Ferry Between the East and the West: Mathematical Economics in the Communist Hungary[1]

Gergely Kőhegyi (gergely.kohegyi@uni-corvinus.hu)

Corvinus University of Budapest

János Mátyás Kovács (janos.kovacs@univie.ac.at)

University of Vienna

Introduction

This paper revolves around the puzzle of sluggish Westernization[2] of economic thought during the communist period. Why did neoclassical economics that Hungarian economists of Marxist persuasion started tasting at the end of the 1950s strike roots only after 1989 in a country that gave the world János Harsányi, Miklós Káldor, and János Neumann, and was famous for having one of the least closed economic research communities and launching one of the most radical market reforms in the Eastern Block? In Hungary the first models describing the planned economy by means of mathematical (partly neoclassical) instruments were built already at the turn of the 1950s and 1960s and many of those instruments were taught at regular courses of the Karl Marx University of Economics in Budapest from the early 1960s. Simultaneously, a growing number of Hungarian researchers proudly followed in the footsteps of promising young scholars such as András Bródy and János Kornai who rapidly became renowned in the international arena of modern economics. Using the then globally accepted label, they named themselves mathematical economists (in contrast to the official designation "political economist"), and established special departments not only at research institutes and universities but also in major government agencies such as the Central Statistical Office and the Planning Office[3]. Both symbolic breakthrough and institution building was greatly facilitated by similar achievements of mathematical economists in the Soviet Union.

[1] This project had been financed by the Triple B (Between Bukharin and Balcerowicz. A Comparative History of Economic Thought under Communism) project and Western Impacts and Transfers in Hungarian Culture and Social Sciences in the 1970s and 1980s (Nr. 125374) OTKA research project.

[2] We use this term in descriptive sense in this paper.

[3] The department of mathematical economics of the Hungarian Economic Association, the only professional organization of economists in the communist era, was established in 1962.

Hungarian scholars with an interest in quantitative economic research published their own journal, Szigma[4], and engaged in a busy multilogue with their peers in both the West and the East. Transnational communication resulted in long research stays, guest professorships, joint research projects and publications, not to speak of prominent positions in international academic associations like the Econometric Society and the International Input-Output Association.[5] Why did this segment of the research community remain a minority in Hungary for about thirty years; a minority that – no matter how strong it was in scholarly terms – proved unable (or did not want?) to orchestrate a belated but genuine „neoclassical revolution?" How could mathematical economics thrive so long while resisting the temptation to join the neoclassical mainstream in the West? We contend that the answer to these questions is to be found not only in a competing enticement by market reforms that kept the majority of Hungarian economists within the realm of verbal ("old") institutionalism, but also in an initially irresistible attraction implied by the hope of comprehending the operation of the planned economy by means of input-output analysis and improving the former through optimal planning based on the latter. Obviously, any explanation relying on that attraction, though necessary, cannot be sufficient since it dwindled as years passed. The historian also must clarify why the research program of optimal planning worked as a trap, which was rather easy to enter but difficult to leave even though one had gathered enough experience about the failure of the program.

As so often in communist history, it would be easy to blame censorship (and self-censorship) for keeping economists in the trap for decades and/or not allowing them to walk out of it in a neoclassical direction, thereby delaying Westernization. Ostensibly, the rapid success[6] of neoclassical thought in the economic research community of Hungary after 1989 makes such an explanation more than plausible (Kovács 2002, 2012). It might seem that quite a number of gifted economists had already joined the "revolutionary movement" in a clandestine manner under communism and could not wait to make their coming-out at last. Undoubtedly, there were some dedicated neoclassical-minded theorists among the younger researchers

[4] It was first issued by the Hungarian Economic Association in 1968. Béla Martos served as its editor-in-chief until 1990.

[5] Bródy was one of the founders of the Association and Kornai was elected president of the Society in 1976.

[6] While one can have second thoughts about the quality of the neoclassical breakthrough, its quantitative indicators, ranging from journal articles through university curricula to East-West research projects, show a sweeping victory of mainstream economics imported primarily from the West (see Kaase and Sparschuh 2002).

during the 1980s, some of whom had an opportunity to familiarize themselves with the then mainstream economic thought at Western universities and bring back that knowledge to Hungary. They served as catalysts of a neoclassical awakening after 1989 while normally, members of the older generations of mathematical economists who had put their faith in optimal planning for a long time did not jump on the bandwagon of neoclassical triumph. Instead, they continued to carry out research in the field of mathematical economics lying, by and large, outside the neoclassical paradigm. They did so with dignity or by sadly licking their wounds.

Had they been scared by the censors back in the 1950s for good? One could hardly accept this assumption knowing that optimal planners experienced the weakening of political control in Hungary long before the collapse of communism and some of them even secured special privileges for themselves as advisors in the framework of a two to three decade-long cooperation with the party-state. True, historians must not disregard the recurrent intimidation of mathematical economists and their partial excommunication from official political economy throughout the communist period. Nonetheless, after a while, mathematical reasoning in economic sciences ceased to be a forbidden fruit with all the excitement of its consumption. In terms of the Kádárist triad of cultural policy pursued from the early 1960s, mathematical economics was not banned with hatred but became tolerated, and even supported by the authorities. To put it bluntly, Hungarian mathematical economists had a relatively good time in the trap of optimal planning for decades. They were convinced to have found not only a political and existential but also a scientific modus vivendi by tacitly abandoning Marxist-Leninist textbook political economy without joining the neoclassical mainstream. They trusted the authenticity and success of their own research program and considered it at least as valuable by scholarly standards as any similar program initiated in the West. Returning to the basic research question of this chapter, we would like to check the assumption that, following a brief phase of devotion, the majority of Hungarian mathematical economists did not want to turn into veritable neoclassical thinkers, quite sincerely so, driven – as time passed – by their scientific preferences rather than their political fears.

The first mathematical economists in Hungary were ready to make concessions without scruples by camouflaging (a) the divergence of their models that invoked an ideally technocratic vision of communism from the real world of Soviet-type planned economy, and

(b) the similarities between their theories and the neoclassical ones. As usual, self-censorship resulted in self-cheating once these scholars fell in love with their concepts of optimal planning, made virtue of necessity, and convinced themselves that a neoclassical turn would not only backfire politically but it also would be scientifically superfluous and even harmful. As if the grapes were sour, they resisted the intellectual appeal of neoclassical economics by picking and choosing some of its instruments but ignoring its underlying philosophy and methodology. Instead of recognizing it as a Grand Theory, they considered neoclassical thought as a collection of technical recipes, from which one chooses say, the principle of optimization without saying a single word of praise, for example, about price theory as such. More than that though, even a frontal attack like Kornai's Anti-equilibrium (1971) did not lead to excommunication from the profession in the West. You could safely claim that the basic concepts of neoclassical economics (a) are unrealistic and reflect an ultra-liberal worldview (b) do not offer the Eastern European economists an opportunity to comprehend their own economies better than your home-made theories; (c) are worth of replacing one extreme (state collectivism) with another (free-market individualism) rather than of returning to sobriety; and (d) these concepts deter the economists from searching for convergence in terms of both economic systems and theories describing them.

At any rate, can mathematical economics prosper outside (or on the edge) of the neoclassical paradigm? Considering the example of Hungary and a majority of communist countries, yes, it definitely can. At least, it could in the past, for a long time, resulting in theoretical discoveries and a whole range of experimental applications in the field of I-O analysis and optimal planning. However, while the analytical results were promising, the normative project of plan improvement failed following a series of trials and errors. Moreover, this project trapped many of its advocates even after the fiasco. Was it the "West" where the idea of general equilibrium slowly lost its popularity that opened their eyes? We rather assume that Hungarian mathematical planners got disappointed with the idea of optimization, more exactly, the idea of optimization in a Soviet-type planned economy, which failed exactly because it was tested in vivo in that very kind of economic system. Whether or not they, driven by frustration, used their mathematical knowledge to suggest a profound and authentic interpretation of that system is another crucial question to answer.

In order to assess the above conjectures, we will first sketch out the ways, in which mathematics infiltrated planning theory and practice in Hungary. Then, we will discuss the institutional preconditions of the evolution of planning concepts and focus on one important research organization, the Institute of Economics, Hungarian Academy of Sciences that hosted two leading mathematical economists, András Bródy and János Kornai at the same time.[7] They took different approaches to the theory of planning in the "triumphant" period of optimization of central plans but agreed on seeking the long-awaited Rational Solution primarily outside neoclassical economics. Finally, our chapter will examine why and how Hungarian mathematical economists lost their trust in the rationality of perfecting the planning regimes, and what other research program they chose instead.

Our study had to cope with the lack of secondary literature published by historians of economic thought.[8] We did our best to fill this gap by participant observation, numerous old and new interviews with our colleagues, memoirs, and archival sources. The reader is warned about possible biases since one of the authors (Kovács) was affiliated as research fellow with the Institute of Economics, a main research site of ours, for more than thirty years.

[7] As the reader will see, there is also a third hero in the story, Mária Augusztinovics, who would deserve a separate study. She was involved at each and every stage of research made by the two "pioneers" who probably would not have been able to reach the Parnassus of Hungarian economic thought without her help. A typical fate of an extremely talented female scholar, she was stuck willy-nilly on a lower level of scientific abstraction for a long time, striving to build optimal planning models in the Planning Office, even as late as the early 1980s. She could step out of the shadows of the two men only thereafter, when she switched to modeling life-cycles and pension systems. For a while, Augusztinovics was married to Bródy and was closer to him than to Kornai in terms of loyalty to Marxism.

[8] For example, Szamuely and Csaba (1998), thus far, the most detailed overview published on the history of Hungarian economic thinking in the communist period, devoted less than a page to mathematical economists. The literature is dominated by works, in which the main representatives of the discipline and their associates share their memories with the reader or offer a snapshot of a certain stage of evolution in their scholarly field. Typically, these are brief texts, including published interviews and obituaries. Important (and refreshing) exceptions are Bródy's long biographical interview from 1994 and Kornai's voluminous memoir from 2007 (2005). A 1996 conference on "legacy, emulation, invention" in economics, in which numerous scholars, old and young, who conducted research in mathematical economics in any phase of their lives, made presentations also proved a very informative source, see Csekő (1996), Csontos (1996), Kőrösi (1996), Nagy (1996), Pete (1996), Simonovits (1996), Vincze (1996). Although normally Péteri (1993, 1997, 2002, 2017, 2019) do not focus on the nexus between mathematical economics and planning theory per se, they give valuable insights, based on careful archival research, in the political and sociological environment of their development.

Traditions, Institutions, Experts[9]

After planting the seeds for mathematical research into central planning during the 1960s, economic sciences in Hungary seemed prepared to reap the first harvest by the 1970s. However, the first harvest also proved to be the last. The idea of rationality to be found somewhere outside the spheres of textbook political economy and reform economics (market socialism) began to fade away slowly but steadily.

