth century, the works of

4 The first attempt to construct a general theory of location is attributed to Alfred Weber [Über den Standort der Industrien (Tübingen: Mohr, 1909); English translation by C. J. Friedrich, Alfred Weber's Theory of the Location of Industries (Chicago: University of Chicago Press, 1929)]. Weber's two major predecessors are considered to be Johann Heinrich von Thünen and Carl Friedrich Wilhelm Launhardt, both of whom made significant contributions to the theory of location and anticipated Weber on several important points, but nevertheless failed to achieve the generality of Weber's work. Note the specific Germanic roots of the theory, which have been maintained by the subsequent contributions of Oskar Engländer, Hans Ritsch, Andreas Predöhl, Hans Weigmann, and August Lösch. All contributions prior to Weber's, including Cheysson's, fall within the area of partial location analysis, and form the area of concentration for this study. No attempt is made to review or assess the rapid progress in location theory of spatial economics made in the twentieth century, since to do so would go beyond the historical perspective adopted for this research.

5 Cantillon, however, did more. See chapters 3-6 of the first part of his Essai sur la Nature du Commerce en général, first printed in 1775, and reprinted, at Paris, in 1952 by the Institut National d'Études Demographiques. It is known that the Essai was written sometime before 1734, since Cantillon died in that year. Concerning chapter three of the Essai, Schumpeter observed: "... this is perhaps the first attempt (if we neglect
Ricardo and West followed similar lines. But only after 1825 were significant strides made in the development of a partial theory of location, with the plaudits for the greatest achievements in spatial economics during the nineteenth century going to the Germans.

von Thünen, Lardner, and Launhardt

The father of location theorists is generally considered to be Johann Heinrich von Thünen, whose original treatment of transportation and location in an agricultural economy has received continued attention and praise at the hands of others. Those aspects of von Thünen's analysis which relate to subsequent developments in the field of spatial economics or distinguish it from Cheysson's analysis are nevertheless deserving of a brief review.

Significantly, transport costs are an important variable in von Thünen's model. The central problem of his spatial analysis is determination of the distribution of agricultural production over a given region. The choice of location for each crop is assumed to rest upon two factors: net price received per unit of output, and rent of land. The latter is the only significant cost of production, since all other location factors, (e.g., the relative prices of capital and labor), are ignored. The former is assumed to depend upon transport costs to a single, specified market.

embryonic considerations in the agricultural literature) at making some headway in this field." [Schumpeter, op. cit., p. 219].

In von Thünen's "isolated state", locational equilibrium is ultimately determined by the substitution principle. Each producer, depending upon his technical production characteristics and the transportability of his output, strikes a balance between market proximity and cheap land in such a way as to minimize the sum of production and transportation costs. According to von Thünen, the final equilibrium pattern of land utilization is resolved into a systematic series of concentric circles around the consumption point, with the area within each circle devoted to a particular use.

Although von Thünen's analysis is essentially an explanation of agricultural locations, Greenhut has shown how von Thünen's approach can be converted into an analysis of the site-selections of manufacturing plants without distorting his theory. All that is required is a re-direction of the inquiry toward ascertaining the location of a given manufacturing process instead of a given agricultural one. In this, transportation costs and land rent remain basic to the explanation of plant location. Even so, what distinguishes von Thünen's analysis from other nineteenth-century developments in location theory is its aggregative approach. On a micro-economic level, this approach is subject to certain limitations. For example, in assuming away locational problems of individual producers once the distributional pattern of agricultural production is complete, the von Thünen framework is insufficient for explaining the individual

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8 Greenhut, op. cit., pp. 6-8.
firm's decision to relocate. Moreover, by assuming a single consumption point in a centripetal market (i.e., one which collects goods from outlying areas), the problem of defining market boundaries between competing sellers of standardized commodities is precluded. By way of contrast, Cheysson was explicitly concerned with this last problem.

No significant progress beyond von Thünen's analysis was apparently made until the advent of the railroad, which tended to revive interest in locational factors in economic theory. In 1850, Dionysius Lardner briefly investigated relationships between transportation costs and the size of market areas. After first noting the effects of transport time upon the size of the ring-shaped zones in a Thünen-like framework, Lardner took up the micro-economic problem of determining the size of an individual firm's sales territory in a centrifugal market (i.e., a selling market from which goods are distributed to scattered buyers in outlying areas). His conclusion took the form of what Hoover has called "Lardner's Law of Squares," viz., that since the radius which determines the market of a

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9This criticism has been voiced by Walter Isard, who nevertheless adds that the Thünen methodology can be of great service for the overall regional type of planning frequently undertaken by international, national, or regional authorities. [See Isard, loc. cit., pp. 92-93].

10Although T. W. Hutchison finds certain "affinities with von Thünen's analysis of the theory of location" in Charles Ellet, Jr.'s Essay on the Laws of Trade in Reference to the Internal Works of Improvement in the United States (1839), so far as this writer is aware, no attempt has been made to analyze Ellet's contributions to location theory.

11"The width of this ring will be determined by the speed with which the articles in question can be transported . . . . It is evident that any improvement in transport which will double its speed will double the radius of the circle. . . . Now, as the actual area or quantity of soil included within such a radius is augmented, not in the simple ratio of the radius itself, but in the proportion of its square, it follows that a double speed will give a fourfold area of supply." [Lardner, Railway Economy (New York: Harper & Brothers, 1850), p. 35].

producer is inversely proportional to the rate of transport, the size of a firm's market area will vary inversely as the square of the mileage rate of transport.\(^\text{12}\) Despite the somewhat unrealistic assumptions upon which Lardner's law is based,\(^\text{13}\) it represents the first significant progress in the analysis of market areas, and it anticipated later developments by Launhardt and Cheysson.

In spite of the pioneering efforts of von Thünen and Lardner, a leading student of spatial economics credits the German economist, Wilhem Launhardt,\(^\text{14}\) with "the first significant treatment of industrial location theory"\(^\text{15}\) and "the earliest systematic treatment of the division of a market area among competing firms."\(^\text{16}\) It is significant that Launhardt, like Cheysson, was a mathematician and an engineer, and that both made

\(^\text{12}\)Ibid., p. 258.

\(^\text{13}\)Hoover notes that Lardner's analysis is valid only if transport costs are uniform and the market is circular, which implies the absence of any rival supply centers. [E. M. Hoover, Jr., Location Theory and the Shoe and Leather Industries (Cambridge, Mass.: Harvard University Press, 1937), p. 19 n.].

\(^\text{14}\)See Appendix II for a brief biographical note on Launhardt. Additional information is provided by E. M. Fels, "Wilhem Launhardt," International Encyclopedia of the Social Sciences, IX (1968), pp. 48-49.

\(^\text{15}\)Isard, op. cit., p. 143 n. One writer advances the name of G. Fr. Schäffle as the first to concern himself with the problem of industrial location. [See Witold Krzyzanowski, "Review of the Literature of the Location of Industries," Journal of Political Economy, XXXV, No. 2 (April, 1927), p. 278]. Schäffle, however, was no match for Launhardt as to analytical insight or scope of achievement. The only significant contribution of the former in the field of location theory seems to have been the postulate that large cities exert an attractive force directly proportional to the square of their size and inversely proportional to the distance between factories. The Schäffle mentioned by Krzyzanowski is apparently the same as Albert E. F. Schäffle, whom Schumpeter also mentions for his Bau und Leben des sozialen Körpers (Tübingen, 1875). [Cf., Schumpeter, op. cit., p. 788; and Krzyzanowski, op. cit., p. 278 n.].

\(^\text{16}\)Isard, op. cit., p. 160.
similar contributions to economics in more than one area of mutual interest.\textsuperscript{17}

Launhardt's contributions to spatial economics were numerous and important. Of particular interest in this study is his examination of mathematical principles which determine the division of market areas between competitive producers.\textsuperscript{18} It was in this direction that Cheysson followed Launhardt's lead, although he raised questions of a different nature than his German counterpart. In the field of location theory, Launhardt has come to the fore as an important figure in the history of market-area analysis, but only recently, due to the relatively late "discovery" of Launhardt by Erich Schneider in 1935.\textsuperscript{19} By contrast, Cheysson's contributions have remained "undiscovered", and have had little or no impact on Anglo-American economic literature.

To Cheysson, spatial considerations represented another problem to be resolved by the method of geometric statistics. His investigation of certain transportation questions first posed by Launhardt's analysis anticipated later issues of theory and policy in the development of transportation economics. In this, as in all else, Cheysson's unique awareness of existing analytical tools and his ability to utilize and integrate these

\textsuperscript{17}Fels [loc. cit.] notes that as contemporaries, both Launhardt and Cheysson analyzed railroad costing and pricing with originality and clarity and that both combined engineering with economics.

\textsuperscript{18}Isard reports that although Launhardt distinguished between this partial problem and the partial problem of determining the site of production within or at the corners of a locational polygon, where the corners represented raw material sources and a one-point consumption place, "... he made no attempt to put them together." [Isard, op. cit., p. 143 n.].

tools into a comprehensive decision-making model stands as his highest single analytic achievement. Moreover, insofar as Cheysson emphasized the monopoly aspects of preferential freight rates, his approach to the market-area problem forms an integral part of the transition of location analysis from the competitive to the imperfectly competitive approach.

Curiously enough, the geometric argument of Cheysson's analysis of market areas is rooted in a family of curves which was first discovered by Descartes as the solution to a problem in optics, and first applied to the division of market areas by Launhardt in 1885. The presentation of Cheysson's "La Statistique géométrique" on June 18 of the same year raises certain difficult questions regarding the priority of analysis as between Launhardt and Cheysson. It is clear that with regard to publication of the analytical points in question, Launhardt preceded Cheysson. The issue is clouded, however, by the latter's oral presentation of his "La Statistique géométrique" in the same year as the publication of Launhardt's book. The full contents of that oral presentation have gone unrecorded, and as Cheysson's correspondence reveals, the Résumé published in 1886 was grossly incomplete.

The extent to which Cheysson's manuscript was altered between June 18, 1885, and January, 1887—when "La Statistique géométrique" was published in extenso—is virtually impossible to ascertain. The possibility remains

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20 The curves which make up this family have come to be known as Descartes' ovals. [See, F. Gomes Teixeira, Traité des Courbes Spéciales Remarkables, (Coimbre, 1908) I, p. 218].


22 Supra, Ch. III, n. 43.
that some specific applications of Cheysson's method were suggested by his belated acquaintance with several contemporary theorists. Some revisions in the published version of "La Statistique géométrique" are obvious, such as the use of von Nördling's railway cost data, and scattered references to 1886 publications. But if Cheysson's own testimony can be trusted, no substantive revisions were made. Even though he recognized Launhardt and other predecessors in the introduction to "La Statistique géométrique", Cheysson asserted that it was only after he had formulated his program and put it to use that he discovered certain analogies between his own work and that of others. He repeated this claim earlier in a letter to Walras, in which he apologized for having rashly thought his discoveries original. At the same time, he informed Walras of his intention to recognize certain forerunners of his method in the published version of his manuscript. In the same letter Cheysson added, "... to speak accurately and fairly of proper names, I must finish studies which I have only just undertaken and for which there has not been enough time up to now." Then he concluded that with regard to publication of his manuscript: "I have ... decided not to treat those questions for which I was not prepared and which were completely unknown to me the day I gave my lecture."23

In view of this evidence, it is a conclusion of this study that while the geometrical apparatus discovered by Descartes was common currency in both France and Germany, it remained for Launhardt to apply the apparatus to the economic division of market areas between competitors, and for Cheysson, working independently, to extend Launhardt's efforts; particularly in

23See, Cheysson to Walras, May 26, 1886, Correspondence, II, p. 129.
investigating the effects of competing modes of transport on the size of an individual firm's sales-territory, and the ability of the individual carrier to attract traffic. 24

The central part of Launhardt's market-area analysis, which has played a major role in the development of spatial economics and is therefore a part of the setting within which Cheysson's performance must be evaluated, is reproduced here (Fig. 4-1) as it appears in Part III of Launhardt's Mathematische Begrundung der Volkswirtschaftslehre:

Suppose there are two goods located respectively at points A and B, such that the good at B is some distance, l, from point A. Further assume that the two goods are of equal quantity and value, with prices $p_1$ and $p_2$ at A and B, respectively. The freight rates for the respective goods (which generally have different weights) are $f_1$ and $f_2$. At any point, such as E, which is x distance from A and y distance from B, both goods (of equal quantity and value) will have the same delivered price, provided the following condition holds: $p_1 + f_1 x = p_2 + f_2 y$. The line which describes this condition is in general a closed curve which belongs to the family of ellipses described by Descartes. . . . This curve encloses the sales territory of the inferior good, i.e. that which is heavier (for equal quantities of equal value).

In the case where $p_1 = p_2$, the curve becomes a circle, the center of which does not coincide with B, but lies to the right of it. In the case where $f_1 = f_2$ (for goods of equal quantity and value) the sales territory becomes bounded by a hyperbola, the open end facing the more

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24 It should be noted that any similarities between the respective market-area analyses of Launhardt and Cheysson apparently provoked no jealousy on the part of the former. Rather, Launhardt hailed Cheysson's "La Statistique géométrique" as a significant extension of mathematical economics (in the Walrasian tradition), which he found particularly encouraging because of France's stubborn neglect of the mathematical method [See, letter from Wilhem Launhardt to Léon Walras, February 19, 1887, in Correspondence, II, p. 193]. Generally speaking, other economists have taken the same view of Launhardt's treatise in reference to Germany. Such was the fervor of Walras' admiration for Cournot, however, that he could never forgive Cheysson for not setting Cournot above all other fore-runners of geometric statistics [See, Walras to Launhardt, February 26, 1887, Correspondence, II, p. 197].
Figure 4-1

LAUNHARDT'S SPATIAL MODEL
expensive (i.e., heaviest) good. In the special case
where \( p_1 = p_2 \) and \( f_1 = f_2 \), this hyperbola becomes a
straight line which bisects \( AB \) at its midpoint.\(^{25}\)

In this manner, Launhardt sketched out the basic principles which de-
termine the division of market areas in a duopolistic sellers' market as
early as 1885. Yet, curiously, despite Cheysson's extension of this analy-
sis in some important respects, Launhardt's contribution was entirely over-
looked until Erich Schneider recognized and extended Launhardt's model in
1935.\(^{26}\) In the meantime, Frank Fetter had independently discovered the
same basic principles in 1924.\(^{27}\)

Under true competitive conditions in the market for finished goods
and the existence of a single, non-discriminatory carrier, Fetter described
the boundary between two geographically competing markets for like goods
as a hyperbolic curve. His "law" states that:

At each point on this [hyperbolic] line the difference be-
tween freights from the two markets is just equal to the
difference between the market prices, whereas on either
side of this line the freight difference and the price dif-
terence are unequal. The relation of prices in the two mar-
kets determines the location of the boundary line. The low-
er the relative price the larger the tributary area.\(^{28}\)

This "law" can be put into mathematical terms with reference to Fig. 4-1.

If \( E \) is a point on Fetter's boundary, then the condition of his "law"

\(^{25}\)Launhardt, *Mathematische Begrundung . . .*, pp. 157-158. For math-
ematical proof of Launhardt's proposition, see Schneider, *Econometrica*, III
(1935), pp. 79-89; and R. G. D. Allen, *Mathematical Analysis for Economists*


\(^{27}\)Frank A. Fetter, "The Economic Law of Market Areas," *Quarterly Jour-
nal of Economics*, XXXVIII (May, 1924), pp. 520-529. A less successful
approach which confined itself to the linear case was presented by J. B.
Clark and J. M. Clark in *Control of Trusts* (rev. ed.; New York: Macmillan

states that \( f_1 x - f_2 y = p_1 - p_2 \), which can be rearranged to form Launhardt's equation \([\text{supra}, \text{p. 104}]\): \( p_1 + f_1 x = p_2 + f_2 y \). In fact, Fetter's conclusion that "the relation of prices in the two markets determines the location of the boundary line" is merely a special case of Launhardt's analysis, where \( f_1 = f_2 \). Many recent treatises on location theory have recognized the importance of Launhardt's contribution and have referred to the above principle as the "Launhardt-Fetter law of market areas."