The 1960s were still an unmistakable success story although the previous 10 to 15 years had been anything but promising. Even if anti-Jewish legislation before the Second World War, the war itself, and – following a few years of relatively peaceful academic activity – the total Sovietization of social sciences had not nearly eradicated economic theory (and mathematical research) in Hungary through murder, emigration, imprisonment, occupational ban, and marginalization, the contingent of economists with mathematical skills would have been very small. Like other countries in Eastern Europe, two main strands of tradition dominated economic sciences in Hungary before the war: the German Historical School and – to a lesser extent – the Austrian School of Economics. Simply put, the former was open to the idea of major state intervention, and even state ownership; the latter considered the introduction of central plans and collective property as large steps along the "road to serfdom." This ideological difference notwithstanding, both schools normally excluded formal models from economic analysis. The only areas where quantitative reasoning found acceptance were in the systematization of empirical data and rudimentary economic dynamics. Between the two wars, the followers of the German Historical School in Hungary celebrated the idea of planning and advocated a dirigiste economic regime, a "bounded" or "managed" economy, as they called their ideal of corporative state capitalism. They formulated the planning procedures in verbal (let alone, elementary mathematical) terms, and proposed that the institutional framework of the central plan be patterned after the war economy as they knew it from the First World War.[10]

---

[9] In preparing this section, we received useful research assistance from our students Dániel Baglyos, Barnabás Benyák, Zalán Cseresznyés, András Hetényi, Balázs Mayer, Tamás Sáfár, and Dániel Tordai.

[10] Admittedly, that pattern fell short of the organization of central planning in the Soviet Union in both width and depth. However, the leading economists of the time such as Károly Balás, Frigyes Fellner, Farkas Heller, Mátyás Matolcsy, Ákos Navratil, Tivadar Surányi-Unger, and István Varga (even those who preferred Austrian economics) did not regard planning as a derogatory term. For those among them who flirted with the national socialists or later with the communists this was a natural ideological gesture. However, cautious liberals like Heller or liberal

One does not know, of course, what would have happened to research into mathematical economics and its application to central planning in Hungary if scholars like János Neumann or Miklós Káldor had not left the country before the war.[11] Would they have survived and been permitted to work in the academia, particularly, in the field of planning doctrines? To take the example of game theory, could Neumann have launched his research program, teaching at a Budapest university from 1945 onward? Could Harsányi have developed the theory further during the 1960s if he had not left the country in 1948?[12] Similarly, would it have made a difference if the local forerunners of econometric research such as István Varga and Mátyás Matolcsy had not been silenced and imprisoned, respectively, after the communist takeover?[13] To put counter-factual questions aside, what is well-known is the sad fact that Varga was the only one from an older generation of eminent scholars who made a comeback in economic research during Hungary's communist era. Varga became influential for a short period around 1956, and at that time he focused on market reforms instead of experimenting with mathematical planning.[14] Those few who kept the fire of mathematical economics warm from before 1945, such as the econometricians Ede Theiss and Kálmán Kádas, were marginalized.

Communist (or social-democratic) economists, well-versed in neoclassical thought like Oskar Lange in Poland, lacking, the supply of mathematical methods in economic analysis emerged from other sources: a few Western textbooks and Soviet works, cooperation with local mathematicians (like Alfréd Rényi in the case of Bródy and Tamás Lipták in that of Kornai), and engineering education (Péter Erdős and Ferenc Jánossy). Many of the freshly-baked planning experts (such as Augusztinovics, Kornai, András Nagy and Márton Tardos) were self-made mathematicians.

---

socialists like Károly Polányi did not reject some kind of state planning categorically, not to mention Károly Mannheim with his eulogy of planning in general.

[11] Actually, Káldor had visited Hungary for some months at the turn of 1946/47 in order to advise the social-democrats but did not return there for about two decades. Then he paid only short family visits and gave lectures.

[12] Béla Balassa, who emigrated in 1956, wrote his first book in the United States exactly on the planning system of Hungary. Would he have become "another Kornai" if he had decided to stay?

[13] They were leading researchers in the Magyar Gazdaságkutató Intézet (Hungarian Institute for Economic Research) founded by Varga in 1927. On combining German-style institutional research with econometrics, see Varga (1947) and Theiss (1947).

[14] For a brief period following the 1956 revolution, Varga replaced Friss as director of the Institute of Economics.

Despite the unfortunate prerequisites to a solid development of mathematical economics, the seeds of the discipline slowly came to fruition. Research and education managed to profit from an ironic combination of two unrelated political factors in the second half of the 1950s: (a) the growing legitimacy of applying mathematical methods in economic research in the Soviet Union and (b) the impasse of reformist thought in Hungary due to the crushing of the 1956 revolution by the same Soviet Union. Let us now consider the domestic institutional and cultural preconditions of the turn toward the mathematics of planning.

Starting with scholarly publications, a growing number of foreign-language books and periodicals on mathematical economics became available in the libraries of the main institutes of economic research and Karl Marx University of Economics in Budapest from the late 1950s. The same applied to translated works. Edited collections of articles and book excerpts published in the West or popular guides to the new discipline such as Szakolczai (1963, 1967), Andorka, Martos, and Szakolczai (1967), Hoch (1968), and Andorka (1970) made the breakthrough. Translations of volumes written or edited by Soviet economists and mathematicians (e.g., Nemchinov 1962, 1966; Khachaturov 1966; Pontriagin et al. 1968; Petrakov 1970; Novozhilov 1971) were also helpful.[15] The books of leading Western authors followed suit. For instance, Jan Tinbergen's Econometrics came out in Hungarian in 1957, William Baumol's Economic Theory and Operations Analysis in 1968, Edmond Malinvaud's Méthodes statistiques de l'économétrie in 1974, and a truncated version of Paul Samuelson's Economics in 1976.[16] Meanwhile, important works by Oskar Lange (1965, 1966, 1967a, 1967b), Michał Kalecki (1980, 1982),17 and Wassily Leontief (1977, 1984) were published in translation. From the 1970s on, an avalanche of collections of papers written by other contemporary great theorists/Nobel laureates (such as Ragnar Frisch 1974, John Hicks 1978, Kenneth Arrow 1979, James Tobin 1984, Lawrence Klein 1986, Milton Friedman 1986, Gérard Debreu 1987, Miklós Káldor 1989) was launched by the Közgazdasági és Jogi Könyvkiadó

[15] At the time, many Hungarian economists understood Russian. They could read not only the works of Leonid Kantorovich or Viktor Novozhilov in their original but also, for example, the Russian translation of Leontief (1953, 1958) on the U.S. economy. Kantorovich's (1965) seminal book on the best use of economic resources has never been translated into Hungarian (cf. Simon and Kondor 1962, 1963). In the 1960s and 1970s, the similarity between the 1968 economic reform in Hungary and the NEP aroused interest among Hungarian scholars about the ideas of Soviet mathematical economists such as Grigorii Feldman, Nikolai Kondratiev, and others.

[16] The uncensored version of the book was released only in 1988.

[17] The translation of Zbigniew Pawłowski's Ekonometria in 1970 also demonstrates the remarkable influence Polish scholars exerted on their Hungarian colleagues. The same applies to the translation of the 1977 book by the Czech theorist Josef Goldmann on macroeconomic analysis.

(Economics and Law Publishing House). In some way, most of the prominent Hungarian mathematical economists and some of their disciples took part in translation and editing.

Numerous foreign authors spent some time in Budapest or met their Hungarian colleagues abroad.[18] Strong academic bonds emerged from these encounters (e.g., between Bródy and Leontief or Kornai and Arrow), not to speak of publications in excellent journals and publishing houses as well as prestigious collective volumes. Bródy's 1966 article in the Quarterly Journal of Economics, and Kornai's recurrent contributions to Econometrica (Kornai and Lipták 1962, 1965; Kornai and Martos 1973) set the bar very high.[19] The former published his books at North Holland and SAGE, the latter at North Holland and Oxford University Press.[20] Early on, they were invited to take part in edited volumes such as Bronfenbrenner (1969) in the case of Bródy; Malinvaud, and Bacharach (1967b) and Nove and Nuti (1972b) in the case of Kornai; and Bornstein (1975) in the case of Augusztinovics. The width of the stream of all these publications demonstrates not only the growing influence of Western (and, to a certain extent, Eastern[21]) scholarship on Hungarian economists but also the growing legitimacy of mathematical economics in the eyes of the authorities.

As will be shown, the domestic publications of Hungarian I-O scholars and optimal planners also started mushrooming in the 1960s and 1970s. The first English-language book on input-output analysis (Lukács et al. 1962)[22] was preceded or followed by a whole series of Hungarian-language works published, besides Bródy and Kornai, by Rudolf Andorka, Mária Augusztinovics, Péter Bod, Gusztáv Báger, Sándor Ganczer, Zoltán Kenessey, György Kondor, Béla Martos, Antal Máriás, András Nagy, Ferencné Nyitrai, Albert Rácz, András Simon, György Simon, András Simonovits, György Szakolczai, Márton Tardos, and others.[23] Later, when the

[18] Kornai still cherishes the memory of his debut in Western high theory when in 1963, he met Maurice Allais, Sukhamoy Chakrawarty, Frank Hahn, Leo Hurwicz, Tjalling Koopmans, Lionel MacKenzie, Edmond Malinvaud, Roy Radner, and Richard Stone at a conference in Cambridge (Kornai 1996).

[19] Since then, just a few Hungarian economists have succeeded in publishing in these journals (see Medvegyev 1984; Simonovits 1975, 1978).

[20] Martos (1975, 1990) was also published by North Holland that agreed on a joint publication project with the Budapest publishing house Akadémiai Kiadó.

[21] This was the only phase of communist history in which Hungarian scholars maintained strong links to leading Soviet and other Eastern European mathematical economists and insisted on publishing in Russian as well.

[22] For the first English-language review of the evolution of the new research program in Hungary, see Horvath (1963).

[23] Although these experts contributed to each other's edited volumes, joint articles were rare among them. For example, Augusztinovics, Bródy, and Kornai did not publish scholarly papers together despite the fact that they were good friends for a long time. For collective volumes, see, for example, Bod et al. (1962), Lukács et al. (1962), Juhász and Morva (1982).

trust in optimization diminished, scientific production did not decline but changed its face. The researchers diversified the models by including non-linear and dynamic analysis or engaged in long-term planning. Both research strategies resulted in important English-language volumes (e.g., Martos 1975; Augusztinovics 1984). As regards scientific papers, in the beginning, the main periodical of the economic research community Közgazdasági Szemle (Economic Review) was reluctant to publish articles with a complex mathematical apparatus, but this attitude softened during the 1960s. With the publication of the journals Szigma and Acta Oeconomica,[24] mathematical economics slowly became a standard discipline in Hungary by the 1970s. For example, Bródy's and Kornai's papers of mathematical relevance on intersectoral relations and optimal planning began to appear in Közgazdasági Szemle in the late 1950s; from then on, just about every important work by the two authors was published in both Hungarian and English.[25]

However, one genre of academic writing was forbidden to most leading research economists: the university textbook. With the exception of Bródy's (1962a, 1962b) textbooks on linear and stochastic programming and a brief chapter written by Kornai (1969) on mathematical methods of planning for a textbook published by Karl Marx University, the articles and books of eminent scholars in the field featured at most in the reading lists of certain courses (or among the informal recommendations by some teachers). Up until 1989, just two of the scholars listed previously was offered a regular professorial job at the University of Economics. In the best case, the others were allowed to hold a few lectures and smaller seminars (Bródy 1994, 328; Kornai 2007, 209–11).

Leaving the terrain of scientific publications and jumping back to the time of the communist takeover, planning theories (both verbal and mathematical) were developed in Hungary by and large under the aegis of four institutions: Karl Marx University of Economics, the National Planning Office, the Central Statistical Office, and the Institute of Economics at the Hungarian Academy of Sciences.

[24] This English-language journal was edited in collaboration with the Institute of Economics from 1966 onward.
[25] Nevertheless, in the beginning, they also had to publish in marginal bulletins run by industrial organizations or in "official samizdat" like the working papers of limited circulation, which were produced by various research institutes.

Karl Marx University: Teaching Mathematics, Ignoring Economics

Initially, Karl Marx University of Economics (Marx Károly Közgazdasági Egyetem) in Budapest was the only institution of higher learning that trained economists in Hungary.[26] Over time, the textbooks of political economy incorporated thoughts about market reforms, shortages, investment cycles, and so on, but even the textbooks published during the 1980s failed to discuss mathematical concepts of planning or other quantitative models in detail.[27] Although from 1961 courses were held and textbooks written on calculus, linear algebra, probability and statistics as well as operations research, the university relegated the theory of planning to the Department of Planning the People's Economy. This unit was small and had low prestige; initially, it completely ignored modern economics and, by and large, its textbook was a summary of what was taught by the Department of Political Economy about real socialism. It hardly included any information on the functioning of real-life planning regimes.[28]

Until 1960, the role of mathematics at the university was restricted to a simple repetition of high-school level basics (Forgó and Komlósi 2015). Even György Péter, an actuarial analyst who became president of the Central Statistical Office, asserted in the 1950s that the four basic algebraic operations would be more than enough for an economist to know (Augusztinovics 2008, 1164). He served as head of the Statistics Department of the university from 1950. In contrast, Béla Krekó, a disciple of András Prékopa – "father" of operations research and probability theory in Hungary[29] – and assistant professor at the Mathematics Department, was committed to introduce the paradigm of optimization in the education of economists. He had

[26] It was founded as Hungarian University of Economics in 1948 to offer a full-time degree program in economics. The Sovietization of the university during the late 1940s was crowned by renaming it Karl Marx University of Economic Sciences in 1953. In fact, until the late 1980s, it taught political economy instead of economics despite a surge of programs in mathematical economics.

[27] See, e.g., Hámori (1986). On the eve of the collapse of communism, low-quality experimental textbooks on micro- and macroeconomics were written by members of the Department of Political Economy (Váradi 2007).

[28] In 1972, students of planning theory (both verbal and mathematical) organized a strike against the course syllabus offered by the Department, and demanded to change the list of mandatory readings by replacing the official textbook with works of András Bródy, Ferenc Jánossy, János Kornai, Włodzimierz Brus, Jan Tinbergen, and selected authors from the Soviet 1920s and the Socialist Calculation Debate. The new textbook (Stark 1981) made a few insecure steps in this direction. On the development of research on mathematical economics at the Department, see Móczár (1980).

[29] Prékopa was a student of Alfréd Rényi (mentor to and friend of András Bródy, see below) who taught operations research to mathematicians from 1958. His main research area was stochastic programming. The research groups and departments in operations research headed by him at two Budapest universities and the Academy of Sciences became strongholds of education and background studies of optimal planning (Prékopa 2018).

futile discussions with the rectorate at the end of the 1950s. When he wanted to include game theory in the curriculum, one of its leading officials responded in an indignant style by saying, “Comrades, we have to preserve the university as a serious institution” (Forgó and Komlósi 2015, 3). Finally, Krekó was permitted to try out linear programming as an elective course with 20 to 30 students in 1959.

In 1961, he was allowed to invite the best 15 to 20 students in mathematics to take part in a new special program called ‘tervmatematika’ (mathematics of planning). In this five-year program 60 per cent of the courses were related to mathematics (calculus, linear algebra, cybernetics, mathematical programming, statistics, game theory, electrotechnics, and physics).[30] The program soon became popular, nurturing generations of mathematical economists. It launched a “deterministic” and a “stochastic” track. Although the program was also supervised by the Department of Planning, the planning courses were taught with hardly any mathematics. The term “neoclassical economics” popped up (if at all), followed by plain faultfinding comments, in lectures on the history of economic thought. The first textbook providing a general introduction into mathematical economics (including input-output analysis and a few neoclassical models) was not published until as late as 1989 (Zalai 1989).

Despite all efforts to the contrary, the quantitative methods courses remained theoretical because the university did not cooperate on a regular basis with either the Planning Office and the Statistical Office or the economic ministries. The courses were related neither to central planning nor to other important issues of macroeconomic research. Examples for optimization were rather taken from company life and referred to challenges such as which factors of production to purchase or how large an inventory to hold (Halpern 2020; Kőrösi 2020). The only textbook-like volume on models of long-term planning, written mostly by researchers at the Planning Office and translated into English and Russian (Augusztinovics 1979), was not taught at the university.

[30] The curriculum was reorganized many times. Besides Béla Krekó and Jenő Szép who held mostly the calculus, linear algebra and operations research courses, Margit Ziermann, a student and co-author of Prékopa taught stochastic processes, and György Meszéna mathematical statistics. Later Géza Denkinger and István Dancs also entered the Department and taught core mathematics courses, Ferenc Forgó joined Szép in teaching game theory and János Paizs econometrics. In order to strengthen the ties to economic applications, Krekó published textbooks for each and every course, which were linked by pivoting techniques that allowed the solution of economic problems through computer programming (see, e.g., Krekó 1972).

National Planning Office: Improving the Plan – Feeling Futile

The main institution responsible for the conceptualization and implementation of central plans was the National Planning Office (Országos Tervhivatal) founded in 1947. One of its main tasks was to coordinate the planning activities of the various ministries before they started negotiating with firms in the respective branches and to aggregate the outcomes of negotiations thereafter. Central planning was dominated by a traditional (verbal) political economy approach with a minimum of mathematical modeling during the entire communist period despite the fact that many attempts were made, inside and outside the Office, to apply advanced scientific tools that outshone the so-called "material balance method" borrowed from the Soviet Union, which did not require any more skill than elementary mathematics.

"The Central Planning Office was an <oasis> in Hungarian public administration. […] A very flexible institution, in which it was important from the very outset that employees must have something in their head," remembered Augusztinovics (2012) long after its demise in 1990. She attributed this flexibility to the fact that – although the Office was a Soviet-style establishment – it was brand-new in the 1940s, free from the legacy of Austro-Hungarian bureaucracy (Augusztinovics 2008, 1165). From 1966 onward, the "mathematics of planning" program of Karl Marx University provided the Planning Office with good-quality experts. Collaborative projects with the Institute of Economics (Közgazdaságtudományi Intézet), which were launched during the early 1960s, also contributed to the growth of mathematical knowledge in the Office. Its Computing Center was founded in 1968.[31]

As regards planning as a scientific discipline, the Institute of Planned Economy (Tervgazdasági Intézet) that had been established between 1963 and 1966 under the aegis of the Planning Office set up a department of mathematical modeling. Here, Augusztinovics was employed as a leading researcher from 1964 to 1968. Before and after, she worked on financial balances and macro-modeling in general in various leading positions at the Office. Zsuzsa Bekker, who focused on growth models, joined the Institute a little later. The majority

[31] In the early 1970s, it owned the highest-performance computer in Hungary (ICL-4/70). The first staff of about 40 operators were trained in London. The research affiliates included Bródy and Kornai. The main task of the Center was to prepare sectoral and central plans with the help of input-output analysis and later linear programming. The Kornai-Lipták model of two-level planning (see below) was also run here.

of researchers there produced verbal studies of central planning.[32] Among them was a brilliant thinker, Ferenc Jánossy, who invented iconoclastic theories of calculating national income and modeling economic development by using old-school statistical apparatus (Jánossy 1963, 1966). He was one of few scholars who – despite mastering higher-level mathematics – refrained from using it to improve planning and did not call himself a mathematical economist.[33]

In spite of all attempts at quantification, mathematical models played a major role only in medium-term, two-level (later, multi-level) planning, an initiative of Kornai in the 1960s (see below), and later in long-term planning, Augusztinovics's favorite field of study. Both were eventually futile undertakings but enjoyed an esteemed reputation among researchers due to the involvement of the two respected scholars, the parallel research programs in the West, and the relative freedom of scientific imagination. An open-minded scholarly approach to long-run economic processes remained exceptional in an organization whose everyday operation was based on a predominantly verbal (book-keeping-style) planning of material balances for annual and five-year plans. In the beginning, the composition of such balances, including the final synthetic "chessboard balance" (intersectoral balance, ÁKM in Hungarian) describing the relationships among the main branches/sectors of the national economy, did not require advanced mathematical knowledge. However, the chessboard contained all the information necessary for embarking upon input-output analysis. Yet, despite the fact that, from the early 1960s, the chessboards were used as I-O tables and researchers in the Planning Office performed complex mathematical operations with them, the planning apparatus was bogged down in old Soviet habits of inter- and intra-departmental bargaining[34] when setting up the macro-plans and breaking them down, via various industry-level agencies (ministries, directorates, trusts, associations, and so on), to the level of individual firms. In this intricate – multi-level and multilateral – bargaining game mathematics played a subordinate role;

[32] Nonetheless, the Institute and the Office raised a large group of quantitative experts including Gusztáv Báger, Zsuzsa Dániel, Éva Ehrlich, Sándor Ganczer, László Hunyadi, Tamás Morva, János Réti, Béla Székely, and György Szepesi. See also note 46.

[33] "There are fans of <verbal> and <mathematical> approach among economists. I do not belong to either of them. Moreover, I consider the contrasting of the two methods a wrong alternative. If you please I am the enemy of verbal method if it is based on […] empty abstractions. However, I am equally an enemy of […] mathematization for its own sake" (Jánossy 1969).