Others, however, continue to cite Fetter as the **locus classicus** of market-area analysis.\(^{29}\)

Cheysson's Performance

It is significant that although Launhardt raised the possibility of freight rates differing as between commodities, he seems to suggest that such differences are attributable to weight factors rather than distance or competition among different carriers. The examples of both Fetter and Launhardt assumed the existence of a single means of transport and uniform freight rates per unit distance between all points in the area under consideration. Neither raised the question of competition between carriers and its effects on the pattern of rates or the size of the market area. Cheysson, however, broached this very problem. As a first approach, Cheysson assumed that base prices between producers were equal. His examination of the problem then focused on the effects of differential freight rates

on geographical market competition and the limits of spatial market boundaries.  

Specifically, Cheysson solved the following problems: (1) the division of market areas between two producers of like goods when one producer is served by a low-cost carrier; and (2) the ability of the low-cost carrier to attract traffic by lowering its rates below those of its competitor.

The solution to these problems involved model constructions in which the following assumptions are warranted:

1. The existence of two sellers of fixed locations operating in a centrifugal market, selling the same good, at the same base price.

2. Individual producers have no control over market price. Delivered prices are equal to the base price at each market center plus transportation costs to a given market point.

3. The demand for finished goods at any point of delivery within the market area is fixed. The quantity of goods demanded at that point is a function of delivered price.

4. The demand for transport inputs is the same at each market center and is constant over time.

5. Buyers are evenly spread over the market and the relation of freight rates to demand is such that there are sales at every point of the market.  

In the absence of external regulation, Cheysson's analysis is valid for both intra- and inter-industry transport competition; yet it is likely that he had only the latter in mind, since according to one authority, French railroad companies after 1859, were "never allowed to compete with one another or to invade one another's territory, and their arrangements for sharing traffic or earnings constantly receive[d] official sanction." [See W. H. Buckler, "The French Method of Controlling Railway Rates," Quarterly Journal of Economics, XX (February, 1906), p. 279].

The assumption of a continuous market is traditional to market area analysis. For the discontinuous case, see Gardner Ackley, "Spatial Competition in a Discontinuous Market," Quarterly Journal of Economics, LVI, No. 2 (February, 1942), pp. 212-230.
Each carrier's freight rates are uniform per unit distance at every point of the market. For any one point, total transport cost is linearly dependent on the distance from that point to the producer.

Sellers attempt to maximize short-run profits. Transportation rates may be set accordingly, free of the restraint of external regulation.

Competitive Rate-Making and the Market Area of the Firm

Cheysson directed his attention to what Launhardt considered a special case, namely, the case where base prices are equal as between market centers. Under this condition, freight rates alone determine the limits of the respective markets. Thus, Cheysson's analysis proceeded as follows:

... let us assume that A and A' are supply centers which are 100 kilometers apart. If both points are equipped with the same means of transport, which travels both directions between A and A', where price per ton-kilometer is 25 centimes, they will be (all other things equal) in exact equilibrium from a transportation point of view. Their respective market areas will be defined by the vertical line DD', which crosses the middle of AA'. But if center A was served by a railroad which subsequently reduced the price per ton to 10 centimes, the market area of A' would be restricted and enclosed within a curve upon which each point, such as M, represents equal transport costs for distances AM and A'M. This curve is a circle, whose center, O, is situated 19 kilometers beyond A', having a radius of 47.5 k.

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32 This assumption is made for convenience. The French government in the nineteenth century had no power to prescribe specific rates, but all proposals for rate changes initiated by the railroad companies were subject to approval by the Minister of Public Works before taking effect. At the same time, however, companies were "encouraged to earn large profits." [See Buckler, loc. cit...].

33 A footnote at this point in Cheysson's argument reveals that he wrote the equation for the circle in Fig. 4-2 as AMp = A'Mp (where p and p' are the transport rates from A and A', respectively. Letting AA'=d, A'O=a^2, OM=R and n=p'/p, he further noted that: (1) OM=R=na, and (2) a=d/n^2-1. Equation (1) gives the radius of the circular market area, and its analogue can be found in Launhardt [op. cit., p. 158]. Equation (2)
Figure 4-2
CHEYSSON'S SPATIAL MODEL

Tariff 0'10 c A' O = 19 k R = 47 k 5
- 0'06 c A' O' = 6 k 1 R = 25 k 4
- 0'03 c A' O'' = 1 k 5 R = 12 k 5
If, to increase its gains, the company which serves A diminishes its tariff of 10 centimes to 6 centimes, it will restrict the circle which encloses A', such that the radius of the smaller circle is only 25.4 k.

Finally, let us assume the tariff falls to 3 centimes: center A' is reduced to a smaller circle whose radius is 12.5 k. While A' starves to death, center A is enriched at the former's expense.34

It is clear from this analysis, as well as the one to follow, that Cheysson made use of the same mathematical framework which Launhardt had previously sketched in more general terms. That framework has continued to play a major role in the development of market-area analysis. As noted above, its geometrical argument was rooted in Cartesian analytics, and presumably, was familiar to engineers and mathematicians in the latter part of the ninteenth century. It is, therefore, as plausible for Launhardt and Cheysson to have developed the economic implications of Descartes' contribution independently as for Fetter to have done so many years later. However, the basic issue involved in this study is not priority of discovery. Rather it is the extent to which the analysis of transportation and location problems was enriched and extended at the hands of Cheysson. It is a familiar thesis that economic analysis is advanced by the application of analytical models to specific problems as well as by their original construction. At least by this criterion, Cheysson deserves to be

ranked along with Launhardt in the development of spatial economic analysis. Cheysson not only expanded the mathematical foundations of Launhardt's economic conclusions; he also made substantive contributions to transportation economics in areas previously unexplored.

In the above model, for example, Cheysson focused attention on the natural advantage accruing to the producer who enjoys a lower freight rate than his competitor. Within the body of existing transportation literature, it has frequently been debated whether rate differentials were the result of natural advantages—i.e., the ability to substitute alternative means of transportation—or of undue preference or prejudice. Artificial advantages have generally been disallowed by regulatory bodies, whereas natural advantages have been upheld, with consequent effects (so clearly perceived by Cheysson) upon the market areas of firms enjoying such advantages.

Cheysson's analysis also uncovers an important consideration in the decision to locate new firms. Suppose, for example, that Firm A is established at the position marked A, and A' is a new firm (i.e., seller of like goods) which decides to come in and share A's market. Presumably, A' will seek to obtain the largest possible market, i.e., push the line DD' as far left as it can. Therefore A' will locate as close to A as possible without getting so close that buyers are indifferent as to whether they buy from A or A'. If buyers are very sensitive to differences in costs of transport, A' will get all buyers who live to its right and A will get all those who live to its left. The circles or curves describing each firm's

market area will be determined given the pattern of freight rates between competitors. By a similar process, the best position for firm A'' can also be determined. 36

Competitive Rate-Making and the Carrier's Ability to Attract Traffic

Perhaps even more historically significant was Cheysson's analysis of an individual carrier's ability to attract traffic under conditions of inter-industry competition. Launhardt described the market boundary between two sellers of like goods as a hyperbola only in the case where freight rates were equal. It is important to note that in this context, Launhardt discussed transportation rates and rate differentials with reference to specific commodities. He assumed the existence of a single means of transport throughout and attributed rate differentials between goods to differences in the weight densities of goods having equal market value. By contrast, Fetter did not entertain the prospect of rate inequality either between commodities or between competing transport firms. His conclusions regarding the nature of market boundaries are also based on the assumptions of equal freight rates between commodities and the existence of a single means of transport.

Besides giving more systematic expression to Launhardt's conclusion regarding the spatial division of sales territories, Fetter added a modern flavor to the analysis. He noted the equality of delivered prices at any point on the hyperbolic boundary separating two sellers and described these curves as "planes of indifference." Thus Fetter strengthened Launhardt's analysis by implying something positive about consumer behavior—-that in

the case of homogeneous goods of equal price the consumer is generally indifferent as to his choice of seller. In substance, however, Fetter did not go beyond Launhardt's earlier analysis.

After examining the effects of differential freight rates upon the sales territory of sellers of like goods, Cheysson turned the analysis around in order to examine the effects of freight-rate competition upon the market limits of carriers involved in the physical shipment of goods to a specified point. He began by positing the existence of competing modes of transport. Then he developed a family of "rate-indifference curves" which described the locus of points of equal transport costs for any given rate relationship between alternate means of transport, and he used these curves to analyze: (1) how the individual firm determines the optimum route of its goods shipment, and (2) how, within limits, each carrier can enlarge its "sales territory" at the expense of other carriers.

In retrospect, therefore, Cheysson's analysis appears all the more surprising for his time, since he not only anticipated Fetter on the "indifference" nature of market boundaries, from the consumer's (or shipper's) standpoint, but he also extended the Launhardt-Fetter analysis to the case of competing modes of transport. This gap in the Launhardt-Fetter analysis went unrecognized in American economic literature until 1950, at which time Cheysson's pre-eminence in this aspect of spatial economics was again overlooked,\(^{37}\) even though Cheysson introduced the problem of optimum physical distribution of goods simultaneous with his investigation of market boundaries for competing carriers.

Cheysson used Figure 4-3 to analyze the choice facing a shipper located at point M and seeking to ship goods to destination A. The dotted lines in the diagram indicate existing highways over which goods may be shipped from point M, and it is assumed that a railroad plies the distance between A and B along the solid line segment, AB. Cheysson's problem is twofold. From the shipper's standpoint, the problem is choosing the cheapest route to destination A. For the railroad, the problem is to determine what specific rate will enable it to compete with the highway as a means of shipment, and in a more general sense, what rate reductions are necessary to enlarge its "market area."

As Cheysson indicated, "merchandise situated at point M will not adopt route MBA in place of continuing to take the more direct route, AM, unless there is a reasonable difference in the rates for the two routes."38 Obviously, if the cost of shipping merchandise along MA is the same as shipping it along MBA, then the shipper will be indifferent as to the route taken. When connected, the locus of points along which shippers at different locations will be indifferent for any given rate relationship between carriers forms the hyperbolic curves of Figure 4-3. At point M, for example, the condition $AM - MB = AB t/T$ holds, where, according to Cheysson, $T$ stands for the transport rate per ton-mile on highways and $t$ stands for the railroad rate.39 Similarly, at all other points along KCK', the transport costs as between carriers are the same for a given consignment of

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39 Ibid. When rearranged in the following fashion, this equation assumes the form of a hyperbola: $AM - MB = AB t/T$. In analytic geometry, a hyperbola is the locus of a point which moves in a plane so that the difference of its distances from two fixed points is a constant. In Figure 4-3, points A and B are the foci for hyperbolas KCK', LDL', and NEN'.
Figure 4-3: Sphere of attraction with a Tariff of .03, .06, and .10.

AND THE ROUTING OF GOODS SHIPMENTS
goods. Cheysson pointed out that all points such as M''', situated to the right of KCK' and within the hyperbolic surface, will form the "sphere of attraction" for the railroad at point B; whereas points outside of this boundary, such as M', will ship by highway directly to A. But according to Cheysson, the railroad may expand its market:

... in order to bring in such points as M' the railroad must lower its rates; for example from ten centimes to six. The boundary of the corresponding sphere of attraction will then be moved to LDL'. Finally, to bring in points such as M'' the railroad must agree to a new rate reduction which will extend the market boundary to NEN'.40

The specific railroad rates used in Cheysson's example have illustrative significance only. What is important in determining the market boundary between competing modes of transport in this case is the rate relationship between carriers, or the ratio, t/T. Cheysson concluded that in the case above, the curvature of the hyperbolic boundary will be greater and its zenith closer to B the larger the relationship, t/T.

This analysis by Cheysson fills certain gaps in the Launhardt-Fetter presentation. Thus, in 1950, C. D. and W. P. Hyson correctly pointed out that Fetter's "law of market areas" was only a special case of a more general law which could be derived once competing modes of transport were contemplated.41 The more general law which they propose suggests that the size of the market tributary to a given supply point is determined not only by the relative prices at the two markets, as Fetter had maintained, but also by the ratio of the freight rates between carriers and the ratio of the price difference to the freight rates. They further described the relationships between the last two variables and the size of

40 Ibid., p. 186.
41 Hyson and Hyson, loc. cit., p. 319. Emphasis supplied.
the tributary area as direct in the case of relative market price and indi-
direct in the case of the relative freight rate. Just as Fetter was un-
aware that Launhardt had previously laid the foundation for his analysis,
the Hysons seemed unaware that in describing the division of market boun-
daries Cheysson had contemplated the existence of rival means of trans-
port. Moreover, he accurately explained the partial role of relative
freight rates in determining market boundaries between two producers of
like goods much earlier.

The Supply of Raw Materials

The analysis of market areas shows a locational relation of one or
more firms to its customers who are scattered over the market area in
such a way that each producer has to sell at more than one place in order
to survive. A related problem is that of determining the supply area
when sellers of raw materials are scattered and the individual buyer must
purchase raw materials from more than one source in order to fulfill pro-
duction objectives. Actual locational decisions often involve a mixture
of market-area and supply-area relationships so interwoven that they are
difficult, if not impossible, to disentangle conceptually for analytical
purposes. Nevertheless, traditional location theory considers the two
problems separately.

In his analysis of rational choice of supply source of raw materials,
Cheysson provided additional insights into spatial economics. To illus-
trate the principles involved in the delimitation of supply areas, he de-
veloped a model in which the choice of road-paving materials of different
quality and different costs must be resolved. This model proposes the
existence of a linear market and three supply centers located at various
points within the total market. Transportation costs from each supply center are assumed to increase in proportion to distance from the center, in either direction, and are represented as linear relationships. The choice of raw materials in Cheysson's example is represented by two alternatives: one type of stone, designated as "domestic," is of mediocre quality, but is easily obtained from neighboring fields at a constant price; the other type, designated as "foreign," is superior in quality but more costly to procure. Because the latter must be shipped from afar, the price of the foreign stones increases as does the distance from the quarry to the respective supply centers in the linear market. Thus, as we move easterly in this market (Fig. 4-4), the price of foreign stones increases (along DF). In addition, there are positive transport costs incurred in getting these stones from the supply center to the site of construction. These latter costs are represented in Cheysson's model by transport gradients which increase rapidly as the distance from the supply center increases. A solution is reached, and the respective supply areas are defined by comparing the total real costs of foreign materials to domestic ones.

Figure 4-4 is a reproduction of this model, described by Cheysson in the following fashion:

Suppose the materials of superior quality are transported by train to stations A, B, and C staggered along the highway, at a total cost of AD, BE, and CF, respectively. These costs increase in proportion to the distance from the quarry and the time involved in rail transportation. From the various stations along the route, the stones are transported by dump-cart to the actual road site so that the cost of the stones increases very rapidly in proportion to the distance from the nearest station. The price of the delivered stones finally attains price MH for the distance AH. On the other hand, the stones found in neighboring fields have a constant value of PQ.
Figure 4-4

CHOICE OF SUPPLY SOURCE
In order to compare these two types of stone, we consider their prices for similar quantities, their supplementary costs corresponding to the labor employed in breaking them up, and so forth. If we acknowledge, for example, that some stones wear twice as well as the others, we should find the cost of using the better stones reduced by one-half. This is expressed in Fig. [4-4] by the line D'H', which cuts line PQ at H'. Thus we find that for the portion of the highway, AH, it would be cheaper to use the more durable materials, while along HK it would be to our advantage to use local materials. Proceeding in the same manner, we will be able to determine the different "zones" which must be associated with each supply source, in relation to its respective purchase price, quality and transportation costs.42

Although the solution to the above problem proceeds on a fairly simple level of abstraction, Cheysson's analysis is important because its solution is seen to depend on not merely the relationship between resource prices and transport rates, but resource quality as well. In this, Cheysson displayed more originality than later investigators of supply-area problems who either abstracted from the consideration of resource quality altogether, or discussed the "theoretical significance" of quality variation but failed to make this consideration an explicit part of their analyses.43

The fundamentals of Cheysson's supply area analysis as well as the diagrammatics of the principles contained therein have, with more or less modification, reappeared in the literature on location economics. Thus, Edward Smykay and others have used transport gradients in much the same way as Cheysson did, above, to show how plant location decisions may be reached by a monopolist interested in minimizing total costs of production


43Of the latter, cf., Hoover, The Location of Economic Activity, and Isard, op. cit.
and distribution within a given market area. And Arthur Smithies has followed a similar procedure, with extensive elaboration, in discussing the optimum location of geographically competing firms.