[34] The structure of departments within the Office matched that of the sectors and branches of the economy.

quantitative procedures of some complexity were mostly referred to if they seemed useful for any of the actors in the game. The following is a telling story from the life of the Office:

By the end of 1958, the ex ante national income […] displayed a deficit of 13 billion Hungarian forints, an enormous amount at that time, some 10 percent of the national income […]. (The expected price increase of material inputs was generally overestimated and the price index of outputs generally underestimated by Ministries and large firms.) The President of the Planning Office offered a prize: a bottle of French champagne for each recovered billion. Deficit-hunting went on in the Planning Office for several weeks without success.

As a final resort, the management reluctantly consented to the compilation and repricing of a rather large interindustry table, something that was unknown and alien to traditional planning practices. "The chessboard game" began. Cell by cell, representatives of emitting and absorbing sectors had to meet personally and negotiate. […] Within one week, all 13 billions were found. […] We drank the 13 bottles of champagne and many more. (Augusztinovics 1995, 272)

Yet, instead of the computing center, plans were fabricated in the shady rooms of the Office, in which clerks rather than technocrats were making deals to finalize the planning indicators.[35] In order to achieve a meaningful selection of material balances, they had to solve numerous problems of measurement, commensurability, prioritization, and so on – problems all permeated by the conflicting interests of winners and losers, be they branch ministries, regional bodies, or ordinary firms. Moreover, these conflicts were mediated by a complicated network of party and state organizations including non-economic institutions like the army. The outcome of bargaining processes overrode any results of optimal planning models during the crafting stage of the central plan instructions that were turned into law. Provided they had not overridden them, the same would have happened in the phase of implementing the instructions, leading to an endless chain of retroactive revisions of the planning figures (and

[35] Augusztinovics remembers: the mathematical models "did not become influential, decisive instruments in planning […]. Our first results were not to the liking of supreme economic policy leaders because one could not squeeze out of the models a larger than three percent growth on average […] or force them to support that billions and billions would be poured into agriculture. Then, we had to be silent for a while. Of course, sooner or later one learns how to constrain everything in a model in a way that we get what we wanted to […]" (Augusztinovics 2000, 45; see also Medvegyev 2015). For the advantages of I-O models in planning, see Augusztinovics (1995).

amendments to the law). True, after a while, the I-O models could be used to validate the changes made at the negotiating tables, either before the plan was approved or thereafter, much more rapidly than earlier. Originally, the clerks were running from room to room in the Planning Office with pencil and eraser in their hands in order to replace a figure in the material balance of a particular product after their boss had taken a phone call from an influential party politician or state bureaucrat.[36] Augusztinovics lamented in retrospect: the mathematical models "remained a façade all the time, they were in the best case thought-provoking but did not ever become instruments of real decision-making. The real decisions emerged from bargaining […]" (Augusztinovics 2000, 12–13).

Under such circumstances, one could not effectively test the applicability of the input-output and optimal planning models,[37] even if the Statistical Office delivered more accurate data as the years went by (see below) and the planners' toolbox expanded in step to include advanced mathematical methods. Whether or not these models could have proven solid instruments of planning at all was never determined. Mathematical economists did not have a choice other than refining them in the hope of being perhaps listened to by the planning officials in the foreseeable future (cf. Ganczer 1973; Simon 1970, 1973; Szepesi and Székely 1974). Since five-year planning continued until 1989, the models did not cease to emerge in the Planning Office during the 1980s, even after many mathematical economists had lost their faith in optimal planning. Quantification was, in the best case, suitable for underpinning a superficial check on the realism of plans produced by verbal techniques. While in this respect their authors exerted some disciplining influence, they were virtually powerless in affecting normative decisions.[38] Mathematical planners in the Office encountered serious difficulties, for example, in

[36] "In the practice of planning, future coefficients […] are usually derived from various sources of information, experience and speculation. These are amalgamated, by intuition, conscious weighing, simple or more complex arithmetic, and pondering, into the most probable guess. This domain of planning must draw on technical expertise and knowledge, general economic know-how and political common sense" (Bródy 1970, 120). Augusztinovics (1984, 45) put it more bluntly: "The decision process is hierarchical and decentralized, even if it looks fully centralized. […] The processes of elaboration and acceptance are intermingled: this dual process is called plan coordination. […] The battle of figures, arguments, and interests takes place on the same battlefield."

[37] For the remarkably small number of ministry-level models in the early 1970s, see Farkas (1973).

[38] Ganczer (1973) reports this failure using the example of the Fourth Five-Year Plan (1971–1975). A large group of experts in the Planning Office was commissioned to elaborate a mathematical model for the plan in March 1969. They wanted to go for sure and decided to work out a linear programming model that was much simpler than Kornai's inoperational two-level planning scheme (see below). While making the calculations, the plan was approved by the government in December 1970, based on data that were largely different from the ones the researchers used to set up the model. The real plan and the model became incomparable; therefore, the former could not be checked by the latter, even retrospectively.

identifying the objective function, according to which the models should have been optimized. Beyond lamenting the lack of "clean" data and arbitrary changes in the plans due to petty bargaining, this could have been the point where optimal planners clashed with their principals the most vigorously. [39]

However, instead of insisting on new priorities in economic policy (horribile dictu, radically increasing living standards and slowing down economic growth, or cutting military spending and trade with the Soviet Union), they normally accepted most of the objectives defined by the ruling elite. Because of firm political taboos, mathematical economists did not think of resisting the will of the nomenklatura publicly. They put up with pointing out inconsistencies in the balances, smuggling a few new priorities into the plans, juggling with multiple draft plans, or playing mathematical tricks, mentioned by Augusztinovics above, which could modify the outcome of plan bargaining.[40] To the luck of optimal planners, by the mid-1980s, the top leaders of the Office and their advisors hardly could be distinguished from those of the Finance Ministry,[41] a stronghold of reform-minded economic policy and a think tank of the post-communist transformation. In retrospect, the Planning Office seems to have been ready to engage in indicative planning, in which mathematical economists could have found ample space for themselves. However, communism collapsed and the Office was closed, leaving behind a large gap in macro-coordination.

Central Statistical Office: From Chessboard to Econometrics

Hungary's tradition of statistical work on government level and higher education programs was informed by the German Historical School, which laid the foundations for statistical research. The Central Statistical Office (Központi Statisztikai Hivatal) established in 1867

[39] It is symptomatic that Augusztinovics (1995, 273) could not imagine that the suggestion made about popular voting on societal preferences by Ragnar Frisch in the early 1970s could ever become viable.

[40] With time, a group of younger able experts crystallized around Augusztinovics, including, e.g., Tivadar Faur, Katalin Haraszti, Júlia Király, János Réti, Béla Székely, and György Szepesi, who were ideologically less committed to central planning and put forward economic policy goals compatible with the radical programs of market reform. Small wonder that they were disliked by officials coordinating the five-year plans, a large majority of the Office's employees, whose work was managed by another department.

[41] István Hetényi, a student of Farkas Heller at the pre-communist University of Economics, later professor of public finance, is probably the best example for continuity. He had supervised long-term planning in the Planning Office until 1980 when he left for the Finance Ministry to lead, as minister, the preparations for the last reforms of the planned economy. Hetényi was not the only reform-minded leader of the Planning Office in the communist era. He worked together with communist technocrats such as Miklós Ajtai, József Drecin, István Huszár, Ottó Gadó, Miklós Pulai, and Péter Vályi.

served as its strong institutional basis even after the communist takeover. Nevertheless, the Office was reorganized by a team led by György Péter, who worked as its president from 1948 to 1968.[42] In his view, a main task of the institution was to supply the Central Planning Office with reliable economic information. In the beginning, he had despised statistics as a discipline of calculating percentages (Köves 2005, 879) but later grew familiar with input-output analysis. While dutifully Sovietizing the statistical regime of the country, Péter developed a comprehensive observation system to measure the performance of state-owned firms. The first – experimental – version of the intersectoral balance was completed by the Office in 1957. In collaboration with the Planning Office, they accomplished a proper decomposition of the productive sectors in 1957 to create the first input-output table for Hungary by 1959 (Kenessey 1959).

In 1963, a special department was established within the Statistical Office to develop the economic applications of mathematical-statistical methods. Two years later, an econometric laboratory and a larger information processing laboratory (later, Infelor) was also set up.[43] While Infelor slowly became a quasi-independent company (Lampl 1971), the Econometric Laboratory remained within the Statistical Office. The members of the Laboratory (such as László Halabuk, Katalin Hulyák, László Hunyadi, Zoltán Kenessey, Judit Neményi, János Paizs, and György Szakolczai), were well-trained researchers in mathematics and statistics who started teaching one another modern econometric methods. They were driven by the urge to understand time series as well as linear and nonlinear regression analysis and other contemporary econometric techniques.[44] The early econometricians of the Office had to overcome the resistance of traditional German-style descriptive statistics reinforced by its Soviet version. In the 1950s and 1960s, official political economy rejected any stochastic approach to central planning, assuming "objective" certainty instead of probability in

[42] Péter frequently attended economic debates on market reforms in the 1950s and 1960s, criticizing overindustralization, emphasizing the role of profit incentives and marketization in general. He became one of the first reform economists in Hungary although he and the chief economist of the Office, Júlia Zala, seldom took part in open political battles.
Following György Péter's mysterious death in 1969, his deputy István Huszár was appointed the new president of the Office. He had initiated in 1968 that János Paizs, a self-made econometrician, starts teaching econometrics at Karl Marx University (Hulyák 2014, 72).

[43] The former was headed by László Halabuk and György Szakolczai, the latter by Ferenc Rabár.

[44] They made parameter estimations of CES production functions for specific industries and input-output calculations for the Planning Office. The Laboratory also built forecasting models and took part in the calculation of price indexes (Szakolczai 1972; Halabuk 1971; Havass 2011).

portraying economic processes. Unsurprisingly, the most educated – more importantly, neoclassical-minded – expert of econometrics in Hungary, Ede Theiss, had only an advisory affiliation with the Statistical Office.[45] Nonetheless, he was instrumental in launching the first experimental econometric macro-model of the Hungarian economy, M-1 (Theiss 1965; Halabuk, Kenessey, and Theiss 1965). The multidirectional causalities among the sectors had been captured with the help of a simultaneous system of stochastic equations. This method was in vogue in the West at the time, and the project including the estimations, forecasts, and simulations was successful enough. The next model, M-2, exerted influence on models in other communist countries; M-3 was a joint Czechoslovak-Hungarian initiative; and the authors of M-4 made an attempt at integrating econometrics and input-output analysis by incorporating an interrelated, deterministic, and stochastic input-output block and representing the effect of non-material production closer to the SNA technique[46] than earlier (Halabuk 1971, 1976; Hulyák 1972; Hunyadi 2012). In 1982, some members of the Laboratory moved to the Institute of Economics. Here, they did not initiate collaborative projects with those researchers of the Institute who had already begun to run econometric programs themselves (Halpern 2020).