Importance of Cheysson's Analysis for the Theory of Railway Rates and Spatial Economics

An obvious result of comparing the Launhardt-Cheysson inquiry into the nature of geographic market areas and supply areas with the performances of later writers on spatial problems is that this aspect of economics had reached a high stage of development as early as 1886, at least in Europe. In England and America, little was accomplished that would bear comparison with Lardner's earlier contribution. Alfred Marshall's Principles, for example, preserved a traditional non-space approach to economic analysis throughout eight editions. Perhaps because of Marshall's dominant influence on subsequent Anglo-Saxon economic literature, the contributions of Launhardt and Cheysson had little impact upon that body of literature and were, in fact, lost for many years. Nevertheless, the partial equilibrium approach to the division of market areas and supply


46 Marshall was not unaware of the relationship between transportation costs and the size of markets, as is evident from his observation that "... a lowering of tariffs, or of freights for the transport of goods, tends to make each locality buy more largely from a distance what it requires; and thus tends to concentrate particular industries in special localities." [See Principles, (8th ed.), p. 273]. Nevertheless, he failed to develop a spatial model for analyzing the implications of his observation.
areas characteristic of modern treatments of the subject continue to utilize the Launhardt-Cheysson framework, and while belated recognition has come to Launhardt, the same cannot be said of Cheysson.

In the United States, growing interest in spatial economic problems after 1930 was in large measure coincident with development of the theory of imperfect competition. As noted above, the performances of J. B. Clark and Frank Fetter did not exceed the combined performances of Launhardt and Cheysson. In the latter's framework, spatial coordinates of selling firms were fixed. Harold Hotelling was the first to vary price and location simultaneously in a spatial model, although Schneider maintains that Hotelling's treatment of spatial equilibrium in an imperfectly competitive market strongly resembles that of Launhardt. E. H. Chamberlin provided an additional impetus to spatial analysis by emphasizing the role of product differentiation in an imperfectly competitive market. Thereafter, locational differences among sellers were conceived as a source of product differentiation and a hallmark of monopolistic competition—and the Launhardt-Cheysson model found ready application in many investigations into the effects of pricing policies and geographical distances upon the division of sales territories between sellers in a monopolistically competitive market.

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50 e.g., Boulding, op. cit., pp. 630-633.
Greenhut has pointed out that studies which attempt explanation of the size and shape of a firm's market area under the assumption of fixed locations are essentially designed to analyze short-run phenomena, whereas those which assume either movable locations (at no cost) or planned future locations are inherently designed for long-run analysis. While the conclusions of the long-run approach must be considered in reaching a general equilibrium theory, the former presents some insights into a particular long-run equilibrium pattern. One aspect of the Launhardt-Cheysson analysis, for example, is the suggestion that by their power to make and adjust rates, railroads can maintain firms in otherwise unfavorable locations by offering low rates, or they can prevent their location at more favorable places by charging high rates. In general, railroads have been interested in stimulating industries along their own lines, and in the United States they have been allowed by the regulatory bodies to lower rates in order to "meet the competition," providing: (1) the rates are compensatory, and (2) they do not give rise to undue preference or prejudice under Section 3 of the Interstate Commerce Act.

Cheysson clearly recognized the importance of competition among transport firms in determining "the prosperity of industrial centers . . . [and] the development of transport enterprises." He analyzed geographical market consequences of lower rates allowed to meet competition both

51 Greenhut, op. cit., p. 25.

52 Cf., La Salle Paper Co. v. Michigan Central R. R. Co., 16 ICC 149 (1909); Reduced Commodity Rates to Pacific Coast, 89 ICC 512, 530 (1924); and Grain Rates from Minnesota & Wisconsin, 68 ICC 665, 672 (1922).

in terms of their effect upon industrial firms and upon transport enterprises (i.e., both increasing and decreasing cost industries). Furthermore, although the question of "undue preference and prejudice" does not arise in Cheysson's analysis, he recognized the lower limit to competitive rate reductions as "operating costs, exclusive of the general costs of the enterprise," adding that beyond this level, "it would be better for the company to abandon transportation [for a given firm] altogether."

Taken together, Cheysson's investigation of railroad pricing in a spatial market and his inquiry into the principles of profit maximization for the individual railroad represent a significant analytical achievement and an important contribution to the understanding of the pricing process of an imperfectly competitive firm. Moreover, Cheysson's recognition of certain problems in the physical distribution of goods is not without interest for the theory of logistics.

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54 Ibid., p. 188. In general, this is the same criterion which the Interstate Commerce Commission has applied to determine whether rates are compensatory, although the terminology most frequently used by the Commission in describing the lower limit to rate reductions includes "out-of-pocket" costs. [Cf., Reduced Commodity Rates ..., op. cit.].

55 Cheysson recognized the back-haul problem as an exception. He noted that: "If all transportation moves in the same direction, for example, in supplying a great city which consumes much more than it produces (as in the case of Paris), the company may, rather than allow its trains to return empty, prefer to carry something in return, even for a low tariff of a few millimes which would just cover fuel and maintenance costs." [See "Geometric Statistics," p. 188].

56 Fig. 4-3, for example, can be visualized as a simple logistics model useful for determining the optimum distribution method required to serve a given market in space. [Cf., Smykay, et. al., op. cit., Ch. IV].
Chapter V

THE NATURE OF PRODUCTION COSTS AND
EQUILIBRIUM OF THE FIRM

An integral part of Cheysson's program of geometric statistics concerns the nature and measurability of production costs. Cheysson clearly recognized the important role of production costs in the determination of profit-maximizing levels of output, as well as the identification problems involved. Thus he felt compelled to elaborate upon the nature and behavior of factor costs, with a particular view to enlightening the manager faced with minimizing such costs in order to improve his firm's profits. Although he recognized profits as a necessary and desirable return to risk, Cheysson failed to consider any return to entrepreneurial ability as an implicit economic cost. Instead, the major costs of production he discussed were those of wages, machinery, and raw materials. Thus, although it is evident that Cheysson's discussion of production costs was incomplete by modern standards, it is important to remember that Cheysson did not intend to advance any theory of distribution, but merely to present several decision-making models regarding the optimum utilization of various factors within a partial equilibrium framework. In the process there emerged some important and original suggestions on wages, resource substitution, investment decisions, and product variation. The purpose of this chapter is to investigate and evaluate the merits of those suggestions.

Cheysson tended to view the determination of wages as a special application of price theory, thus building upon the (empirical) law of demand which he developed earlier. He treated the demand for labor as a derived demand, depending ultimately upon consumers' demand for commodities. Finding a close link between the commodity market and the factor market, Cheysson took the same empirical approach to labor demand as he had to commodity demand. He noted that under competitive conditions, market prices are dictated by costs of production, and to facilitate his discussion of wages he assumed that wages represent the only variable cost of production, thus setting up a functional relationship between wages and sales. He stated that "... if we vary only the rate of wages, then wages will govern production costs, and through competition, come closer and closer to controlling the sales price." \(^3\)

In his discussion of wage-equilibrium, Cheysson drew a demand for labor curve which was a decreasing function of the wage rate. At the same time, on empirical grounds, he argued that the quantity of laborers offering their services at any given time, in any given industry or firm, is a direct function of the wage rate. He combined these concepts in the graph identified here as Figure 5-1.

Consistent with his earlier practice, Cheysson measured the price variable on the horizontal axis and (presumably) the quantity variable on

\(^2\)Supra, Ch. III.

\(^3\)"Geometric Statistics," p. 188.
Figure 5-1

SUPPLY AND DEMAND FOR LABOR
the vertical axis. A similar representation, in graphical terms, was made as early as 1870 by the British engineer, Fleeming Jenkin. What heightens interest in Cheysson's analysis, however, is the nature of his discussion regarding the stability of equilibrium in the above model. This discussion, including Cheysson's explanation of Figure 5-1, is presented below:

It is clear that the higher the wage, the higher the production costs will be and consequently, the lower the consumption of labor. There is some wage rate which commands a prohibitive sales price. The quantity produced, that is to say, the demand for labor, thus decreases in inverse proportion to the wage rate, according to the law expressed by the curve AMC.

On the other hand, the amount of labor offered will increase with an increase in wages. Starting with the rate OD, which begins to attract a few laborers, the workers will become more and more numerous in the industry in proportion to the increasing amounts paid to labor. This supply relationship can be expressed by curve DME, which rises rapidly as the wage increases. This offer curve, a function of the price of labor, cuts the ... [demand] curve at M. The wage OH which is determined by this intersection corresponds exactly to the equilibrium wage.

Thus, if the wage rate rises above OH and becomes, for example, equal to OK, it will produce on the one hand an abundance of workers, the supply of which is represented by KN; on the other hand, an increase in labor costs will occur, thus driving away a portion of the consumers and causing the amount of labor demanded to fall to KN'. At this point more workers are supplied than the amount necessary to produce the smaller output demanded. Let us then assume that

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4 Perhaps carelessly, Cheysson did not label the vertical axis in Figure 5-1. His explanation, however, indicates that the variable which this axis represents is a quantity: either of output or of labor, for he posited a direct relationship between the amount of output produced and sold and the quantity of labor employed in its production. The labelling of the axis in question as "number of workers" seems consistent with Cheysson's meaning.

this over-supply of labor will force a wage cut back to point 01. This time the opposite movement will occur. We will never be able to find enough workers for the growing market, and the wage will have to increase. It will thus oscillate on both sides of the value OH each time it accidentally deviates from this point. But as long as the two curves, AMC and DME, remain the same, the intersection will always be returned to M through a force similar to that which returns a suspended object to equilibrium once its center of gravity, lying on a vertical line beneath its point of suspension, has been displaced.®

What stands out in the above passage is the explicit suggestion that any deviation from equilibrium will cause successive price oscillations on both sides of the equilibrium value until equilibrium is restored. This suggestion is significant because neither Walras nor Marshall seemed to openly entertain the possibility of discontinuous adjustments in price and quantity once equilibrium is disturbed.® Instead, they explained stability in terms of continuous adjustments on either side of equilibrium, depending on the direction of the initial disturbance.® Presumably, this subtle distinction between Cheysson on the one hand and Walras and Marshall on the other, caused Schumpeter to credit Cheysson with a "cobweb" model of wages.®

®Following Nicholas Kaldor, we shall define as "continuous" those adjustments which proceed at a steady rate in time or those in which the time lags between the appearance of successive quantitative changes are such as can be neglected. Similarly, an adjustment is "discontinuous" if the full quantitative adjustment to a given price change occurs all at once, at the end of a certain period [See, "The Determinateness of Static Equilibrium," in Essays on Value and Distribution (London: G. Duckworth & Co., 1960), p. 29].
®Schumpeter, op. cit., p. 842 n.
Schumpeter's claim has been closely examined in this study but is not fully accepted. Although it can be shown that a "cob-web-type" model is consistent with Cheysson's argument, the assumptions necessary to establish such a model are highly specialized and entail "reading in" to Cheysson perhaps more than that of which he himself was aware. The remainder of this section is devoted to examining the validity of Schumpeter's claim in this regard.

A Reconstruction of Cheysson's Wage Model in Light of Recent Theoretical Developments

If there is a genuine connection between Cheysson's wage model and the basic "cobweb theorem" of Professors Schultz, Tinbergen, and Ricci, it concerns the recognition of time lags and discontinuities in price and output adjustments in disequilibrium. On conceptual and theoretical grounds, both models differ regarding the type of adjustment-response assumed and the nature of the necessary conditions for stability of equilibrium.

Nicholas Kaldor has correctly asserted that the cobweb theorem applies only to cases of "completely discontinuous" adjustments of output to changes in price, a prospect of which Cheysson seems to have been aware. Nevertheless, other writers have maintained that the essential feature of the

10The term, "cobweb," was first suggested in 1934 by Kaldor [loc. cit., p. 30] for the theoretical explanation of commodity cycles worked out independently by Henry Schultz, Jan Tinbergen, and Umberto Ricci. As it happened, all three papers were published in German, two appearing simultaneously in the same journal [Cf., Henry Schultz, Der Sinn der statischen Nachfragen, Heft 10, Veröffentlichungen der Frankfurter Gesellschaft für Konjunkturforschung (Bonn: Kurt Schroeder, 1930), p. 34; J. Tinbergen, "Bestimmung und Deutung von Angebotskurven, Ein Beispiel," Zeitschrift für Nationalökonomie, Wein, Band 1, Heft 5 (1930), p. 671; and Umberto Ricci, "Die 'Synthetische Ökonomie' von Henry Ludwell Moore," ibid., p. 656].

11Kaldor, loc. cit., p. 30 n.
dynamic cobweb model is the assumption that the output in successive production periods is responsive to the demand price in the preceding period.\textsuperscript{12} This lagged-response in supply will create a converging, diverging, or perpetually oscillating path with respect to long-run equilibrium, depending upon whether the absolute slope of the demand curve is less than, greater than, or equal to the slope of the supply curve.\textsuperscript{13}

There is no persuasive evidence that Cheysson entertained the possibility of such a supply reaction in his wage model. It is clear that equilibrating adjustments in Cheysson's model are not instantaneous, but neither the manner of construction of Cheysson's diagram nor his explanation supports the supply-response lag of the familiar cobweb theorem. In fact, it can easily be demonstrated that whereas Cheysson was concerned with establishing the stability of a stationary equilibrium, the introduction of the basic cobweb lag into his model renders it dynamically unstable. Proof of this assertion is offered below.

Figure 5-2 reproduces Cheysson's model, as depicted in Figure 5-1, but incorporates the familiar supply-response lag of the cobweb theorem. The unique feature of this model is that the quantity of labor supplied in period 2 is a function of the demand price, i.e., wage, in period 1. Thus at wage OK, \( Q_1 \) represents the quantity of labor supplied to the firm in


Figure 5-2
CHEYSSON'S WAGE MODEL WITH "COBWEB" LAG
question. But at $Q_1$ the demand price for labor is $OJ$ (not $OI$, which represents the wage cut assumed by Cheysson in his example). At this lower wage, however, only $Q_2$ laborers will enter the firm, thus creating a condition of excess demand and forcing the wage up to $OP$. Since $OP$ is not an equilibrium wage the cycle continues, in similar fashion, along the path represented by the dotted lines in Figure 5-2.\(^{14}\)

Cheysson's emphasis on the stability of the model in Figure 5-1\(^{15}\) casts considerable doubt on the possibility that what others consider the essential feature of the cobweb theorem, was, in fact, part of his analysis; since to admit as much would have denied the stability of his model. A more plausible explanation of the nature and direction of the dynamic adjustments generated by Cheysson's model is offered in this study.

Paul Samuelson has pointed out that the equations of comparative statistics are a special case of general dynamic analysis and that different dynamic setups lead to different stability conditions, with subsequently

\(^{14}\)At this point it is convenient to offer a pedagogical note on the stability conditions of the basic cobweb model. Comparisons of price analyses before and after Marshall have often been confused by the fact that Marshall reversed the order of the price and quantity variables on the familiar two-dimensional graph so as to make price the dependent, and quantity the independent variable. By way of contrast, earlier treatments, such as Cheysson's, followed the convention of portraying price as the independent variable. Modern economics, following Marshall, requires the following condition for stability in the cobweb model: that the absolute slope of the demand curve is less than the slope of the supply curve—reference being made to the quantity (i.e., horizontal) axis. See Foundations, p. 265. When the axes are reversed, so is the condition for a stable equilibrium. Thus the above model produces a diverging cobweb path even though the demand curve is flatter than the supply curve.

\(^{15}\)Cheysson proclaimed: "... far from having an arbitrary and capricious value, the wage rate established by a given combination of supply and demand cannot deviate from its normal position without incurring consequences which force it back to equilibrium" ["Geometric Statistics," p. 191].
alternative theorems in comparative statics. In the Walrasian system, for example, the stability conditions of a static equilibrium rest on the assumption that for a positively or negatively sloped supply curve, a price set too low produces a positive excess demand, causing buyers to raise the price to equilibrium; whereas a price set too high generates a negative excess demand, causing suppliers to lower the price to equilibrium. These price adjustments are assumed to be continuous and to take place gradually, through a process of \textit{tâtonnement}, or groping, towards equilibrium. It is further assumed that in a stable model, all price adjustments are in the direction of equilibrium. On the other hand, in the Marshallian system, quantity is assumed to be the adjusting variable, whenever "demand price" and "supply price" are unequal. Adjustments in the Marshallian system are likewise assumed to be gradual and continuous; and in a stable model, always in the direction of equilibrium. As long as the supply curve is positively sloped, the necessary condition for stability is the same in both systems—namely, that the absolute slope of the demand curve is less than the slope of the supply curve. When the supply curve is negatively sloped, the stability conditions differ as between Walras and Marshall, but insofar as Cheyssson's model did not posit such a supply curve, these differences are not significant for present comparisons.\footnote{\textit{Foundations}, pp. 260 ff. Also, p. 22, where Samuelson states: "While of course it is always possible to lay down arbitrary definitions of stability, it is impossible to deduce them without the implicit introduction of dynamical considerations concerning the behavior of a system out of stationary equilibrium. Depending upon the dynamical set-up envisaged, different stability conditions are implied. Thus, given supply adjustments of the type assumed in the cobweb cycle phenomenon, it is well known that the ordinary Marshallian condition of a positively rising supply curve may not result in 'stable' equilibrium." "Stability," as used in this context (and in this dissertation) refers to the ability to return to equilibrium following displacement from an initial stationary equilibrium.}

\footnote{The reader interested in pursuing this point should consult A. Kooros, \textit{Elements of Mathematical Economics} (Boston: Houghton-Mifflin, 1965), pp. 64-66.}
As indicated, what is unique in Cheysson's analysis is that unlike Walras or Marshall he explicitly suggested that the return to equilibrium could come about only after a series of more-or-less random, intermediate price and quantity adjustments had been effected. According to Cheysson, it is possible for the price-adjuster to "over-shoot" equilibrium, thus occasioning a future adjustment in the opposite direction. In this regard, the physical analogy of the pendulum, which apparently retained figurative significance for Walras and Marshall, was much more descriptive of the real nature of adjustments to Cheysson. In fact, he suggested that the return to stationary equilibrium may come about not as a result of a continuous upward or downward revision of prices, but as a consequence of discontinuous upward and downward swings in price on the same path to any stationary equilibrium.

A number of possible time-paths toward equilibrium emerge from Cheysson's model, but the nature and number of the stabilizing adjustments are much less precise than in the basic cobweb theorem. Price changes in Cheysson's model are initiated by employers in a given firm whenever they face a disequilibrium situation as between the supply and demand for labor. The existence of a disequilibrium wage is communicated to the employer by a change in sales, since sales are represented in Cheysson's model as a function of wages. Changes in sales, of course, result in involuntary accumulation or depletion of inventories. Cheysson's model suggests that due to imperfect knowledge, employers typically over-react to disequilibria conditions, so that wages are apt to change in alternating directions on both sides of the equilibrium value. Stability may be assured, however, by the

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18Samuelson offers the same suggestion in Foundations, p. 261.
introduction of a learning-mechanism into the model. Once it is determined that any existing wage is a disequilibrium one, the learning-mechanism will guarantee that the same wage will not be repeated or exceeded, ceteris paribus, in subsequent wage adjustments by employers. This type of behavior results in a time-pattern of adjustments which may assume the form of a cobweb, but by the nature of the construction and dynamic assumptions of the model, it remains distinct from the basic "cobweb theorem" explored above.

Following is a reconstruction of Cheysson's wage model in which the implications of the above discussion are extended by this writer to produce the result which Schumpeter attributes to Cheysson. The stability condition for this model, as implied by the learning-mechanism, is that subsequent price changes in disequilibrium are always less than the preceding price change, and in the opposite direction of the preceding price change.

It will be recalled that Cheysson prefaced his discussion of wages with the assumption that wages represent the only variable cost of production, so that a firm's sales are directly related to the level of wages it pays. Thus, in Figure 5-3, when the wage rate rises to OK for any reason, both the cost of labor and the price of goods increases, and in Cheysson's words, some consumers are "chased away" from the market. In order to maintain the same level of profit the producer must restore lower prices, which implies cutting wages. In Walrasian terms, the excess supply of labor at wage OK causes buyers of labor to lower its wage. But instead of continuous wage adjustments such as OP, OH, Cheysson suggests that employers will over-react to the condition of excess supply. He wrote:

Let us ... assume that this over-supply of labor will force a wage cut back to point O1. This time the opposite movement will occur ... and the wage will have to increase. It will
Figure 5-3
CHEYSSON'S WAGE MODEL
WITH CONVERGING EQUILIBRIUM ADJUSTMENTS
thus oscillate on both sides of the value OH . . . . But as long as the two curves remain the same, the intersection will always be returned to M . . . .19

At this point, the learning-mechanism becomes crucial to the stability of the model. By his explanation, Cheysson seems to implicitly assume that in the absence of perfect knowledge, the employer will continue to overreact to disequilibrium situations. But having come this far in the adjustment process, it is obvious to the employer that OK is not an equilibrium solution. Therefore, in the succeeding period he will raise wages by some amount less than OK; such as OP. However, since OP is not an equilibrium wage, the cycle will continue, tracing out a path similar to that represented by the dashed lines in Figure 5-3. Eventually, equilibrium will be restored at wage OH.

It must be observed that although stability is assured through the learning-mechanism, there is no determinate a priori adjustment path or time dimension in every case. Equilibrium may be re-attained after one price adjustment or after an indefinite number of adjustments, depending upon the magnitude of the initial displacement from equilibrium and the knowledge of the market possessed by employers. Cheysson's "cobweb," therefore, need not be symmetrical at all times or in every case.

What this reconstructed version of Cheysson's wage model shares with the basic cobweb model is a similar view of the dynamic adjustments necessary to restore stationary equilibrium and an appreciation of existing time lags in the adjustment process. The basic distinctions of Cheysson's model are that: (1) equilibrating adjustments are discontinuous on the demand side and instantaneous on the supply side, rather than vice versa;

and (2) given a negatively sloped demand curve and a positively sloped supply curve, stability in Cheysson's model depends upon the learning-mechanism rather than the relative elasticities of the curves. Several extensions of the basic cobweb model have been proposed which approximate this model in one way or another. R. M. Goodwin, for example, has suggested a cobweb model which employs a learning mechanism on the supply side.\textsuperscript{20} Arnold Collery has suggested a number of alternative price expectations other than the one proposed by the basic cobweb model and has summarized the mathematical results of these alternatives.\textsuperscript{21} And R. G. D. Allen has examined several cobweb models where stocks are assumed to exist and price changes in subsequent periods result from changes in these stocks.\textsuperscript{22}

Cheysson's failure to identify the explicit nature of the time lag involved in the adjustment process and the omission from his discussion of the role of inventories may be considered shortcomings of his analysis. However, in a market characterized by complete uncertainty, adjustment lags between firms may be variable; and it has already been indicated in this study that at least theoretically, inventory adjustments are a necessary adjunct to changes in sales. Thus, the introduction of inventories into the analytical schemata presented by Cheysson can easily be made, though Cheysson failed to do so in any explicit fashion.\textsuperscript{23}

\textsuperscript{20}R. M. Goodwin, "Dynamical Coupling with Especial Reference to Markets Having Production Lags," \textit{Econometrica}, XV, No. 3 (July, 1947), pp. 181-204.


\textsuperscript{23}Elsewhere Cheysson talked about "provisions" as a form of capital, but only in the classical sense of "wage goods." [See, "Capital and Labor," \textit{loc. cit.}, pp. 134 ff.]. The idea of commodity stocks held to facilitate sales is missing, however, in this specific instance.
Once inventories are given an explicit role in Cheysson's model, the interaction between production and employment decisions, where both are responsive to inventory changes, is more easily understood.

This interaction has been summarized by C. C. Holt, Franco Modigliani, and others, in a manner reminiscent of Cheysson's discussion of the nature of stable equilibrium:

The production of one...[period] affects the net inventory position at the end of the...[period]. This in turn influences the employment decision in the second...[period] which then influences the production decision in the third...[period]. Thus there is a continual dynamic interaction between the two decisions. The influence of net inventory on both the production and employment decisions produces a feedback or self-correcting tendency which eventually returns net inventory to its optimum level regardless of whether or not sales have been forecasted accurately.\(^\text{24}\)

Whether or not a simple inventory model or a more complex "cobweb" model, can be attributed to Cheysson on the basis of the analysis presented in this study, it is obvious that he understood the "self-correcting tendency" of successive adjustments in disequilibrium, particularly as it applies to wages.

Cheysson on Factor Proportions and Technological Unemployment

The logical consistency of the foregoing analysis rests on Cheysson's assumption of a single variable-cost factor and the consequent

\(^\text{24}\)C. C. Holt, et. al., Planning Production, Inventories, and Work Force (Englewood Cliffs, N. J.: Prentice-Hall, 1960), p. 62. Emphasis supplied. Cf., Cheysson's discussion of equilibrating adjustments, supra. Cheysson notes that at wage rates above equilibrium, "...more workers are supplied than the amount necessary to produce the smaller output demanded," whereas, at rates below equilibrium, "...we will never be able to find enough workers for the growing market." Since the amount demanded by consumers is communicated to producers through sales, the former case implies
tendency to view sales of output as a function of wages. It therefore applies in greatest measure to those industries where the ratio of labor inputs to capital inputs is extremely high. Today such industries abound in underdeveloped countries, and France in the nineteenth century was not unlike an underdeveloped country by present comparison. A large share of its industry then remained labor-intensive. Towards the end of the century, however, industrialization was proceeding rapidly and labor was becoming increasingly organized.

Cheysson attempted to draw upon the foregoing discussion of labor market equilibrium in order to demonstrate the effects of "exhorbitant" wage demands by organized labor. He recognized that artificially high wage levels could prejudice existing factor proportions in favor of capital and consequently, give rise to technological unemployment. And he sought to demonstrate the effects of disequilibrium wage levels upon the entrepreneur's choice of optimum factor proportions and optimum production period.

Cheysson clearly perceived that in most cases the introduction of machinery increased the productivity of workers already on the job, and that some optimum combination of capital inputs and labor-time existed for any given production process. From an economic standpoint, this optimum input mix is the least-cost combination of factors which will produce a given output. One solution to this problem is to identify the lowest point on the firm's long-run average total cost curve, but this solution reveals little about how factors are substituted for one another. Another

that inventories involuntarily rise; the latter that they involuntarily fall. The return to equilibrium in Cheysson's model can therefore be viewed as the result of a series of wage and inventory adjustments.
approach, which has its analogue in the theory of consumer behavior, is
offered by J. R. Hicks, in Value and Capital. As an approximation to the
problem of input substitution, Hicks considers the case of a firm employ­
ing two factors of production, whose output is fixed, so that it cannot
be affected by ordinary changes in prices. The problem is then defined
and resolved in the following manner.

The problem . . . is to produce the given output at a minimum
cost. It can be illustrated by a diagram such as Figure [5-4]. The production curve will be shaped like an indifference
curve, being convex downward (diminishing marginal rate of sub­
stitution between factors). The position P, where PK touches
the production curve, will be a point of equilibrium if the
ratio of the prices of the factors is as MK to PM. Suppose now
that the price of A falls. The amount of factor B which has
an equal value to ON of A now falls from MK to MK_1; and the
total cost of production (in terms of factor B) falls from
OK to OK_1. But since PK_1 does not touch the production curve,
costs can be reduced still farther (to OK_2) by going along
the production curve to P' where P'K_2 is parallel to PK. At
the new point of equilibrium more A is employed and less B;
there has been a substitution in favor of A and against B.25

Cheysson's approach to the same problem was considerably different.
Unlike Hicks, Cheysson dealt with time directly, by introducing a link
between the introduction of machinery and the rapidity with which a given
output can be produced. The problem which concerned Cheysson was the de­
termination of the firm's optimum combination of labor and capital in­
puts over time, in a fixed output case where the length of time involved
in production may or may not be important. Since the cost of machinery
is assumed constant in Cheysson's example, his solution depends primarily
upon the wage rate.

Specifically, Cheysson investigated the Ricardian proposition that
rising money wages encourage the introduction of labor-saving devices.

Figure 5-4
HICKS' INPUT-SUBSTITUTION MODEL
While Charles Babbage could write, in 1832, that "the solution of this question depends on facts, which unfortunately have not yet been collected," Cheysson asserted in 1887 that this phenomenon was empirically validated by "contemporary practices as well as by looking back through history." What he sought to do, therefore, was to place this proposition in an analytical context so that the businessman could, assuming he knew the existing wage rate and the (constant) cost of various capital inputs, determine the optimum method of production and the optimum production period simultaneously. The solution to this problem is given by the lowest point on the total production costs curve in Figure 5-5.

From the standpoint of modern economic analysis, Figure 5-5 is extremely unorthodox. Moreover, its inner consistency is greatly obscured by Cheysson's cryptic description of its mechanics. His conclusion, although correct, is not easily reached; but once established, the approach used by Cheysson turns out to be revealing in several respects. In "La Statistique géométrique" Cheysson wrote:

The height of wage structures signals the advent of machinery: such as the engine, which would be inadmissible in a country where labor costs are low. But such is the case in countries characterized by high wage rates. Thus we find there is a clear relationship between wage rates and the importance of machinery among the means of production. This relationship can be affirmed through contemporary practices as well as by looking back through history. Figure [5-5] serves to clarify this notion.

Suppose that we are engaged in certain earthworks; for example, the digging of a canal or an embankment for a railroad. We would employ more or less machinery depending upon the wage rate and the speed at which the job could be completed.

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Figure 5-5

OPTIMUM FACTOR PROPORTIONS AND PRODUCTION PERIOD
If manpower costs nothing, as was the case of the Egyptian peasants under the Pharaohs, all of the work would be done by hand, such as the veritable armies of slaves who constructed the pyramids. If, on the other hand, the cost of labor is high and the length of time involved in construction is important, we would replace more and more workers with machines; in such a way that the cost of equipment necessary to perform the same task will vary from zero to some maximum, corresponding to the amount of labor suppressed.

We have represented in Figure [5-5] the cost of excavating 1,000 cubic meters of earth, over a fifty day period, based on the use of the simplest tools, such as the pick and shovel, to the most complicated, such as the powerful draglines which perform the same work in much less time; for example, in reclaiming parts of the Isthmus of Panama [from the sea].

The total cost of production will be equal to the sum of the costs of equipment and labor. These costs will vary according to the wage rate, and they are expressed in Figure [5-5] by the fan-shaped curves varying from 0 to 7 francs per day.

According to the hypothetical conditions represented in the diagram, for a wage rate less than 2 francs per day it is to the advantage of the enterprise to use manual labor exclusively and to take the entire fifty days to complete the excavation of 1,000 cubic meters. When the wage rate reaches 3 francs, it becomes advantageous to use more equipment so as to reduce the number of work days to 27. If the wage rate reaches 5 francs, the number of work days declines still further and the role of machinery is increased even more. Finally, at a wage rate of 6 francs, machinery is employed to the definite exclusion of manual labor.

The internal consistency of Cheysson's model rests upon the following considerations: (1) The problem is posed in terms of a fixed work crew of homogeneous labor inputs, each receiving the same wage per day. The total wage bill, therefore, is a function of the number of days the work crew is employed, the wage rate, and the (fixed) number of labor inputs. (2) Capital inputs are heterogeneous, but the price of each input

28 At this point, Cheysson added the following footnote: "For a zero wage rate, the total cost of production is the same as the cost of machinery used. For any positive wage, such as 5 francs per day, the most favorable combination of labor and machinery corresponds to the lowest point on the cost curve, that is, point P, which combines 24 work days with 183 francs as the cost of production."

is known and constant. (3) All machinery used in the production process is assumed to be labor-saving. (4) Output is fixed for the problem under investigation.