While economic theorists always complained that the Statistical Office delivered neither sufficient nor accurate information, the level of precision of the data increased remarkably in the communist era. Obviously, political biases, ranging from military secrets to artificial prices, continued to deform statistical information, and the lowest-level economic actors were astute enough to start plan bargaining already during the data provision phase. The planning bureaucrats would have magnified these errors and falsifications to their extreme if I-O analysts, optimal planners, and econometricians had not succeeded in confining distortion through their models time and again.

[45] Theiss advanced his knowledge of neoclassical economics at leading U.S. universities (Chicago, Columbia, and Stanford), worked with Ragnar Frisch and Henry Schultz, and published in *Econometrica* and the *Journal of Political Economy*. Instead of emigrating after 1945 or 1956, he exposed himself to humiliation, being deprived of organizing a Hungarian school of econometrics. From 1948, Theiss served as head of the Statistics Department at the University of Economics. In 1950, he was accused of "mathematical formalism" and dismissed. He was permitted to teach again (but only law students) in 1959. Instead of becoming a celebrated pathbreaker of Western economics in Hungary, Theiss died as an isolated scholar. As so often in Eastern Europe, the subsequent generations had to reinvent what he had already known (Kádas 1980; Huszár 2008; Hunyadi 2012).

[46] The M-4 model fitted into the pattern of the LINK project that connected the trade accounts of several countries by uniform specifications to better understand trade flows.

Institute of Economics: Making Mathematics Legitimate in Political Economy

The fourth institution that made a lasting contribution to developing planning concepts and methods in Hungary was the Institute of Economics at the Hungarian Academy of Sciences. In terms of original discoveries that might match similar results in mathematical economics in the West and the East, it proved the most productive in input-output analysis and optimal planning. Scientific innovation stood in strong correlation with the privileges the Institute's researchers enjoyed in accessing literature, choosing projects, fostering international relations, and publishing.

In the wake of Imre Nagy's "New Course," the Institute was established in 1954 with the aim of "laying the scientific foundations of economic policy." It published Közgazdasági Szemle, the main scientific monthly of the discipline to the present-day in Hungary.[47] Founding director István Friss was appointed by the conservative faction of the Central Committee to counterbalance Nagy's reform program. However, a majority of affiliated researchers identified themselves with that program since they had been selected by Friss according to their scholarly talent rather than political loyalty.[48]

Even those among them who had some prior knowledge of mathematics refrained from applying quantitative research techniques at the very beginning.[49] They put faith in the possibility of restarting market reforms after the 1956 revolution, at least until the so-called Varga Commission that had suggested a further liberalization of planning was disbanded by the government in 1957. It was only during the later years of the first – militant – phase of Kádárist "consolidation" that several members of the younger generation, many of whom

[47] The journal that had had various predecessors from 1874 on was founded in 1895. Between 1949 and 1954, it was called the *Hungarian-Soviet Economic Review* (Magyar-Szovjet Közgazdasági Szemle).

[48] On Friss's professional and political ambiguities, see Péteri (1997, 2002, 2019). Among the recruited scholars Erdős and T. Nagy were prominent reform economists of the time while their younger colleagues (e.g., Bródy, Kornai, A. Nagy, and the maverick Tibor Liska) joined them in their struggle with the textbook political economists.

[49] Bródy was a conspicuous exception (see below).

burned their fingers in 1956, were persuaded to withdraw to a safer space within academia and use mathematics as a kind of dissident jargon.[50]

Amidst the post-revolutionary hangover, a number of frustrated market reformers were looking for a refuge where they could tide over hard times and from where they could emerge well-equipped with sound techniques of economic measurement, analysis, and prediction. They felt uneducated and inaccurate, and decided to overcome forced parochialism. Eagerly catching up with then-mainstream theories in the West, they wanted neither to fully renounce their Marxist convictions nor to exclude the possibility of rejoining reform programs at a future point. They hoped that – provided they could reassure their main adversaries about the political innocence of mathematical methods – the scientific language might protect them for the simple reason that it was impenetrable to the censors.[51] They did not anticipate, however, that such a discursive refuge could turn into a trap in the long run.

This strategy of self-camouflage did not prove entirely successful. Although Bródy's proud Marxist/collectivist stance as well as Kornai's sharp attack on general equilibrium theory may have demonstrated a fair degree of ideological obedience, suspicion toward mathematical economics burst out repeatedly. It was fueled by some leading scholars of the Institute, including deputy director Tamás Nagy, an influential reform economist and dedicated Marxist, even as late as the end of the 1970s.[52] Nevertheless, in the shadow of its persistent commitment to market reforms, mathematical-economic research programs continued to remain a tolerated (or provisionally supported) albeit secondary feature of the Institute. Prior to the introduction of the New Economic Mechanism (NEM) in 1968, the Institute of

[50] It did not help them that a number of the first mathematical economists in the communist era, such as Andorka, Szakolczai, Theiss and Varga, were stigmatized as "agents" of the previous regime.

[51] "We did have to pour Marxist holy water on mathematical economics in order to be allowed to deal with it. When physicists realized that, by frankly admitting what they thought, they – like Giordano Bruno – committed themselves to the flames, invented mathematical physics that the clergy did not understand" (Bródy 1994, 294). "Mathematical language was incomprehensible to commissars, party officials, and all who kept watch on institutes, publishers, and journals. Having seen a few equations in a manuscript, they put it down with a shiver" (Kornai 2007, 152). Erdős chose a different strategy of survival. After 1956, instead of relying on his profound mathematical knowledge, he left the reform battles for research on capitalist economies and became a critic of Keynes.

[52] He used to make condescending remarks about mathematical economists, which prompted Kornai (1981) to publish a bizarre article, full of self-critical comments on mistakes these economists made, in defense of the discipline. This is how Nagy invited Bródy to join his research group in the 1960s: "Andriska, come over to us, you are a smart researcher, but the precondition of your transfer is that you will not deal with mathematics because I do not understand it" (Bródy 1994, 300–301).

Economics served as a major pool of ideas on market reform and – under the directorship of the father of NEM, Rezső Nyers, from 1974 onward – became an academic stronghold levelling criticism at the counter-reform measures taken by the party-state after 1972/73. Mathematical knowledge did not count for much in this rearguard battle.

At the turn of the 1960s and 1970s, Bródy and Kornai were permitted to organize small research groups that attracted gifted young economists and mathematicians to the Institute. As mentioned, neither of them nor their close associates were allowed to teach regularly at Karl Marx University. Thus, they were not urged to build up a systematic body of knowledge in mathematical economics (Simonovits 2019). Yet, they affected many students of the university's "mathematics of planning" program through their works and numerous formal and informal discussions held at the Institute and even at the university.[53] The bulk of research into mathematical methods of planning in Hungary revolved around the Institute in concentric circles. For example, from the early 1960s onward, the Institute worked together with the Central Statistical Office and the computing center of the Planning Office (and later with its research institute) with hardly any friction. To an extent, cooperation was based on personal relationships[54] without aggressive political control. Astonishingly, the breakthrough of mathematical economics during the 1960s proved irreversible. In 1964, István Friss solemnly stressed that "if one could dispute the application of mathematics in economic science for a long time, there is no room for such doubts after the [positive] experiences during the past years" (Augusztinovics 1964, 65).[55] Apparently, this declaration was not just caused by internal lobbying by mathematical economists in the Institute but also by the influence of their Soviet colleagues, which resulted in mutual research visits and the publication of Nemchinov's path-breaking edited volume in Hungarian in 1962.[56] The process of legitimization seemed to end with an invitation, sent to Kornai who – accused of revisionism – had been fired in 1958, to rejoin the Institute in 1967. (The decision was made by Friss in both cases.)

[53] Meanwhile, Tamás Nagy taught political economy at the university, without any special reference to mathematical economics.

[54] Not only Bródy and Augusztinovics were married. Kornai and Zsuzsa Dániel who also worked on mathematical planning were married as well. Bródy and Jánossy (who was the stepson of the Marxist philosopher György Lukács) were good friends and most of them maintained friendly relations with Martos, A. Nagy, and Tardos. The latter was son-in-law of Péter. As years passed, many of their younger colleagues joined this network.

[55] In 1964–1965, a number of important Hungarian works in mathematical economics were published: e.g., Bródy 1964, Kornai 1965, Simon and Kondor 1965, Theiss 1965.

[56] The volume included a chapter written by Kantorovich on optimal planning.

As the previous sections suggest, there was a fairly cohesive group of dozens of scholars cultivating mathematical techniques of economic research in the partner institutions of the Institute of Economics.[57] Within the latter, two generations combined forces before 1989.[58] This was a small and stable research community, with two international stars surrounded by their associates who were barely threatened by external professional competition and enjoyed considerable freedom of thought within their research groups. However, ultimately they had to adjust to the mix of family atmosphere and quasi-feudal hierarchy prevailing in the Institute.[59]

During the 1960s and early 1970s, the majority of older researchers in mathematical economics focused on the theory of central planning in some sense. Professional solidarity among them was relatively strong for many reasons, ranging from the scientific vernacular they spoke to being occasional victims of harassment. The same applies to Bródy and Kornai who – irrespective of a growing divergence between their research programs and political attitudes – did not air their dirty linen in public.[60] The early research projects of the Institute in mathematical economics focused on input-output models (Ausch, Bródy) and optimal planning/programming (Kornai and Martos, András Nagy). Kondor and Simon studied both fields. According to Virág (1973), Simonovits (1996), and Csató (2019), the principal research

[57] A smaller research unit, the Institute of Market Research (*Konjunktúra- és Piackutató Intézet*) where, among others, János Gács, Kamilla Lányi, András Nagy, Gábor Oblath, Péter Pete, András Simon, and Márton Tardos worked for a long time also needs to be mentioned in this regard. In the 1960s, they were building optimal models for planning foreign trade and rationalizing the New Economic Mechanism, and later engaged in econometric research in various fields of macroeconomics. With time, Gács, Nagy, Pete, and Tardos moved to the Institute of Economics.

[58] The older one included, besides Bródy and Kornai, Sándor Ausch, Anna Gelei, Róbert Hoch, György Kondor, Béla Martos, Éva Radnóti, and György Simon while the younger one consisted of Péter Bodó, Éva Bondár, Judit Barta, Győző Gábor, László Halpern, József Horváth, Zsuzsa Kapitány, Gábor Kertesi, Ilona Kovács, János Köllő, Gábor Kőrösi, Mária Lackó, György Molnár, Miklós Ördög, Judit Rimler, András Simonovits, Judit Szabó, Tamás Tarján, György Tényi, and Ildikó Virág. Many of them focused on I-O analysis and/or optimal planning (and all of them applied some sort of formal models) at a certain point in their careers. While frequently leaving the country for conferences, longer research stays, or teaching, with the exception of Bodó and Kondor, none of them emigrated.

[59] Normally, the younger researchers came from Karl Marx University or the Faculty of Mathematics of Loránd Eötvös University, and were recruited by the heads of the research groups who protected them from political intervention "from above" both inside and outside the Institute. With the gradual decline of political control, the young generation of researchers became dependent mainly on their group leaders, basically the same persons for decades. Fluctuation between the groups was weak, and loyalty overrode voice and exit.