Total costs, as Cheysson point out, are equal to the sum of labor and machine costs, and are measured on the left axis (OK) in Figure 5-5. Following the text of Cheysson's argument closely, it is apparent that the vertical axes represent extreme positions. Point K on the left axis represents the use of capital inputs only, and an almost instantaneous production period. Similarly, points on the right axis represent the exclusive use of labor inputs and a consequent production period of fifty days. Cheysson indicated that, in this example, when the daily wage rate is two francs or less, cost-minimization is achieved by the exclusive use of labor inputs, since the lowest point on the total cost curve in each case where the wage rate is two francs or less is a point on the right axis. On the other hand, the least-cost point for wages of six francs and above corresponds to point K, where "machinery is employed to the definite exclusion of labor."

As indicated earlier, Cheysson's example does not confine itself to the use of a specific kind of capital input. Instead it includes a range

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30 Both in the "Résumé" and in the 1887 version of "La Statistique géométrique" Cheysson labelled the left axis of Figure 5-5: "frais d'outillage par 1000 m." While the French "outillage" can be translated as "machinery," it can also be translated as "apparatus." The omission of the definite article in the contraction, "d'outillage," indicates that the term is used in the generic sense, which makes it more consistent with the "apparatus" translation. In other words, it is suggested that what Cheysson intended the left axis of Figure 5-5 to measure was the combined cost of the factors assembled for a given task, namely, excavation of 1,000 cubic meters of earth. Thus, "total costs" is used in this study to label the left axis in Figure 5-5. This interpretation also appears consistent with Cheysson's labelling of each of the fan-shaped curves as "frais totaux de production."

31 Despite certain conceptual difficulties connected with instantaneous production in this case, such a result might be approached by the judicious use of dynamite.
of inputs from the most simple and inexpensive equipment to the most complex and expensive. The model implies a correlation between high capital-labor ratios and the use of sophisticated and costly capital, as well as vice versa. Logically, this is because the former type of capital is capable of displacing more laborers per unit of output. These considerations help to explain the shape of the total cost curves in Figure 5-5. For low wage rates, total costs increase as we move leftward from points on the right axis. The introduction of machinery is a lumpy process, and in Cheysson's model the rate of increase in total costs proceeds initially at a decreasing rate; then successively, at increasing and decreasing rates. Presumably this is because labor is initially displaced by the simplest, most inexpensive tools, so that the marginal "economy" to the firm of discontinued wage payments approaches the marginal cost of additional units of capital. Beyond some point, however, total costs rise sharply because the marginal cost of additional capital inputs exceeds the marginal "economy" of fewer wage payments. The presence of indivisibilities and imperfect substitutability between factors might also account for various inflection points in Cheysson's total cost function. For higher wage rates, the relationship between labor costs and capital costs is such that the introduction of machinery lowers total costs immediately, presumably because of the higher marginal "economy" in disuse of labor inputs. But here again, beyond some limit, total costs begin to increase over previous levels. Finally, it should be noted that the introduction of more costly capital inputs simultaneously reduces the length of the production period.

One problem not squarely faced by Cheysson concerns the nature of the total cost curve in Figure 5-5 when capital inputs are assumed heterogeneous. Being a lumpy process, the introduction of different types of machinery
is likely to result in discontinuities in the cost curve. Yet Cheysson's curves are smooth and do not reflect such discontinuities. Certainly Cheysson was aware of discontinuities in a firm's cost function as a result of fixed investment. His analysis of investment decisions presented below [Figure 5-6] firmly establishes that fact. Therefore, it must be assumed that Cheysson smoothed out the cost curves in Figure 5-5 in order to obtain continuous functions. Unfortunately, he did not offer a clear explanation of the shapes of his total cost curves in that diagram, so that this writer has had to "second-guess" him in this regard.

Cheysson correctly identified the optimum combination of factor inputs as that indicated by the lowest point on the total cost curve corresponding to a given wage. This solution gives the most efficient method of producing a given output and in that respect is analogous to Hicks' analysis. But at the same time, Cheysson's handling of the capital-input heterogeneity problem is not altogether satisfactory. However, Cheysson revealed--here as in his analysis of equilibrium wages--a basic feeling for the inter-relationship between comparative statics and dynamics. He never seemed to lose sight of the importance of time, whether in the process of market adjustments or the process of production. Moreover, his investigation of the input substitution problem is significant, despite its shortcomings, because it set forth in an analytical apparatus, better than anyone before, the economic criteria for determining optimum factor proportions for a given level of output.

It is significant that Cheysson's analysis of factor proportions followed on the heels of his description of wage-equilibrium. In fact, Cheysson clearly used the above analysis to caution laborers not to push for unreasonable (i.e., disequilibrium) wage increases because of the unemployment effects which would follow. As a preface to his examination of factor
substitution, Cheysson noted:

Beyond a certain limit, an increase in wage rates makes it impossible to withstand external competition and to satisfy the internal demand of consumers. In this manner, an increase in wages exhausts the market and, consequently, eliminates jobs. Therefore, this should be carefully contemplated by the most sincere friends of the worker (and I dare to consider myself among them); for, as we all know, before resigning himself to being controlled by his workers' demands, the manufacturer resorts to an expedient which, at the time, is no more favorable to the worker than closing the factory, namely, the intervention of machine labor.  

More recently, the same kind of argument has been used by R. S. Eckaus to describe unemployment and underemployment in underdeveloped countries. Eckaus has argued that if wage rates are kept above equilibrium because of market imperfections, an artificially high ratio of the price of labor to the price of capital will result, and assuming factor substitution is in fact, possible, "a structure of production may result with a higher capital-labor ratio than otherwise." Particular, he observed that "in low per capita income countries which are just on the threshold of economic development... new industrial projects [where labor unions can most effectively press their wage demands] may face the prospect of wage rates quite different from those prevailing in the handicraft and agrarian sectors and thus may be compelled to use different factor proportions." The same argument is, of course, valid in developed countries where market imperfections exist.

Prior to this study the importance of Cheysson's analysis for the subsequent direction of economics was completely overlooked. Many theorists


34 Ibid.
chose to follow Walras' lead, which described production and pricing decisions on the basis of fixed technological coefficients. As one observer has remarked, "This ... assumption ... is astonishingly restrictive: it not only eliminates the problem of optimum factor proportions but also the problem of choosing an optimum plant ..." Yet, despite the significant accomplishments of Austrian capital theory, the tendency to analyze the production process in terms of fixed technological coefficients lingered for some time.

In 1930, the analysis of time in the production process was extended to a general equilibrium context and greatly advanced by Gerhard Mackenroth. Mackenroth showed that leading explanations of the pricing process, particularly those of Walras, Pareto and Cassel, held only for a timeless economy. He therefore rearranged the necessary equations to include time and durability factors and the rate of interest. His achievement was a notable one, and although Mackenroth apparently never read Cheysson, it is clear that his discussion captured the spirit of Cheysson's earlier analysis. For example, he concluded:

The entrepreneur, trying to determine the optimum method of production, not only has the choice between different combinations of original or produced means of production, but he also has to decide upon the optimum length of the production period ..., although within limits. The limits are determined by the technical possibilities and the technical knowledge of the entrepreneur, as in the case of the technical coefficients. But if there are several ways open to the entrepreneur for regulating time of production ..., it is on the prices of all the means of production, the price of the product, and the rate of interest that the optimum time of production ... depend[s].


37Ibid., p. 654.
This passage underscores one obvious shortcoming of Cheysson's partial approach to the problem, viz., its failure to consider the monetary rate of interest as a determinant of the method of production and the time involved therein. The only alternatives in Cheysson's discussion of factor substitution are hand-labor and machinery. The latter represents a capital instrument rather than a sum of disposable capital. Problems of internal vs. external financing did not concern Cheysson at this point; hence his neglect of the interest rate as a decision variable.

It is possible, however, to define the rate of interest, in a stationary state, so that it is equal to, or at least approaches, the income stream derived from the services offered by a given stock of capital goods. Fitting this definition to Cheysson's model would then lead to the same conclusion later reached by Irving Fisher, that the higher the rate of interest, other prices being equal, the shorter the optimum time of production, and vice versa.

For many reasons, Cheysson's input-substitution model remains more than a historical curiosum. It represents significant progress in an area of economic analysis where considerations of the length of the production period have only recently been considered a part of the problem. It provides some valuable insights into the nature of the pricing process and the question of factor substitution for the individual firm. It also represents the first rigorous attempt to analyze the role of artificially high wages in precipitating technological unemployment.

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38Ibid., p. 653.

39For a mathematical elaboration of this point, see Irving Fisher, The Rate of Interest (New York: Macmillan & Co., 1907), Appendix to Ch. IV, 2 and 3.
Anticipations, Internal Rate of Return, and the Theory of a Single Investment

The preceding analysis of factor substitution was based on the assumptions of fixed output and fixed prices of equipment. But as a practical man of affairs, Cheysson was acutely aware that the widespread use of machinery entailed substantial capital expenditures and a concomitant increase of productive capacity over time. He was also aware of the practical demand for an analytical device which would enable the individual firm to determine under what conditions additions of fixed capital were economically desirable. As he declared, entrepreneurs "... face the very delicate problem of trying to find the exact proportion which should be maintained between fixed and circulating capital ...; whether ... [he] should engage in capital expenditures in order to perfect his stock of equipment, or if it is better for him to maintain the status quo." 40

Cheysson realized that, of necessity, such decisions were customarily made under conditions of uncertainty, particularly with respect to future demand. 41 The ultimate decision regarding a single investment is therefore based on the entrepreneur's anticipations of future sales. At any given time, the cost of an investment project can be determined on the basis of factor costs and the interest rate on borrowed capital. But as long as future demand remains unpredictable, the profitability of a single investment is uncertain. In some (monopolistic) industries, demand


41"... the manufacturer, with his eyes fixed on the ... demand curve, will accept or reject investment plans, depending on whether or not he believes he will be able to attain the production limits which make such investment fruitful." (Ibid., p. 197)
may be fairly stable over long periods of time, thus reducing somewhat
the uncertainty surrounding investment projects. This was particularly
true of the railroad industry in the nineteenth century, when fewer sub-
stitute modes of transportation existed than do at the present time. It
was such a firm that Cheysson had in mind when he set forth the following
investment-decision model:

... let us suppose that a plant, such as that of a rail-
road, has attained its production limit. We will call this
limit its "point of saturation". At this point, the com-
pany will have to ask itself, in view of increasing trans-
portation use, whether it is profitable to increase its
carriage force, double the number of engines, tracks and
stations, extend its buildings; in other words, convert
circulating capital into an additional amount of fixed cap-
it a l—represented in Figure [5-6] as CC'=h. In giving a
satisfactory answer to this question we must devise a dia-
gram which will indicate the consequences of the projected
investment, for these capital expenditures will burden the
sales price of each unit produced by adding interest and de-
preciation charges. The curves of total production costs and
unit production costs each experience at this point, a sharp
rise, equal to MN and M'N'. But from this point on, their
rate of increase slows down. If traffic continues at its
former increasing rate or accelerates because of the improve-
ment of existing equipment, total gross revenue will hence-
forth increase. Total net revenue, after having submitted
to a sharp decline, will slowly but surely rise again. And
when the traffic attains point OF, the net revenue will have
reached its former position, where A'F=AH.

In order to justify the investment, however, it is not enough
to have regained the previous amount of net revenue, since
the matter of paying for the services of the additional capi-
tal (CC'=h) remains. Therefore, let us introduce a new curve
which represents a net percentage return, or dividend, and is
easily derived from the absolute net profits curve. It can be
seen that this curve, as the former, declines sharply at the
point of capital expenditure and does not regain its former
position, IH, until we reach traffic OL, which is noticeably
greater than the traffic at OF, where total net revenue be-
came equal to its former level. If the traffic exceeds this
limit (OL), then and only then, will the investment be profi-
table; otherwise, it would be too costly and we would find
it more prudent to give up the idea of expanding.42

42Ibid., pp. 194-195.
Figure 5-6

AN INVESTMENT-DECISION MODEL
It is important to note certain particularities of this model before proceeding farther. "Traffic," measured along the horizontal axis in Figure 5-6, is a surrogate variable for output, in a more general framework. Since Cheysson makes specific reference to a railroad company, however, the model shows the characteristics of a decreasing-cost firm. All of the cost and revenue functions, with the exception of total gross revenue, become discontinuous at the point of additional investment and resume their respective paths at output levels beyond OH. Thus, capital expenditures required to realize the addition to fixed capital are assumed to occur in a lump sum. Presumably, Cheysson intended the left vertical axis as a measure of "dollar-value," with perhaps the right vertical axis set up to measure percentage values, thus allowing simple comparisons of rates of return at various levels of real or potential output.

The key to the problem posed by Cheysson lies in his "percentage net return" schedule (i.e., "produit net %"). Although Cheysson is less than perfectly clear on this point, his "percentage" curve is interpreted here as a return to capital. He clearly stated that this curve is derived from the absolute net revenue, or profits, curve, but he stopped short of explaining just how the derivation proceeds. It is obvious that the "percentage" curve must be a ratio of net revenue to some other magnitude. In the absence of any further explanation, it could be interpreted either as a ratio of net revenue to total revenue; net revenue to total costs; or net revenue to capital investment. But Cheysson's use of the term, "dividend," as a synonym for "net percentage return" seems to support the interpretation of that concept as a ratio of profits to capital, since in ordinary usage, "dividend" describes the income return on a particular investment. Moreover, this interpretation seems consistent with the behavior
of the curve itself, in relation to the absolute net revenue curve from which it is derived. If this interpretation is correct, the "percentage net return" curve is determined by the ratio of net revenue to the amount of capital invested over the relevant range of output. In Figure 5-6, for any output less than or equal to OH, the capital investment is equal to OC. Beyond OH, capital investment is equal to OC'. Since the numerator of the ratio which describes the percentage net revenue curve is increasing over the range of output, OH; and since the denominator (OC up to output OH; OC' beyond that) is constant (in each case), percentage net revenue can be expected to increase more rapidly than absolute net revenue, as in fact, it does in Figure 5-6. This might also be true if "percentage net return" was related to total revenue, or to total costs, but only if net revenue increased more rapidly than either total revenue or total costs. In Figure 5-6, this does not appear to be the case over the entire range of output, at least not by construction. Thus the interpretation of "net percentage returns" as a return to capital is strengthened.

Cheysson's model is based on empirical rather than a priori concepts, and in this respect bears little relation to Austrian capital theory, which focused on the physical productivity of capital, length of the production period, and a theoretical explanation of interest, largely within a general equilibrium framework. Cheysson did not attempt to explain how interest arises, but how investment decisions should be made at the micro level. Expectations about the future income stream of a given capital investment

\footnote{43 T. W. Hutchison has observed that "Austrian" capital theory is almost exclusively Boehm-Bawerkian, since Menger and Wieser profoundly disagreed with it in their own writings on the subject. [See, A Review of Economic Doctrines, 1870-1929 (Oxford: Clarendon Press, 1953), p. 165].}
were allowed a major role in such decisions. On this and several other points, Cheysson's criterion for individual investment decisions resembles the Keynesian concept of the "marginal efficiency of capital." In the General Theory, Keynes described the marginal efficiency of capital as a ratio which is found by relating the expected future return from an investment to the current income that would have to be sacrificed in order to make the investment. \(^{44}\) Keynes laid great emphasis on the following points concerning the marginal efficiency of capital:

1. It depends on the rate of return expected to be obtainable on money invested in a new asset; not on the historical result of what an investment has yielded on its original cost if we look back on its record after its life is over.

2. It concerns the increments of value due to the employment of one more value unit of capital rather than increments of physical product due to the employment of one more physical unit of capital.

3. It is a ratio, not an absolute quantity, and it is based on the series of increments which a quantity of capital is expected to obtain over its whole life, not just the increment of value obtainable by using an additional quantity of capital in the existing situation.