[60] Of course, their tongues were much sharper among themselves. For instance, Bródy (1994, 316) liked to call Kornai "the last advocate of Stalinist planning" and made fun of the alleged imperfections of his mathematical skills while Kornai ridiculed Bródy's Marxist nostalgia and superficial reading of literature. Otherwise, they respected each other and wrote cordial reviews about each other's books with only a few exceptions (cf. Kornai and Simonovits 1981), organized conferences together, and assisted each other abroad.

fields covered by both generations in the Institute at the turn of the 1960s and 1970s were as follows: closed and open, static and dynamic input-output models, and the Neumann model (Bródy, Halpern), "searchlight programming" (Simon) as a decomposition procedure, non-linear programming (Martos), equilibrium theory (Kornai), team theory (Simonovits) "vegetative" (non-price) control (Kornai, Martos, Simonovits, and Virág), queueing theory (Simonovits), planners' behavior (Lackó), decision theory (Tényi), growth models (Virág, Horváth, and Rimler), planning labor market and vocational training (Bondár, Horváth, and Tényi), consumption theory (Hoch, Ilona Kovács, Ördög, and Radnóti), and macroeconomic modelling (Kondor, Simon, and Gábor).

Interestingly, the most powerful academic initiative to rationalize medium-term central planning based on the idea of two-level planning came from outside the Institute of Economics in the course of the 1960s. Its pillars rested on a nearly decade-long cooperation of multiple state agencies and research institutes and embraced dozens of researchers under the guidance of Kornai, then formally still an outcast (Kornai 1965).

Ironically, mathematical economics became largely uncontested within the Institute only after Kornai's (1965) and Bródy's (1970) seminal works on optimal planning and input-output analysis, respectively, had been completed and the attraction of these research programs started petering out. At first sight, this cries for a political explanation, for it might seem as if mathematical methods were tolerated or even promoted once a growing number of researchers had abandoned applying them as means for intervening in the "high politics" of central planning. Accordingly, from that time on, they were free to build quantitative models of shortages, the labor market, shadow economy, and economic fluctuations, or even to indulge in the intricacies of economic control, just to name a few successful research projects, provided they did not challenge the institutional and ideological core of the five-year plans. Moreover, the model builders were permitted to use any mathematical techniques they thought opportune. Yet, in terms of methodology, some of the new models were more rigorously neoclassical than those of optimal planning, and the results of many of them were more explosive politically (see Postscript).

Undoubtedly, they grew less normative and more descriptive and analytical in nature. However, with normativity their "meliorist" attitudes (cf. perfecting the planned economy)

faded away and slowly were replaced by a cool-headed, impartial approach colored by a kind of "inverse normativity" pointing toward capitalism. Quite a few economists at the Institute were equipped to transition to neoclassical scholarly culture by the mid-1980s, at least as far as their mathematical expertise was concerned, and this had little to do with self-restraint in matters of high-ranking party and state affairs. Just the opposite happened: by then official political economy and its guardians in the higher echelons of the party-state became too weak to resist the proliferation of critical economic thought underpinned by an ever deeper mathematical knowledge. Nevertheless, this deepening never would have taken place without the groundbreaking contribution of the first cohort of input-output specialists and optimal planners.

At the same time, the members of the older generation – while pulling their disciples into mathematical economics as well as nurturing and safeguarding them – did not push them out from the "refuge," prompting them to convert to neoclassical economics. What is more, during the 1970s, they continued to refine I-O analysis and planning models, in harmony with close colleagues outside the Institute (e.g., Augusztinovics 1979).[61] True, their attention switched from five-year plans to planning economic processes in the long run (see below). It was only Márton Tardos (who joined the Institute in 1980) and András Nagy (who rejoined it in 1973) among the older scholars who acquainted some of the younger researchers with standard neoclassical thought – ironically, through its critique offered by new institutional economics.

This schematic story of the evolution of quantitative methods in economic research that cultivated in the Institute of Economics would not stand the test of reality if, next to the textbook political economists and the mathematical economists, a third group of actors, the reform economists, were ignored. For example, the weakening of the party-state's resilience to criticism mentioned above was due, to a large extent, to the radicalization of reformist thought. Moderate or radical, the market reformers were similar to the textbook political economists (a rare species among the members of the Institute by the way[62)] in doing predominantly verbal research while reminding the observer of the mathematical economists

[61] She left the Planning Office for the Institute in 1984.

[62] In the Institute even the dedicated Marxists (such as Bródy, Erdős, Friss, Hoch and Nagy) distanced themselves from textbook political economists. The latter were called *polgazdos* ("polecon" may be the translation) with some contempt.

when rejecting the sub-scientific discourse of the official textbooks. The reformers raised serious doubts upon state planning and contributed to its ideological disenchantment, which was received by many mathematical economists with mixed feelings. The latter also disapproved of the bureaucratization of planning and plan bargaining, namely, the distortion of scientific planning procedures by lobbies within the nomenklatura. However, they were afraid that the devaluation of central planning would eventually result in an overvaluation of the market and a decline in the quality of macro-management. Despite such disagreements, both groups shared the ideal of independent thinking, disliked parochialism,[63] cherished the memory of the 1956 revolution, and so on, that is, common attitudes sustaining solid bonds between their members. Furthermore, over the years, it was increasingly difficult to find a mathematical economist in the Institute who did not agree with the reformers on a considerable degree of marketization or even join verbal institutional research programs on that issue. To be sure, it was much easier for them to do so than for reform economists trying to learn how to build formal models.[64]

Two main representatives of mathematical economics

Although in terms of methodology András Bródy and János Kornai had chosen different points of departure for doing economic research on the planned economy (in the mid-1950s, the former opted for quantitative modeling while the latter opted for verbal, quasi-sociological research), later they took parallel roads leading to then-mainstream economics in the West. If space allowed we could write pages on the similarity of their social roots as well as political and cultural motivations – rich families, Bildungsbürgertum, cosmopolitan attitudes, Holocaust survival, joining the communist party and fascination with Marxism, the trauma of

[63] To be sure, all research on mathematical planning presented in this chapter was dwarfed by a great diversity of verbal approaches of mixed quality, thriving outside the Institute, to the problematic of planning. These approaches, which unfortunately we cannot cover here, equally embraced (1) the confirmation of traditional (Stalinist) principles of central planning and a large variety of (2) diluting or (3) denying them. To give examples, Kálmán Szabó (1960) represented the first, Ákos Balassa (1979) the second, and Tibor Liska (1988) the third approach. Sometimes, even those experts stuck to traditional principles (e.g., directive planning) who otherwise worked on optimization (cf. Morva 1965, 1966). As for research programs unfolding within the Institute, there were excellent verbal studies providing historical comparisons of planning regimes and policies in the Eastern Bloc from a reformist perspective and offering the mathematical economists original variables to model. See, for instance, Bauer (1981) and Soós (1986) on investment cycles.

[64] The interest of younger mathematical economists in market reforms was facilitated by the fact that, in contrast to how their older colleagues felt in the early 1960s, they already were not enchanted by the idea of improving planning (see below).

1956, respect for scientific knowledge, a spirit of rebellion, and so forth – that would explain why the two young, self-educated intellectuals turned to Western economic theories. As mentioned, they helped (but also competed with) each other on their unfinished trip to neoclassical theory until they drifted apart. The causes of bifurcation of their research programs also would require a space dedicated to major differences in scholarly styles, attraction to other social/natural sciences, mathematical skills, demand for their works in scientific markets, political attitudes, and so on.

Bródy had introduced Kornai to input-output analysis whereas Kornai became more erudite in optimal planning than his friend and colleague. As Kornai (2018, 6) remembered, "in terms of methodology, Bródy (and many more Marxists, for example, Mária Augusztinovics) and I, who was not a Marxist but a fan of neoclassical theory in this phase of my life, were allies. […] We wanted to use mathematical methods, which forged a sort of alliance between us, I would say, complicity in the sense of understanding each other." He imported Western-type research techniques, broke with Robinson Crusoe-like routines of scientific organization and set up research teams whose members were assigned special tasks including literature reviews, case studies, model building, and testing, with particular attention to publication. While Kornai benefitted from a set of managerial skills, in addition to an ability to reinterpret and systematize ideas, Bródy was a lonely rider and a daring dreamer. "A majority of researchers in the Institute profited from or simply worked on projects developed from his flashes of inspiration" (Molnár 2019). Kornai carefully nourished many of his discoveries in comparison to Bródy who was not keen to flesh out his original insights in detail.[65] The role of the enfant terrible was always closer to his heart than that of the well-disciplined, widely respected researcher. Their younger colleagues had a chance to choose from these two scholarly attitudes or combine them freely.

The two charismatic scholars held sway over the research programs of the Institute of Economics in mathematical economics for a long period. In the beginning, Bródy's preoccupation with I-O models and Kornai's concentration on optimization complemented each other. Ironically, in working together on various projects, Bródy the Marxist grew less

[65] György Molnár (2019) recalls that, as a young mathematician, he tried to correct one of Bródy's proofs. "It was full of mistakes and I was convinced and eager to show that his theorem was false. After having fixed the proof, I realized that the theorem was true. Bródy saw the truth somehow through the algebraic structure of the input-output model but was not interested in puttering around the technical details at all."

skeptical about neoclassical virtues than Kornai, who had initially underpinned his studies of mathematical planning with neoclassical principles. Later, Bródy moved to the study of dynamic processes with a special interest in economic cycles and their mathematical complexities whereas Kornai, following a desperate struggle with general equilibrium theory, immersed himself in the scrutiny of disequilibrium with a renewed curiosity in institutional analysis. Meanwhile, problems of economic control, particularly whether it can lead to balanced growth, intrigued both of them immensely. The concept of equilibrium did not lose its appeal to them entirely even if they revisited it with growing suspicion. Bródy's (1994, 317) following words underline why their programs nonetheless diverged:

> Equilibrium is a very nice concept, without it one cannot do disequilibrium economics either. However, one also cannot create a theory that would guarantee, either via the market or the plan, that the equilibrium materializes. Moreover, and this applies to Kornai's works after Anti-equilibrium, my objection was that he wants to control the economy to adjust to an equilibrium that is again determined from outside.