4. The current return to capital which enters into the supply price of output has no close connection with its marginal efficiency. Likewise, the aggregate current return to capital has no direct relationship to its marginal efficiency.

Theoretically, Cheysson's argument states that a proposed investment in fixed capital should be undertaken if, and only if, the expected rate of future return from the investment exceeds the current (internal) rate of return on existing investment. It appears consistent with the above points stressed by Keynes. Some elaboration of the fourth point is required, however, if the significance of Cheysson's conclusion is to be fully understood. Although the current return to capital which enters

into the supply price of output has no close connection with the marginal efficiency of capital in a **deterministic sense**, it is by comparison of the expected future rate of return with the current internal rate of return that Cheysson reaches his conclusion on the desirability of new investment. Keynes, on the other hand, compared the marginal efficiency of capital to the current market rate of interest, which may or may not be equal to the current internal rate of return. Insofar as Cheysson's model neglects to consider the market rate of interest as the true opportunity cost of a potential investment of fixed capital, it is open to criticism. If the current market rate of interest is either above or below the current internal rate of return, then the former is the relevant basis of comparison for determining the desirability of a new investment. Cheysson's analysis therefore holds only if the current market rate of interest equals the current internal rate of return, or if the entrepreneur has no access to the loan market. In the latter instance the internal rate of return would represent the relevant opportunity cost of the new investment.

Despite this deficiency, it seems fair to credit Cheysson with an anticipation of the marginal efficiency of capital concept. Keynes was the first to admit that this concept was not new, and by his own admission, its roots are to be found in Marshall and its analogue in Fisher's *Theory of Interest*. 45

45 *Ibid.*, pp. 139-141. The identity of Keynes' "marginal efficiency of capital" and Fisher's "rate of return over cost" has been challenged by A. A. Alchian, in "The Rate of Interest, Fisher's Rate of Return Over Costs and Keynes' Internal Rate of Return," *American Economic Review*, XLV, No. 5 (December, 1955), pp. 938-943. Joseph Conard finds Alchian's analysis "interesting and important," but believes that "under the simplifying assumptions which both Keynes and Fisher were making these concepts are identical and were similarly used." [*An Introduction to the Theory of Interest* (Los Angeles: University of California Press, 1963), p. 76].
No doubt earlier anticipations of the same principle can be found in the history of economic analysis. Nevertheless, Cheysson seems to have been the first economist of record to employ the same idea, or at least a remarkably similar concept, in a geometric model of considerable analytical proportions.

It should not be assumed that Cheysson went any farther than suggesting the use of an internal rate of interest as the logical basis for a single-investment decision. He did not, as did Keynes, attempt to construct an investment demand curve; nor did he propose, as did Kenneth Boulding, that what the rational entrepreneur seeks to maximize over the life of any investment is this internal rate of return. Cheysson's internal rate of return, like Keynes' "marginal efficiency of capital," applies to a particular kind of an investment account, notably a fixed asset. The use of this internal interest rate as a basis of comparison with other rates, either internal or external, does not imply that maximization of the internal rate is the goal of economic activity over time. It was established earlier that to Cheysson, profit maximization represented the short-run goal of economic activity, and nothing in his conception of investment decisions over the long-run challenges this position.

This point is emphasized here in order to extricate Cheysson from the extensive debate in the 1930's and 1940's over what it is that entrepreneurs seek to maximize over time. Principal participants in the debate


47Traditional price theory, of course, assumes profit maximization as the rational goal of economic enterprise. But most of what has been written on the theory of the firm excludes the element of time, and in a "timeless" economy there is no room for the "internal rate of return." Profit maximization over time must be redefined as maximization of the difference between the present value of a future cost stream, both found by discounting at some rate of interest.
were Paul Samuelson and Kenneth Boulding. The latter maintained that "the magnitude which the perfectly rational and perfectly foreseeing investor wishes to maximize is . . . the internal rate of return," defined as the discount rate which makes the present value of a future stream of revenues derived from a single investment equal to the present value of its cost stream. On the other hand, Samuelson asserted that total profits is the proper magnitude to be maximized, where this magnitude is defined as the present capitalized value of the investment account, discounted at the market rate of interest. F. A. Lutz later showed that the different magnitudes produced different results in an actual investment situation, and that Samuelson's criterion is the proper one so long as a loan market exists and entrepreneurs have unlimited access to that market--provided, of course, they can pay the going rate of interest.

Cheysson on Product Variation and Quality Competition

Prior to the publication of E. H. Chamberlin's *Theory of Monopolistic Competition* in 1933, traditional economic theory had offered little on the role of product variation in the determinateness of individual equilibrium. Instead, equilibrium analysis focused on price and output adjustments in markets of homogeneous goods of fixed quality. It would be naive to assert that product differentiation was non-existent or historically unimportant before the appearance of Chamberlin's probing thesis; yet it is

obvious that quality considerations had not become an integral part of the theoretical framework of partial analysis before this date. To a considerable extent, this is still true.

It is somewhat surprising, therefore, to discover that questions of product quality and product variation did not escape Cheysson's attention; and that he made an early and successful attempt to discover how, under certain assumptions, a firm reaches "product" equilibrium when its productive capacity is sufficiently flexible to permit the manufacture of several types of products of various quality. At the same time, he recognized the desirability of a competitive firm's ability to vary its product in order to protect itself against cyclical fluctuations in prices of raw materials or manufactured goods. In "La Statistique géométrique" Cheysson wrote:

Let us . . . consider the manufacturer whose workshop is set up in such a manner that he is able to manufacture, indiscriminately, several types of products. There is, for example, in the plant a cloth spinner and a weaver who are both free to produce thread of varying degrees of fineness and fabrics of different weaves. Thus there is a certain amount of flexibility in the manufacturing process. The manufacturer must capitalize upon this flexibility if he is to maximize net returns and profit from fluctuations in the prices of raw materials and manufactured goods.51

With this passage as a preface, Cheysson developed a simple mathematical model for choosing among alternatives the most profitable product, given the cost of raw materials for each product and the technical limits of production. In this model, all production costs, with the exception of raw material costs, are assumed constant and independent of the type of good manufactured. The time period relevant to the analysis is a short period (i.e., one day) in which there is sufficient time for some rather basic adjustments by entrepreneurs: the firm's product is held capable

of considerable modification, but the possibility of changing over to a radically different type of product with altogether dissimilar uses and attributes is excluded. Differentiation in product is of the "vertical" type.52 This implies two things: (1) "higher" or "lower" quality comparisons can be made such that, for a given set of prices, improvements in quality are considered preferable by all buyers; and (2) such improvements entail greater cost. Product differences due to location or innovation are not considered, and it is assumed that quality changes by one firm do not elicit similar changes by other firms. For each variety of product, the amount demanded is limited and is defined by the fixed conditions with respect to the nature and price of substitute products and the price of the product in question. The actual market price of each product is assumed by Cheysson to be an external variable; the firm is assumed to have no control over price, which differs for each product, reflecting qualitative differences and presumably, industry supply and demand conditions.

In Cheysson's example, vertical variability is restricted to a single dimension, such that quality is variable only in one respect, is continuously variable, and for every level of quality there is a different, and only one, cost function. Qualitative changes alter the costs of production, but only that part of costs represented by raw materials. It is assumed that the costs associated with qualitative changes can be measured, but Cheysson does not necessarily assume that qualitative differences themselves can be measured, thus avoiding a host of practical and theoretical difficulties.53 The reasoning throughout assumes that entrepreneurs

52 This term is attributed to Lawrence Abbott ["Vertical Equilibrium Under Pure Quality Competition," American Economic Review, XLIII, No. 5 (December, 1953), pp. 826-845].

53 E. H. Chamberlin has observed that "... 'product' variations are very often qualitative, rather than quantitative, and in this case cannot
desire profits, have perfect knowledge, and act rationally. Finally, pure
competition obtains throughout, and output is equal to sales in every case.\footnote{As Chamberlin has indicated, "slight differences in product are not
inconsistent with pure competition, provided that \textit{for each variety} there
be a large number of producers competing in a single market." \cite[op. cit., p. 72 n.]{Chamberlin}}

The profit function for the firm in Cheysson's example is assumed to
be linear, and is given by the equation: $B_i = V_i n_i - p_i n_i - F$, where "$i$" takes
on values from 1 to 5 and,

\begin{align*}
V &= \text{sales price per unit produced.} \\
n &= \text{number of units manufactured each day.} \\
p &= \text{cost of the raw materials for each unit produced (i.e., the sum of the cost of each raw material, say cotton and wool, which enters into the production of one unit of output).} \\
F &= \text{the constant which represents daily manufacturing and general costs, but does not include the cost of raw materials.} \\
B &= \text{daily profits.}
\end{align*}

The problem is to choose the single product which maximizes $B_i$, given the
actual sales price in each case. Theoretically, the relationship between
any two of the variables indicated may be examined while the remainder are
held constant. Thus, as a starting point, Cheysson assumed that the firm
knows the (constant) price it must pay for each raw material and the propor-
tions of each raw material required for the production of each unit of
the various goods in question.


\footnote{As Chamberlin has indicated, "slight differences in product are not
inconsistent with pure competition, provided that \textit{for each variety} there
be a large number of producers competing in a single market." \cite[op. cit., p. 72 n.]{Chamberlin}}
Total daily output for each product may be assumed fixed by the technical limits of production. Presumably, improvements in product quality are achieved only by sacrificing some output, since different machine times will be required for different products. In fact, Cheysson's diagram is accurate only if it is assumed that successively higher quality choices lead to successively smaller daily outputs. Cheysson glossed over this fact, however, by stating merely, that "we will know the quantities of ... n for each kind of thread." 55

With p and n as parameters in each case, the profit equation reduces to a first-degree equation in two variables, V and B. This equation enables us to trace out the upward-sloping lines in Figure 5-7 for each kind of thread, numbered 1 to 5. These lines depict the relationship between the sales price for each unit of product and the amount of profit derived daily from the sale of n units of each product. Each line has a different slope because of the higher marginal costs of producing thread of better quality. 56

Given the actual market price for each product, Figure 5-7 reveals the most profitable product to produce. It is possible, however, that the firm be indifferent as to its choice of product. Thus, Cheysson observed:

This graph shows us how we can regulate the manufacture of goods according to the sales price. It shows, for example, that it is equally advantageous to sell thread no. 5 at 6.25 francs as thread no. 4 at 5.09 francs; thread no. 3 at 4.20 francs; thread no. 2 at 3.25 francs and thread no. 1 at 2.15 francs. The spinner will do best to adopt the most lucrative alternative in relation to price; that is to say he should adopt the most profitable product to manufacture. 57


56In the profit equation, \( B_i = V_i n_i - p_i n_i - F \), \( B_i \) takes on different values for different values of V, p, and n. Thus, "each kind of thread (or fabric) will be represented by a line of different slope which expresses the progression of profits realized by each product in relation to its respective sales price." [Cheysson, loc. cit.].

57Ibid., p. 206.
Figure 5-7

PRODUCT DIFFERENTIATION
AND PRODUCT EQUILIBRIUM
Other market prices may present a more clearcut choice. If, for example, the prices in the following table are observed for each product, Figure 5-7 will immediately reveal the daily profits associated with the sale of a given amount of each product, and consequently, the most profitable choice of product.

Table 5-1

PRICES AND DAILY PROFITS FOR VARIOUS PRODUCTS

<table>
<thead>
<tr>
<th>Product</th>
<th>Observed Sales Price</th>
<th>Daily Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>2.33</td>
<td>4</td>
</tr>
<tr>
<td>No. 2</td>
<td>3.80</td>
<td>5</td>
</tr>
<tr>
<td>No. 3</td>
<td>5.28</td>
<td>6</td>
</tr>
<tr>
<td>No. 4</td>
<td>6.00</td>
<td>4</td>
</tr>
<tr>
<td>No. 5</td>
<td>6.25</td>
<td>2</td>
</tr>
</tbody>
</table>

The most profitable product in this case is thread no. 3. Different market prices for each of the products may, of course, lead to different solutions, as will different raw materials prices, wages, etc. The whole point of Cheysson's analysis is that by maintaining flexibility in the production process, the firm can adjust its product selection, in the very short-run, to offset cyclical price fluctuations, at least within certain limits.

58"If the price of raw products . . . varies, we then have to deal with variables, V, B, and p. The problem must then be treated by three-dimensional statistical procedures; that is to say, we will have to set up a special table for each new price of cotton or wool . . . . We would also proceed in the same manner, if instead of raw materials, wages or general costs varied." [Cheysson, loc. cit.].
Cheysson's analysis rests upon a set of highly restrictive assumptions and is therefore severely limited in scope. Nevertheless, it represents an original and important step in the progress of ideas on the economic role of product variation. Moreover, recent examinations of quality decisions have relied on similarly restrictive assumptions. For example, Lawrence Abbott has pointed out that one form of pure competition exists when the sales price for a product is uniform and firms may vary output and quality. Abbott examined equilibrium adjustments for a firm operating under pure "quality" competition by studying the relationship between product changes and the costs associated with them in a single-price market. He recognized, correctly, that qualitative changes in such a market would not be profitable unless they stimulated an increase in sales. Thus, short-run equilibrium would occur when the firm chose that combination of product quality and its associated costs which, in relation to a given price, would maximize profits.

Cheysson's model compares favorably with Abbott's both in general approach and results. Like Abbott, he investigated the relationship between product quality and its associated costs. In Cheysson's model, too,

59Not all of the assumptions stated earlier were explicitly set forth by Cheysson, but at the same time, nothing in the presentation of his model is inconsistent with the assumptions described. More than a few of the assumptions necessary to the validity of Cheysson's analysis were indicated by a study of more recent investigations of the problem. [e.g., Chamberlin, op. cit., pp. 74-81, and "The Product as an Economic Variable," Quarterly Journal of Economics, LXVII, No. 1 (February, 1953), pp. 1-29; Stephen Enke, "Profit Maximization under Monopolistic Competition," American Economic Review, XXXI, No. 2 (June, 1941), pp. 317-326; Brems, Quarterly Journal of Economics, LXII (1948), pp. 418-440; Abbott, op. cit., pp. 826-845; and Robert Dorfman and P. O. Steiner, "Optimal Advertising and Optimal Quality," American Economic Review, XLIV, No. 5 (December, 1954), pp. 826-836].

60Abbott, loc. cit., p. 826.
equilibrium occurs when the firm selects the combination of product and costs which maximizes profits. An important difference is that Abbott discusses the case in which price is fixed regardless of product and only output and "product" are allowed to vary; whereas Cheysson was concerned with the case where output is given for each product while price and "product" are allowed to vary.

The chief advantage of Cheysson's model is that it provides useful insights into the kind of adjustments other than price and output changes which are found in markets where both prices and products are free to vary. Moreover, in Cheysson's model, price and output changes are linked directly to quality variations in product. This last link is, however, loosely established in Cheysson's model, and as such constitutes one of the major weaknesses of his analysis. But even so, Cheysson's attempt at explaining product equilibrium provided a theoretical framework for examining this much-neglected aspect of competition. Alternative, but not very different, frameworks were provided by Chamberlin and Abbott at a later date. Chamberlin was aware of the problems which underline the weakness in Cheysson's analysis. He stated that, "the clumsiness of representing 'product' variation graphically makes it impossible to summarize the whole adjustment in a single diagram." He therefore determined optimum price and optimum product separately, then asserted that the case where the seller is free to vary both "... is a simple matter of addition." By contrast, Abbott was able to isolate and describe the nature of output and product adjustments in a competitive firm, but he did so by sacrificing price as a variable.

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62 Loc. cit.
Recent attacks on the problem of product variation have made some progress in integrating into traditional economic theory the optimizing principles for equilibrium in the three-variable case: price, output, and product. But in view of the current state of knowledge in this particular area, Cheysson's attempt to describe "product" equilibrium, even under highly restrictive assumptions, remains a useful first approximation.

In concluding this chapter it is important to note that Cheysson forged several unique tools for analyzing certain aspects of production which had received little prior attention. His analysis of factor substitution, of investment decisions, and of product variation, in particular, offered several original insights into the theory of production. Outside of the applied fields, these tools showed promise for the general direction of neoclassical production theory. Yet it was only much later that economic theorists returned to some of the questions which had preoccupied Cheysson earlier.