András Bródy: Doyen and Enfant Terrible of Hungarian Economics

András Bródy (1924-2010) was born in Budapest in 1924, as a son of a director of one of the most significant publishing houses in Hungary (*Hungária Kiadó*). Although his upbringing was modest, the family had a German nurse, a large library and many acquaintances in the contemporary literary, artistic, and scientific society. As a child, he studied foreign languages (German and English), music (he played on several instruments) and sports. According to the principles followed by his family, he had to start working early, even when he was still a high-school student (first in the printing press, then as a sales agent of the publishing house). but he also benefitted from the formal and informal relations of his family. Bródy met the Marxian philosopher György Lukács, his wife Gertrúd (who frequently conversed with Bródy about scientific problems) and his adopted son, the economist Ferenc Jánossy thanks to these connections. He was also in contact with (via the publishing house and his first wife Márta) the Vajda János Literary Society whose members felt sympathy for left-wing politics. There were many significant literary figures in this society, but he also met Alfréd Rényi, the mathematician, here (Rényi was the grandson of the esthetician and literary critic Alexander Bernát) whose acquaintance proved to be formative for Bródy.

In Bródy's life, women play a very important role. His relationship with the left, his choice to study economics, and later his research interests were inspired by an influential woman (wife or girlfriend) at various stages of his life. Religion did not have a great impact on him (Bródy was half-Jewish and his family was not religious), but politics did. First, because of the 'numerus clausus' law, he could not enter the Technical University of Budapest, although originally he hoped to become an engineer. Therefore he switched to mathematics, because the renowned mathematician, Lipót Fejér permitted him to attend courses at the Budapest University of Science. His studies in mathematics, of which he only completed two years, were interrupted by forced labor service (which most members of his unit did not survive) during Second World War. After the war, he continued his studies in mathematics at the University of Szeged, where the head of program was another leading mathematician, Frigyes Riesz.

Returning to Budapest in 1945, he joined the Hungarian Communist Party. At the time, he was convinced that the communist party took the right course of action; he participated in agitation campaigns against the "reactionary forces" and also in the infamous "blue ballot" Hungarian parliamentary elections (where the Hungarian Communist Party manipulated the results). However, the confiscation of his parents' villa and the nationalization of the publishing house slightly undermined his conviction. True, Bródy himself became the first director of the state-owned publishing house but he was dismissed in 1948.

An important reason for his dissatisfaction with and opposition to the communist government was that the Communist Party appointed trustees in the board of the publishing house who had Nazi past and that a volume published for Stalin's birthday was scrapped because of the bad quality of the printing paper. His disappointment was reinforced by the show trial of László Rajk, the censoring of the Hungarian Writers Union, the political conflicts around the Lukács circle, and the announcement of the dictatorship of the proletariat by Mátyás Rákosi.

After the dismissal, he became a turner in the Tube Factory of Csepel Works (*Csepel Művek*). He was excluded from the Party, but he did not want to leave the country even when his parents emigrated during the 1956 Revolution. Bródy returned to Budapest from the border, with his children, wife and brother. While working as a turner, Bródy enrolled in the evening school of the Hungarian University of Economics. In the final year, he started to prepare for an academic career: "I knew that science is the freest area" (Kovács 297). First, he made an

input-output table for the Ministry of Engineering Industry (*Kohó- és Gépipari Minisztérium*). Since his results implied that the planned investment costs exceeded the benefits, he was fired. Second, he worked as a statisticianin the Csepel Works where he learned how to handle large data sets to support inferences. In 1955, he became a researcher at the Institute of Economics of the Hungarian Academy of Sciences.

Mathematical economics seemed to be a neutral area at that time in Hungary, pursued by only a few researchers. At the time, mathematical economics consisted mostly of actuarial calculations and statistics. However, when Bródy and some of his colleagues (Béla Martos, Margit Zierman and Tamás Lipták[66]) began to consider mathematical economics as an inherent component and essential application of economic theory, their approach was soon attacked by "traditional" political economists of the communist era, mainly by Tamás Nagy. Thus this sub-discipline became a dangerous area. This is the reason why Bródy's first papers are cautious introductions to the methods of input-output analysis (Bródy 1957, 1958, 1960).

Getting acquainted with Western economic literature was a rather unpleasant experience for him. He read the textbook of Samuelson (1948) and some papers of Ede Theiss and Kálmán Kádas in Hungarian Economic Review (*Közgazdasági Szemle*). These scholars subscribed to *Econometrica* and wrote popularizing articles on Western economic thought. Bródy's first positive reading experience was Maurice Dobb's book (Dobb 1948) on Soviet economic development, which he prepared for publishing at the publishing house. Bródy also met Dobb in person and it was Dobb who offered him the opportunity to visit the Institute of Richard Stone. Bródy spent two weeks in Cambridge at Kings College in 1962.

In this year, he published his first paper in English (Bródy 1962) on the uniqueness of Marxian production prices. Two years after, Wassily Leontief invited him to Cambridge MA, as a Ford fellow, he spent six months at Harvard University and another six months at Cambridge University (as a member of the research group of Richard Stone), and finally a couple of weeks in Brussels. At Harvard, he had the opportunity to use a high performance computer, and this is where he met Anne P. Carter, who later became his co-author. In 1988, the two of them organized an input-output conference and founded the International Input-Output

[66] In the beginning, Bródy mediated between János Kornai and Tamás Lipták when they started developing the concept of two-level planning.

Association, where Anne P. Carter was the first president, and Bródy was the editor in chief of the society's journal, *Economic Systems Research*. He held this position until 1994.

When Bródy returned to Budapest, conflicts with his colleagues, that had always been present, became even more pronounced. Earlier he disagreed with György Cukor, the head of his department at the Institute, because Bródy concluded from his calculations that the Hungarian economy is "overindustrialized" and György Cukor denied the possibility of this. He also disagreed with the "mechanism-reformists" because in Bródy's opinion there does not exist such mechanism (either planning or market mechanism) which converges to equilibrium. He had a methodological disagreement with János Kornai concerning his Anti-equilibrium (Kornai 1970) where Kornai criticized the abstractions of general equilibrium theorists. Kornai thought that such an equilibrium was pure fiction. However, in Bródy's opinion this fiction is inevitable if one wants to understand how the whole system works (Kovács 326).

Since Bródy felt that he became alienated from others in the Institute, he accepted a professorship at the newly founded University of Lusaka in Zambia. First, from 1970 to 1972 he gave courses in economics and continued his research with the high performance IBM computer of the university, which was more or less used by him. In 1974, he was invited to be head of the Faculty of Economics and Business. Bródy enjoyed composing the curriculum and teaching but concluded that the country that had just become independent made the same mistakes as those in the Eastern Bloc after 1945 while did not avoid making typical Western mistakes either. This experience reinforced his quasi-anarchistic attitude to any state East and West, North and South.

In 1977, he returned to Budapest, where he wrote and published his second book (Bródy 1980). In 1980, Leontief invited him again to the United States. Since Leontief could not find funding for the research group of which Bródy was part of, he worked in the Batelle Laboratories for one year. In this innovative non-profit firm he set up an input-output analyst group. In 1981, he accepted the invitation of Sukhamoy Chakravarty to the University of Delhi, where Bródy wrote his third book (Bródy 1982). In 1982, he returned to Hungary, while accepting visiting professorships (at University of Nizza in 1989, at La Trobe University in Australia in 1991, and at Hitotsubashi University in Japan in 1997). In 1987, he contributed to the New Palgrave Dictionary of Economics with an article on "prices and quantities".

When he finally returned to Hungary, he did not join the reform movements in the 1980s, even though he criticized the official Party line. After 1989, he refused to be advisor to both the liberal Alliance of Free Democrats (SZDSZ) and the Hungarian Socialist Party as well as to their coalition government in 1994. Indeed, he wrote many articles in newspapers and journals criticizing daily politics. Meanwhile, he continued research work and, as invited lecturer, gave courses at the Budapest University of Economics (later renamed to Corvinus University of Budapest), in the László Rajk College for Advanced Studies, and the Ferenc Jánossy College for Advanced Studies. In 1997, he was awarded with the Széchenyi prize (one of the highest governmental awards in Hungary), but he never had been elected to be a member of the Hungarian Academy of Sciences. He did not stop doing research until his death, independent of the blame or recognition of the actual government, regime, colleagues or fashions.

Mathematical Theory of Value

Bródy's first theoretical inspiration to turn to economics was definitely Marx's Capital. Ostensibly, Marx's theory was a frequent subject of conversation in the Lukács family, but Bródy read *Das Kapital* in German in his father's library earlier (in 1943). Later he read it again carefully when he had a glandular disease and was forced to stay in bed for three months. Thus it was not György Lukács who introduced him first to the writings of Marx.

In the 1950s, Bródy started to prepare an index for Capital (it was published in 1959 (Bródy 1959)). The main motivation of this work was that he realized that the standard "Eastern" interpretation of Marx is misleading, and that leading Hungarian theorists in political economy such as Tamás Nagy and Róbert Hoch misused Marxian concepts, because they always echoed the Soviet interpretation.

Probably due to his training in mathematics and the deep conversations with his friend, a leading mathematician Alfréd Rényi, Bródy envisioned a mathematical structure of the Marxian reproduction schemes. At that time, Bródy and Rényi did not know either Leontief's or von Neumann's writings (Kovács 1994, 298). Bródy's first publication in the field of mathematical modeling (co-authored with Rényi) was about the theoretical background of centrally managed price adjustment (Bródy 1956). In their view, prices with a given profit rate are generated in an iterative process of circular adjustment, where current prices are

computed from prices distorting the unit cost of the previous period. In this article they specified the conditions of convergence of such a process. Later Bródy recognized that this was simply a rediscovery of the infinite series solution of the Leontief model, yet, on the dual side.

In parallel to this research project, he was interested in the computational methods of economic planning. These were the two main sources of motivation to address the input-output models. First, Bródy published expository and supplementary papers (Bródy 1957, 1958, 1960) on input-output analysis. He showed that the margin of error in the results of input-output analysis is smaller than in the data. This is exactly Bródy's main argument for the application of this type of economic analysis, because it necessarily implies robust conclusions concerning the production structures, prices, and growth rates. In addition to theoretical research, he participated in the computation of the first Hungarian SAM in the Central Statistical Office (KSH) directed by György Péter.

In 1961, he defended his dissertation to the nomination of candidate of science (PhD), which was a synthesis of his knowledge of input-output analysis at that time. Also, it was his first attempt to clarify the Marxian background of these structures. He proved the uniqueness of production prices and the rate of profit (later he recognized that this proof was only a special case of von Neumann's proof (Kovács 1994, 314)).

In 1964, he continued his research on the application of input-output models at Harvard University, in Leontief's research group, where he worked with Anne Carter. In this framework they computed the main parameters for the United States. This work was carried out by using a high-performance computer, which was a significant experience for Bródy: he was impressed by the possibility of solving problems that require large data sets. Returning to Budapest, he completed his research project on input-output analysis by a final clarification of the theoretical background in the spirit of labor theory of value and especially of Marx. This was also a mathematical reformulation of Marx's theory of reproduction and a unification of linear-type economic models in the same mathematical structure. In 1969, he published his book, *Proportion, prices and planning: A mathematical restatement of the labor theory of value* (Bródy 1969) (also translated into English: (Bródy 1970)), in which he aimed to construct

a model that can be directly applied to data, which is numerically computable by using computers, and with which consistent economic plans can be generated.