CHAPTER VI

AN OVERALL VIEW OF CHEYSSON AND HIS CONTRIBUTIONS

Cheysson as Economist and Engineer

This dissertation has shown that Cheysson made important and original contributions to the economic theory of the firm, especially in the applied fields. His development of analytical tools was not always as complete as his predecessors', or as Marshall's, who is generally considered the master of partial analysis. Nevertheless, Cheysson understood managerial behavior from personal experience, and he revealed a unique talent for solving economic problems of practical importance. In this, his engineering training served him well. During the nineteenth century the engineering profession was especially esteemed in France, and as Alfred Marshall has observed, "there is perhaps no other country in which the ablest lads are so generally inclined towards it."¹

From a methodological standpoint, Cheysson approached economics, as we know it, on two different levels. As a science, he felt the proper province of economics was the establishment of those principles which regulate the production and distribution of wealth. Mathematical principles are useful here, since production and distribution deal with variables, the quantifiable nature of which can generally be agreed upon. But as an art, economics deals with human behavior in the largest sense, as well as with

the institutions and customs which facilitate production and favor public prosperity. In this last area, mathematics is inadequate to handle the number and nature of variables which enter into the "social problem."

This line of thought is noticeably different from that followed by other writers in the neo-classical tradition. For example, Talcott Parsons has shown that in the economic writings of Alfred Marshall it is impossible to distinguish Marshall the economist from Marshall the sociologist. 2

Unlike Cheysson, Marshall's approach to economic theory was linked with his attempt to discover certain welfare measures. Dupuit and Walras approached economics in much the same way. Each considered man and society the true province of economics, but those neo-classical economists who have attained lasting stature in the history of economics attempted to extend mathematical analysis to the study of human behavior in order to make economics more scientific. It is here that Cheysson took issue with the rest. Economics, for him, remained essentially a moral science, not to be confused with "exact sciences," such as mathematics or physics.

It might be convenient to introduce here a dichotomy which Cheysson did not make, but of which he might approve. That is to treat his "La Statistique géométrique" not as a treatise on "political economy," in the sense that Cheysson thought of that term, but as a contribution to "managerial economics," or even "industrial engineering." This would tend to explain: (1) why Cheysson was careful in "La Statistique géométrique" to apply mathematics only to those economic relationships which were distinctly measurable and uncontroversial; (2) why he did not consider economics, as he knew it, adequate to describe his analytical method and therefore

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gave it a new name (i.e., "geometric statistics"); and (3) why "La Statistique géométrique" initially appeared in an engineering journal instead of a journal of political economy. The latter cannot be explained simply by the Paris Group's monopoly of the *Journal des Économistes*, since by 1887, two other economics journals had been established: *L'Économiste Français* and the *Revue d'Economie Politique*. The same convenient dichotomy might also explain why "La Statistique géométrique" attracted so little attention in France among those who called themselves "economists."

The more noteworthy writers on neo-classical economics (e.g., Marshall, Walras, Pareto, etc.) appeared to function simultaneously on two levels of inquiry: the abstract level of pure theory and the realistic level of social considerations. Cheysson was capable of functioning on both levels, but he always preferred the latter. As late as 1891 he admitted to Walras: "I have, as you well know, a personal penchant for the applications of mathematics and especially geometry to certain aspects of political economy ... but ... the reality and the gravity of problems of applied economics divert me from the more disinterested and abstract speculations of pure economics."

Apparently Walras abandoned hope of winning Cheysson over to the side of pure economics after this, and consequently, pure economics was denied more than a brief visit by Cheysson's analytical mind.

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3 Cheysson to Walras, April 24, 1891, *Correspondence*, II, p. 444.

4 In a letter to E. de Fagues, Walras said of Cheysson: "He is certainly devoted, in principle, to the new [mathematical] method. But he is professor at the School of Political Science where Mssrs. Léon Say and Paul Leroy-Beaulieu rule; most probably they proposed his candidacy to the political economy section of the Academy of Moral and Political Sciences ... and consequently, we cannot expect him to personally intervene in our favor." [Letter from Léon Walras to E. de Fagues, May 3, 1891, in *Correspondence*, II, p. 445].
Today there is little doubt that the kind of questions investigated by Cheysson in "La Statistique géométrique" are a part of "economic analysis," particularly in the narrow sense that term is given by contemporary French economists. One modern spokesman of the French viewpoint is Jacques Lesourne, Director of the Société d'Economie et de Mathématique Appliquées. He defines economic analysis as "a scientific method aimed at providing the executive staff of an enterprise with elements which can serve as a basis for their decisions." Lesourne's definition is interesting, as well as typically French, because of the prominence it gives to the engineering function and to the development of empirical information. It would appear that in this respect, the tradition begun by Cournot and kept alive by Cheysson is today more alive in France than ever.

Because of the originality of his analytical contributions, Cheysson remains an economist of the first rank. If the essence of what economists today call "econometrics" is the marriage of economic theory and statistical analysis, then Cheysson must be considered a precursor of modern econometrics. Schumpeter, at least, was unequivocal on this point, saying of Cheysson's "La Statistique géométrique" that, "Railroad costs and tariffs are only one of several subjects there dealt with in the true spirit of econometrics."

Cheysson's advances along these lines did not rest on measurement alone, but sought to combine both theory and statistics in the process of model-building. In this respect he is above the criticism levelled against purely empirical approaches which neglect theory, such as that taken by

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6 Schumpeter, op. cit., p. 949 n.

Although Cheysson's "econometric performance" was found lacking in the kinds of statistical techniques which are a part of the modern econometrician's tool-kit, much of the groundwork for future econometric studies was nevertheless laid in "La Statistique géometrique," in 1887. In the present study, Cheysson's contribution to econometrics was based primarily on his work with statistical demand and cost curves; although the spirit of econometrics, as Schumpeter noted, is in evidence throughout.

With regard to the determination of market and supply-area boundaries, Cheysson accented the work being done in Germany by Launhardt and devised new applications of the Launhardt technique. These applications had important implications for the development of transportation rate theory and logistics theory. The major problem in this part of Cheysson's analysis was the adoption of some rather restrictive assumptions, such as: transport rates proportional to distance, linear distances traveled between market points, etc. Such assumptions continued to be employed, however, by later writers who were considered "pioneers" in the same area of analysis.

On other fronts, Cheysson appears to have recognized the possibility of discontinuous price and output adjustments in disequilibrium, and his discussion of a stable equilibrium wage seems to be consistent with a kind of "cobweb-type" phenomenon, but not in the same sense as the original "cobweb-theorem" of Henry Schultz and others. The fact that Cheysson's analysis in this regard is consistent with a cobweb-type model does not, however, establish conclusively that Cheysson actually visualized

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such a model. In fact, Schumpeter may have "over-interpreted" Cheysson on this point. In the final analysis, the matter of Cheysson's "cobweb model of wages" is one of individual interpretation.

In his contributions to the theory of production, Cheysson rose to additional heights or originality. His analysis of factor substitution in a two-input model specifically allotted for "time" as a factor in the optimum period of production. Moreover, it appears to be the first attempt at graphical representation of the "Ricardo Effect." Similarly, Cheysson's examination of the economics of product quality and product variation was the earliest "sophisticated" treatment of that much-neglected aspect of price theory this writer has been able to find. On the theory of a single investment, Cheysson clearly indicated that such decisions are made at the margin, and he anticipated the importance of a kind of "marginal efficiency of capital" concept in the investment decision. All of these were objective contributions, and Cheysson made little or no effort to juxtapose his conclusions on a structure of welfare considerations.

This is the name which Hayek has given to the Ricardian proposition than an increase in wage levels in any country encourages the substitution of machine labor for manual labor [See F. A. Hayek, "The Ricardo Effect," Economica, IX, N.S. (May, 1942), pp. 127-152].

One minor exception is presented in Cheysson's discussion of additional fixed investment in the railroad case (Supra, Ch. V). In speaking of the increase in railroad traffic which would make additional capital expenditures profitable, Cheysson remarked: "Undoubtedly, this increase in traffic will only be obtained if the transportation rate is lowered; in other words, if the public is given a share of the gains derived from the capital improvements. This benefit will thus be divided between the manufacturer and his customers, with the share accruing to the latter becoming larger and larger under the influence of competition. Therefore . . . , ultimate price reductions can be desirable from the standpoint of public benefits received, capital improvements, and manufacturing progress." ["Geometric Statistics," p. 197]. There is here no clearcut concept of a specific welfare measure, however; only a vague idea that price reductions and output increases improve the public well-being.
Cheysson's contributions to economic analysis were not without flaws. In his development of micro-economic models he spent very little time explaining the theoretical bases for the relationships he used. Perhaps something was lost in the transition of his ideas from oral presentation to written exposition. More likely, however, this drawback stems from his almost complete reliance on observation. In constructing economic models, Cheysson worked within the confines of economic theory but relied upon empirical research to establish the economic relationships which he expressed by geometric curves. He did not always attempt to explain why certain relationships assumed the forms they did, but accepted them as descriptions of reality. This practice places an unusually heavy burden on Cheysson's readers, who must occasionally "fill in" certain gaps in the theoretical arguments which confront them. Several models presented in Chapter V represent cases in point. This shortcoming may have created a tendency on the part of Cheysson's more critical readers to dismiss his economic models out of hand, either as technically vague or incomplete. It is a conclusion of this study, however, that certain lacunae in Cheysson's analysis were the result of methodological peculiarities rather than lack of competence on Cheysson's part.

Overall, Cheysson's performance in "La Statistique géométrique" represents an important chapter in the history of neo-classical economics, rather than its current status as a mere footnote—and that only rarely. Many of the questions which Cheysson investigated in the nineteenth century have had a way of not infrequently cropping up again in the economic literature of the twentieth century.
Cheysson and Economic Policy

This study has not made a point of reviewing or analyzing policy prescriptions. Nevertheless, historians of economic thought often regard the link between an economist's theoretical performance and his policy proposals important. Where Cheysson is concerned, there appears to be no significant link between the two, and the lack of originality in Cheysson's policy proposals coupled with economists' preoccupation with such things accounts in no small measure for the curious neglect of his analytical accomplishments. Cheysson did not enlist his theoretical findings on the nature and operation of the firm in formulating policy proposals for society because he maintained the separateness of "applied economics" vs. "pure economics". By "policy," economists usually mean "public policy," whereas Cheysson's analytical achievements were directly related to the formulation of successful "business policy" from the standpoint of the firm.

Cheysson's utterances on public policy were basically conservative, and stimulated more by moral considerations than economic ones. His suggestions for social reform all had economic implications, however. Following LePlay, Cheysson asserted that the basis of economic progress is the attainment of "social peace," which implies close cooperation between the individuals of the family and between the economic factors of production. All of Cheysson's policy proposals aimed at strengthening social cooperation. Any policy which improved cooperation between the basic social and economic units in society was favorably received. Some specific proposals, such as the fight for testamentary freedom, originated with Le-Play; others with LePlay's followers. But in achieving social and economic reforms, Cheysson relied primarily on private initiative. For its part,
the duty of the state was simply to encourage the reform movement, subsidize various cooperative societies, and give good example in its relationship with government employees.

Cheysson's analysis of railroad costing and pricing has been favorably compared to similar studies performed by Dupuit, by Wilhem Launhardt, and by Clément Colson. But unlike them, Cheysson did not offer specific policy formulations based on his theoretical investigations. Dupuit based several policy proposals on his theoretical findings, as did Colson. Launhardt favored marginal-cost pricing and differential freight rates and opposed private ownership of railroads. In all this, Cheysson offers no parallel, yet his analytical contributions are capable of standing on their own merits. His reluctance to accept a priori explanations of human behavior undoubtedly fed his distrust of policies to improve economic welfare based on such explanations, so the dichotomy between pure theory and applied theory remained very real to Cheysson.

Cheysson and the Polemics of his Period

It was pointed out in Chapter I that Cheysson took an active part in discussion of the social and political issues of his day. His polemical writings are not without interest, since they provide additional insights into the totality of his thought.

One problem which consumed much of Cheysson's attention was the population question. Throughout the nineteenth century, France experienced a declining population, and in the latter part of the century she was in

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the throes of depopulationist fears. Although France had suffered war
casualties and even territorial losses, first in the Napoleonic Wars and
later in the Franco-Prussian Conflict, the major factor in its declining
population was diagnosed as an abnormally low birth rate. From 1821 to
1881, the number of live births in France fell from 57 per 1000 inhabi-
tants to 26. In 1885, France had the lowest birth rate in all of Europe.

Cheysson called the population problem "le péril national," and cited
the French laws of inheritance as a major cause of the declining birth
rate. He argued that the existing laws forced an equal division of wealth
among all heirs, in many cases breaking up an estate. This in turn, served
to limit the number of children families would voluntarily choose to pro-
duce. But in the recovery of testamentary freedom Cheysson saw more than
advantages for population growth. Under forced division, industry remained
extremely unstable and condemned to perpetual liquidation, so that a great
deal of invested capital was often sterilized.

France's population problem was a kind of Malthusian spectre in re-
verse. In fact, Cheysson attacked Malthusiansiam in several minor arti-
cles and population studies. According to Cheysson, the Malthusian pre-
scription of "moral restraint" was of no use in checking population growth,
since it is practiced "not by the poorer classes, who are very prolific,
but by the well-to-do classes who are systematically sterile." The
result is that population goes unchecked and the composition of the popula-
tion is altered in favor of "inferior" types. He also criticized Malthusian

11Émile Cheysson, "Observations sur l'Influence des Lois successorales
et Expansion de la Race, communication a la Société d'Économie Sociale,
seance du 10 Juin 1903," La Réforme Sociale, 5th Ser., VI (Dec. 16, 1903),
p. 889.

12Émile Cheysson, "Le Mouvement de la Population en France et a l'Étranger," La Réforme Sociale, VI (July 1, 1883), pp. 64-65.
population theory for abstracting from man's moral and productive faculties, and for neglecting the effects of emigration on population.  

Cheysson analyzed the cause of French sterility as economic and moral. He assumed that parents rationally calculate the benefits and the sacrifices of having children, and how many, and base their decisions on such calculations. Accordingly, the inheritance laws, as well as certain taxes, tended to distort the "cost" figure in such calculations. The state could therefore induce families to have more children by granting testamentary liberty, repealing certain taxes, and granting tax reductions to large families. On moral grounds, Cheysson felt that parents had to be made aware of their social responsibilities. He noted that, within limits, a country can choose between human capital and other forms, and that to sacrifice the future (i.e., restrict population) in order to increase present capital is both insane and ruinous.

Cheysson also engaged in polemics against socialism and against labor unions. Few could doubt Cheysson's zeal for labor reforms and his concern for the well-being of the worker, but he viewed strikes as destructive of economic progress and labor unions as inappropriate to modern industry.

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14 Cheysson, La Réforme Sociale, VI (1883), pp. 61 ff.


He criticized Marxian doctrines on two grounds: "First, they flatter the appetites, give vent to lusts, and are taken to heart more readily than the austere predications of duty and savings. Second . . . , they assume a scientific aspect which impresses gullible individuals."\(^{17}\) Cheysson found Marxian expletives on the misery of the worker in contradiction to economic facts. In a somewhat laborious appeal to history and statistics, he argued that labor's share of total output, in real terms, had constantly increased throughout the nineteenth century. \(^ {18}\)

These writings added little to the analytical contributions which formed the major interest of this dissertation, but they do testify to Cheysson's ability to marshal facts in the service of economic arguments, and this ability should be given considerable weight in an overall assessment of Cheysson's ideas.

Cheysson's Influence on the Progress of Economic Analysis

Cheysson's important contributions were not entirely overlooked during his lifetime. Walras, Launhardt, Pantaleoni and Colson were all familiar with his analytic performance. But Cheysson never received recognition of a lasting nature. His contemporaries referred only to specific parts of his analysis, without evaluating his entire program. Or they lauded his


"exceptional competence," but in a vague manner which did not reveal the true nature of his contributions.¹⁹

One contemporary of Cheysson, Henri St-Marc, offered a distinction between nineteenth-century French economists occupied with questions of finance and statistics and those devoted to political economy. St-Marc placed Cheysson among the former (although we have seen that he had a foot in both camps), and added that in this regard, "... [his] works are universally utilized and admired, perhaps more so in Germany than elsewhere."²⁰ Yet one fails to discover any lasting influence of Cheysson's analytical contributions on German economic thought, and only Launhardt saw fit to praise Cheysson's analytic achievements.

In large measure, Cheysson was a victim of his own methodological convictions and the intellectual environment of nineteenth century France. His analytical contributions were not likely to receive much attention by the economic orthodoxy in France. Outside of France, those who thought Cheysson's work important (e.g., Launhardt, Pantaleoni) were members of the mathematical school which held up Walras as its leader. Ironically, several members of this group, including Walras, felt that Cheysson had much to contribute to the scientific advancement of economics, and would have welcomed him as a member.²¹ Cheysson's stubborn refusal to join them did not endear him to Walras. And the theoretical stagnation which marked

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¹⁹e.g., Cossa, op. cit., p. 390; Colson, loc. cit., pp. 167-168.
²⁰St-Marc, op. cit., p. 119.
²¹Cf., letter from Wilhem Launhardt to Léon Walras, February 19, 1887, in Correspondence, II, p. 193; and letter from Maffeo Pantaleoni to Léon Walras, July 18, 1890, in Correspondence, II, p. 417.
French economics not only denied Cheysson a ready audience in France, but undoubtedly stifled further significant achievements in pure economics on his part. Meanwhile, the Lausanne School carried the day, and peak performances were turned in by such twentieth-century writers as Pareto and Fisher. Somehow, Cheysson's contributions were lost sight of in the onslaught.

Recognition of Cheysson's work by writers of this century has been extremely rare. Staehle and Schumpeter were moved to credit Cheysson with an anticipation of econometric model-building, and Schumpeter further credited Cheysson with original contributions to the theory of wages, transportation, spatial economics, and product variation. But modern treatments of Cheysson's economics, including Schumpeter's, have been extremely superficial. It is hoped that this dissertation has helped to tip the scales in the opposite direction.

Regardless of Cheysson's future place in the history of economic analysis, there is merit in studying past contributions precisely because the past is still with us. Economic problems may change through time, as may solutions to economic problems. But analytical methods of the past continue to provide insights into solutions to present and future problems. Since economics is not the result of a straight-line progression of knowledge from primitive times to the present, "lost" contributions or those held in abeyance for long periods of time represent detours in the path of economic theory. Hopefully, investigations of these detours will provide economists with a perspective for avoiding future digressions. Precisely because of this, economists can still learn from their earlier counterparts, including Emile Cheysson.
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APPENDIX I
A BIBLIOGRAPHY OF ÉMILE CHEYSSON'S ECONOMIC WRITINGS


1This bibliography is in chronological order and includes both books and articles. All titles have been translated for the convenience of the reader. Those articles translated expressly for this study also appear in the general bibliography.


APPENDIX II
SOME LESSER-KNOWN CONTRIBUTORS
TO MATHEMATICAL ECONOMICS


JULES DU MESNIL-MARIGNY (1810-1885), a French economist, former student at the École Polytechnique, and member of the Société d'Économie Politique, was the author of several books, including: Économie politique devenue Science exacte (1859); Les libres Échangistes et les Protectionnistes Conciliés, ou Solution complete des principales Questions économiques (1860); and Catechisme de l'Économie politique basée sur des Principes rationnels (1863). Himself a mathematician, du Mesnil-Marigny had befriended the younger Walras and had encouraged his interest in mathematical economics.

MATHIEU WOLKOFF (1802-1874), was born in Russia and remained there as professor of political economy at the St. Petersburg School of Civil Engineering until 1853, when he moved to Paris. He was a member of the Société d'Économie Politique and frequently contributed articles to the Journal des Économistes. He is noted especially as a disciple of von Thünen, having translated the first part of Thünen's Isolierte Staat into French in 1857.
G. FAUVEAU (????-??), former student of the École Polytechnique, contributed a number of articles to the Journal des Économistes in which he applied mathematical reasoning to economic questions on the theory of value, taxation, and money. Fauveau authored one book entitled, Considerations mathématiques sur la Théorie de l'Impôt [Paris: Gauthiers-Villars, 1864], in which he introduced the calculus of variations into economics for the first time. In 1867 he published an article in Journal des Économistes entitled, "Considerations mathématiques sur la Théorie de la Valeur," in which he discussed and extended Cournot's work, extending his theory of monopoly to the case where the product to be sold deteriorates over time. He also discussed Cournot's duopoly theory from the standpoint of various aspects of imperfect competition.

J. DE LA GOURNERIE (????-??), is mentioned by D. P. Locklin in his survey of the literature on railway rate theory [Quarterly Journal of Economics, XLVII (February, 1933), p. 181], for his Études économiques sur l'Exploitation des Chemins de Fer, and in Pantaleoni's Pure Economics for the same work. Beyond that, it is difficult to identify de la Gournerie owing to his total absence from standard reference works. He was probably an administrator rather than an economist. Cheysson's analysis of profit maximization under monopoly conditions (the railroad case) resembled de la Gournier's to some extent.

WILLIAM WHEWELL (1794-1866), was primarily a philosopher and a mathematician, and published his major works in these fields. But he was also one of a small group of British authors who made contributions to the early development of mathematical economics. Moreover, according to R. D. Theocharis,
"he was more than a translator of existing doctrine into mathematical language ... his first approximation to a solution of the problem of the dynamic stability of equilibrium" was "really noteworthy." Whewell spent his entire academic career at Trinity College, Cambridge, and was appointed Master of that college in 1841. His contributions to mathematical economics are contained in volumes 3, 4, and 9 of the Cambridge Philosophical Society's Transactions.

JOHN TOZER (1806-1877), was a lawyer by training and profession. In 1839 he became a Cambridge fellow and he contributed much to the Transactions of the Cambridge Philosophical Society throughout his life. Two of the articles he contributed are of interest for economics and both have been listed in Jevons' bibliography of mathematico-economic writings: "Mathematical Investigations of the Effect of Machinery on the Wealth of a Community in which it is Employed, and on the Fund for the Payment of Wages" (1838); and "On the Effect of the Non-Residence of Landlords, etc., on the Wealth of a Community" (1840). Both articles appeared in the Transactions, volumes 6 and 7.

HENRY D. MACLEOD (1821-1902), was of Scottish origin; he graduated in 1843 from Trinity College, Cambridge, with honors in mathematics. He later became a bank director and wrote several noteworthy books on the theory of credit and banking. His Elements of Political Economy appeared in 1856 and his History of Economics in 1896. Macleod was a lawyer by training and a self-made economist. According to L. H. Haney, "Macleod's one great idea is that economics should be made a science of exchanges and deal exclusively in exchange value." He is reputed to have influenced the French economist,
Chevalier, and the Italian, Pantaleoni, as well as Jevons and perhaps, Walras. Hayek says of Macleod that his discussion of the theory of value "... had glimmerings of ideas which were later developed by the marginal utility and the mathematical school."

KARL H. RAU (1792-1870), was born and educated at Erlangen and became professor of political economy at the University of that city in 1816. In 1822 he was called to the chair of economics at the University of Heidelberg. He later enjoyed a career as statesman as well. According to Haney, Rau does not merit attention so much for original contributions to theory as for effective exposition. His Lehrbuch der Politischen Ökonomie (1826) was tremendously successful both at home and abroad, perhaps in part because it was adapted to the needs of the statesman and financier.

LUJO BRENTANO (1844-1931), was born in Frankfurt into a talented family of poets, writers, and philosophers. Brentano himself received a law degree from the University of Heidelberg and later, a degree in economics, having written his thesis on von Thünen's theory of distribution. Early in his career as an economist, Brentano served under Ernst Engel in the Prussian Statistical Office. Later he taught at a number of German universities, including Berlin, Breslau, Strasbourg, Vienna, Leipzig and Munich. The two major problems with which Brentano was concerned in his writings were the improvement of the wage-earner's lot and the preservation of harmony between capital and labor. Herbert Kisch has noted that "Brentano was neither an original theorist nor an economic historian whose basic research opened new vistas of the past." Yet he was influential as a social scientist largely because of his talents of exposition and popularization.
WILHELM LAUNHARDT (1832-1918), a German engineer, has only recently begun to receive the recognition due him as an original thinker and mathematical economist. Neither Palgrave's Dictionary nor the Encyclopedia of Social Sciences mentions his name, although the new International Encyclopedia of the Social Sciences in some manner offsets the neglect of its predecessors. Launhardt spent most of his life in Hanover, where he taught highway, railroad and bridge construction at the Technological School of Hanover. He made important contributions to welfare economics, to pricing policies for public utilities, to industrial-location and market-area analysis, and to transportation-engineering economics. In addition, his Mathematische Begrundung der Volkswirtschaftslehre (1885) gave the Austrian theory of subjective value a mathematical formulation, in this resembling Walras. By virtue of his professional training and his contributions to economics, Launhardt had much in common with Cheysson.

GEROLAMO BOCCARDO (1829-1904), was appointed professor of economics at the University of Genoa in 1860. He later became a statesman and exercised a strong influence upon the social policy of Italy. On the whole, Boccardo belongs to the English Classical School; Schumpeter calls his Tratto teorico-practico di economia politica (1853) "another Millian treatise," and "the answer to the student's prayer before exams." Boccardo succeeded Francesco Ferrara as editor of the Biblioteca dell' Economista. Despite the mixed influences of the classical school, the Historical School, and of Herbert Spencer in Boccardo's thought, he nevertheless appreciated the new progress achieved in the application of mathematics to economics, and announced his intention to include in the Biblioteca such works as those of Cournot and Whewell. Probably of particular interest to Cheysson was
an article by Boccardo entitled "Lavori pubblici," in the Dizionario dell' Economia politica e del commercio (1857), [Vol. II, pp. 652-659], in which, according to Jevons, "the author treats excellently of the utility, profit, cost, etc., of public works" and investigates mathematically the relations of prime costs, interest, maintenance costs and return.

ALBERTO ERRERA (1842-1894), born in Venice of Spanish origin, was an economic historian and statistician who paid for his opposition to Austrian rule by spending three years in prison. Errera was professor of economics successively at Venice, Milan, and Naples. He is listed in Jevons' bibliography of mathematico-economic writings for his review of Walras' Éléments, which contains a summary of Walras' theory of exchange. Apparently, however, there are no other writings to distinguish him as an economist.

ANDREA ZAMBELLI (????-??), like Errera, is recognized here for a review of Walras' theory of exchange, equally unoriginal, which assumed the form of a (published) letter directed to Professor Errera. Very little is known of Zambelli's background and career, except that he was a professor of geometry at the Technical Institute of Venice.

ARTHUR T. HADLEY (1856-1930), distinguished American educator and social scientist, President of Yale University, associate editor of the Railroad Gazette (1887-89), and frequent contributor to the Yale Review, is best remembered for his Railroad Transportation, Its History and Its Laws (1885), in which he presented the theory of railway rates in mathematical form. Before assuming the position of President of the University, Hadley was professor of political economy at Yale, from 1883-1899. He also authored a general treatise in economics in 1896.
APPENDIX III
MATHEMATICAL PROOF

The Division of Market Areas when One Firm Enjoys the Natural Advantage of Alternative (Cheaper) Means of Transportation

Cheysson gives the equation for the circle in Fig. 4-2 as $AM_p = A'M_p'$, since at any point on the boundary, the condition holds that the total transport charges are the same for distance $AM$ as for $A'M$. In the above equation, $p$ and $p'$ represent the freight rates per unit distance from shipping points $A$ and $A'$, respectively. For convenience, we shall re-write $p$ and $p'$ as $p_1$ and $p_2$. The following equations are likewise given by Cheysson: $AA' = d$; $A'O = a$; $OM = R$; and $n = p_1/p_2$. The radius of the circular boundary is determined by the product of the ratio of freight rates ($n$) and the distance from shipping point $A'$ to the center of the circle ($a$). Thus, according to Cheysson, $OM = R = na$ and $a = \frac{d}{n^2-1}$. [See, "Geometric Statistics," p. 184 n.]. While this conclusion may be intuitively obvious, a more rigorous proof can be offered in clarification, and that is the purpose of this appendix.

In addition to the above equations, let $CA' = b$. Letting the vertical bisector $DD'$ represent the y intercept in an Oxy plane, $b$ is then seen as the distance from the origin to the shipping point $A'$, and is equivalent to $\frac{d}{2}$ in Cheysson's formulation.

**Proof:**

Following R. G. D. Allen, since the firms are $2b$ kilometers apart, $A$ is the point $(-b, 0)$, and $A'$ is the point $(b, 0)$. Since $M$ is a point $(x, y)$ on the boundary, then:
\[ AM = \sqrt{(x+b)^2 + y^2} \quad \text{and} \quad A'M = \sqrt{(x-b)^2 + y^2} \]

and \[ p_1 \sqrt{(x+b)^2 + y^2} = p_2 \sqrt{(x-b)^2 + y^2} \],

i.e., \[ p_1^2 (x^2 + y^2 + 2bx + b^2) = p_2^2 (x^2 + y^2 - 2bx + b^2) \]

Collecting terms and dividing through by \((p_2^2 - p_1^2)\), we have

\[ x^2 + y^2 - 2b \frac{p_1^2 + p_1^2}{p_2^2 - p_1^2} x + b^2 = 0 \]

as the equation referred to our selected axes. If we now write:

\[ c = \frac{2}{p_2 + p_1} \quad \text{b > b}, \]

The boundary is then seen to be a circle with center at \((c, 0)\) and with radius \(\sqrt{c^2 - b^2}\). [Cf., R. G. D. Allen, Mathematical Analysis for Economists, p. 81].

To derive Cheysson's conclusion, let \(z = \frac{p_2^2 + p_1^2}{2} \). Then,

\[ R = \sqrt{z^2b^2 - b^2} \]

i.e., \(R = b \sqrt{z^2 - 1}\). Since \(z = \frac{n^2 + 1}{n^2 - 1}\), then

\[ R = b \sqrt{\left[ \frac{n^2 + 1}{n^2 - 1} \right]^2 - 1} \]

\[ = b \sqrt{\frac{n^4 + 2n^2 + 1}{n^4 - 2n^2 + 1} - 1} \]
\[ \frac{\sqrt{n^4 + 2n^2 + 1 - n^4 + 2n^2 - 1}}{(n^2 - 1)^2} \]

\[ = \frac{b}{n^2 - 1} \sqrt{4n^2} = \frac{2bn}{n^2 - 1} = \frac{d}{n^2 - 1} \]

\[ R = na * \]

Q. E. D.

*This writer is grateful to Professor Sidney L. Carroll for providing the reconciliation of Cheysson's mathematical conclusion with that of R. G. D. Allen.*
VITA

Robert Francis Hebert, son of Robert M. and Shirley H. Hebert, was born in Donaldsonville, Louisiana, on April 2, 1943. He graduated from Ascension Catholic High School in Donaldsonville, Louisiana, in 1961, and received a Bachelor of Science degree in Business Administration, majoring in economics, from Louisiana State University in Baton Rouge, Louisiana, in January, 1965.

From February, 1965, through August, 1966, he pursued the degree of Master of Science in Economics at Louisiana State University. He served as a Teaching Assistant in the Department of Economics in the Fall of 1965, and was awarded the M. S. degree in August, 1966.

He was a graduate assistant in the Department of Economics from September, 1966, to May, 1968. During the Summer of 1967 he held a National Science Foundation Summer Internship at Louisiana State University; and from September, 1968, to May, 1969, he served as Instructor of Economics in that Department. From June, 1969, through May, 1970, he held an L. S. U. Graduate School Dissertation-Year Fellowship. He is now a candidate for the degree of Doctor of Philosophy at the August commencement.
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Major Field: Economics

Title of Thesis: "A Critical Evaluation of Emile Cheysson's Contributions to Economic Analysis"

Approved:

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