In the preface of the Hungarian edition he asserted that the most important results centered around the "Growth rate of the components of production processes and production itself, the relationship between the value product and product value and the related dynamics, and the wealth of society and its change." (Bródy 1969, 10) The book starts with a mathematical model of simple reproduction.

When $\boldsymbol{A}$ denotes the matrix of technical coefficients of sectors, where the last column contains the coefficients for the reproduction of labor force (except the last element which is equal to zero) and the last row contains the average working time to produce the products in each sector; $\boldsymbol{x}$ denotes the vector of production levels and $\boldsymbol{y}$ denotes the vector of means of subsistence, then $\boldsymbol{x} - \boldsymbol{Ax} = \boldsymbol{y}$. Thus if $\boldsymbol{y}$ is given (for example, as a planning target), $\boldsymbol{x}$ can be determined using the so-called $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ Leontief-inverse (where the symbol $\boldsymbol{I}$ denotes the unity matrix), so that $\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y}$.

Bródy (1969, 42-43) emphasizes that if $\boldsymbol{Ax} = \boldsymbol{x}$, then this is exactly the case of simple reproduction (using Marxian terminology), since aggregate production equals aggregate consumption. Indeed, if $\boldsymbol{Ax} < x$, then expanded reproduction is possible (with $\boldsymbol{x} - \boldsymbol{Ax} > 0$ denoting the surplus product and where $\boldsymbol{Ax} > x$ corresponding to the case of narrowed reproduction (with $\boldsymbol{x} - \boldsymbol{Ax} < 0$ deficit). Then, he argues (using the Perron-Frobenius theorem) that since every product has to use labor as an input, matrix $\boldsymbol{A}$ is irreducible, and thus, if the highest eigenvalue of the coefficient matrix equals 1, then the economy is characterized by simple reproduction., On the other hand, if it is less than 1, then expanded reproduction is possible. In case of simple reproduction, the $(\boldsymbol{I} - \boldsymbol{A})$ matrix is nonsingular, thus, the Leontief-inverse exists and the matrix equation is solvable. However, the system is underdetermined, since the solution only gives the proportions of production and not its levels. Although if, for example, the sum of available working hours is given, then the production levels are also determined.

Bródy also incorporates in his book the duality relations of this production model, which is based on his earlier research with Rényi. Denote the vector of product values with $\boldsymbol{p}$, where the last element is unity, i.e., let labor force be the numéraire of the values. In case of simple

reproduction, the value of labor force equals the new value generated by it, that is, $\boldsymbol{pA} = \boldsymbol{p}$, which means that $\boldsymbol{p}$ is the left side eigenvector of $\boldsymbol{A}$. In addition, since the Leontief-inverse can also be interpreted as the infinite but convergent power series of the coefficient matrix $\boldsymbol{p} = (\boldsymbol{I} - \boldsymbol{A})^{-1} = \boldsymbol{I} + \boldsymbol{A} + \boldsymbol{A^2} + \boldsymbol{A^3} + \cdots$, that is, "values are determined by direct labor expended on the products plus labor expended on means of production used up in this process, plus labor expended on means of production used up in the process of producing the latter means of production, and so forth to infinity" (Bródy 1970, 28)

If $\boldsymbol{pA} < p$, then the expanded reproduction is possible with $\boldsymbol{p} - \boldsymbol{pA}$ accumulated surplus value and if $\boldsymbol{pA} > p$, then the economy is characterized by "value shortage".

After laying the foundations, Bródy (1969, 99-124) points out that his model is closely related to many other models. Indeed von Neumann's economic model, Leontief's dynamic model, the model of linear programming, and game theory (in fact, he considers only von Neumann's first game theoretical model (Neumann, 1928) of two-person zero-sum games) can be transformed into the same mathematical structure. In other words, a special basic form of these models leads to the same results from the same data. Thus, Bródy (1969, 99) argues that it does not matter whether the research is based on the "deterministic-causal" point of view of labor theory of value, or on the "optimizing-teleological" point of view of marginalism. To elaborate on this analogy, his argument is as follows. Let us consider the $\boldsymbol{Ax} = \boldsymbol{b}$ matrix equation. If one only intends to find the solution $\boldsymbol{x}$ of this equation, she proceeds according to the "deterministic-causal" approach, but if one transforms this problem into an optimization problem where she wants to find **x** that minimizes the residuum $\boldsymbol{r} = \boldsymbol{b} - \boldsymbol{Ax}$, she follows the teleological approach.

In the second part of the book, he addresses the possible extensions and applications of his model in socialist planning, including its attractive characteristics related to error computation and the possibility of computer implementation.

The Theory of Economic Motion

András Bródy was interested in the dynamics of the economy from the beginning of his scientific career. This interest was probably sparked by his early collaboration with Alfréd Rényi as they interpreted iterative price adjustment, which was a common practice in

economic planning, as a stochastic process. This approach is often mentioned in his publications (Bródy 1969, 1994, 2004), even in the static models of the equilibrium (stationary path) of Marxian reproduction processes, especially concerning the dual side. In an interview (Kovács 1994, 306), Bródy also mentioned that his research on economic systems always aimed to clarify first, the statics of the system, and second, its dynamics.

In his early publications, in parallel with the iterative price adjustment problem, he investigated the uneven characteristics of production in state-owned firms. His first explanation to this phenomenon was the forced increase of the intensity of work at the end of the month (*hóvégi hajrá*) (Bródy 1956b). The essential finding of this article is that the cyclical characteristic of production (mainly in the production of final products, which significantly influence the planning targets) is due to periodic accounting required by the administration. Bródy confirmed the existence of this phenomenon by statistics, since he examined not only the (often distorted) official production reports but also the energy consumption patterns, for example, in the central agency of power distribution. Moreover, he offered a behavioral explanation to the phenomenon, based on special incentives, which he thought to emerge from the nature of firms in planned economies.

In the early 1960's, he wrote papers on investment (Bródy 1961) and capital intensity (Bródy 1963), but his formative experience concerning research on economic dynamics was a meeting with Evsey Domar at MIT. Bródy attended his lectures when he visited Leontief's research group in Cambridge, MA. As he mentions in an interview (Kovács 1994, 315), once he returned to Budapest, his research on economic systems aimed to clarify the statics of the system, and the dynamics with and without technological development. This provided the basis for three of his books to be written later.

Bródy was convinced at this time that investment and savings are not balanced. Therefore he found Domar to be a like-minded person (Kovács 1994, 315). Bródy agreed with him that the inequality of investment and savings must be the basis of economic dynamics.

In 1965, he invented a simple model for economic growth, which was later published in the *Quarterly Journal of Economics* (Bródy 1966). In this paper he points out that the crucial element that restricts the possibility of growth is human capital, in the sense of the "production of workers" (Bródy 1966, 137). Thus, he starts from the closed dynamic Leontief

model, which he considers the "simplified and statistically implementable version of von Neumann's growth model'', where $\boldsymbol{x} = \boldsymbol{Ax} + \rho \boldsymbol{Bx}$. He suggests representing time with the diagonal matrix $\boldsymbol{T}$, which contains the t_i life spans. Then B can be replaced by $\boldsymbol{B} = \boldsymbol{TA}$ and $\boldsymbol{x} = (\boldsymbol{I} + \rho \boldsymbol{T})\boldsymbol{Ax}$.

Although, while in Budapest, he wrote a paper on the calculation of the equilibrium growth rate (Bródy 1967), in his first book where he gives the unification of many theories and categorizes the dynamic Leontief model as a multi-sectoral Harrod-Domar model, he contends that there does not exist a process for either of these equilibrium models, which converges to equilibrium. Thereby, he turns step by step (Bródy 1968, 1974, 1975) to the cyclical characteristics of economic systems.

In 1980, he published his second book entitled *Cycles and Control* (Bródy 1980) that explicitly attempts to formulate a mathematical model of the classical theory of markets and cycles. The word "classical" here refers to the works of Adam Smith, David Ricardo, Léon Walras, and naturally Marx. Bródy (1975 and 1980, 44) intends to derive the dynamic process of price formation from the classical texts. The dynamics of prices is not a uniform convergence toward equilibrium but a cyclical variation around it, which is analogous to the motion of the pendulum or that of planets. This form of motion, which implies a cyclical variation in quantities as well, is characterized by a kind of inertia. Hence it cannot be described by a first order differential equation as, for example, in the case of the *tâtonnement* process formalized by Samuelson (1941). However, it can be described by a system of second order differential equations where not the first, but the second time derivatives of prices are proportional with excess demand.

After having introduced these dynamic foundations, Bródy (1980) applies his concept to the Marxian model of production prices (which, according to him, is equivalent to many other, even "marginalist" models). Then he concludes (Bródy 1980, 138) that a consistent dynamic model based on the classics corresponds to the form of the economic motion outlined by Marx. This model can be applied to real data, and the forecasts computed from this model reflect the characteristics of real economic motion, and partly provide a numerical explanation of why real economies deviate from the (equilibrium) growth path.

He also mentions (Bródy 1980, 139) that the "standard view" concerning cycles was that they are caused by the market mechanism of capitalist production, although there existed cycles before the evolution of capitalist production, for example, the seven years of great plenty and seven years of famine in the Bible, and in socialist economies as well. Following this observation, he searched for short and long cycles not only in the economic history and demographic time series like in Kondratieff cycles (Bródy 1997, 1999a, 199b) but also in biological systems like the pig cycle (Kovács 1994, 340). Probably this interest was the main motivation to reconsider Goodwin's predator prey model (Goodwin 1967) in collaboration with a mathematician, Miklós Farkas. This idea also served as a foundation for his explanation concerning economic crises in the world and the errors of (mainly Hungarian) economic policy. He wrote many articles in newspapers and a book (Bródy 1985) about this topic, rather in a journalistic than scientific style.

Later Bródy modified his concept on the dynamics of economics when he became familiar with the mathematical tools of chaos theory. He posited that often there are neither stable equilibria nor stable cycles in the economy (Kovács (1994, 307-308)). Indeed, there are no analytically identifiable paths. The pattern of economic motion is similar to the so-called attractor in chaos theory. The change in economic variables appears completely irregular, but it stays near the equilibrium. In Bródy's opinion (in the 1990's), the most important question in economic research is what abstract forces hold the economy near the equilibrium. This is the central problem presented in his last book (Bródy 2004b).

János Kornai: an Easterner in the West and a Westerner in the East

János Kornhauser[67] was born in Budapest in 1928 as the son of a lawyer. His father worked at the German Embassy and dealt with the legal issues of German companies in Hungary. This profession provided an outstanding level of well-being for the whole family, to János and his two brothers and sister. They lived in a luxury apartment in the downtown of Budapest, and had a German nurse. The father was Jewish, thus, after Hitler's accession to power, he gradually lost most of his business contacts but maintained the family's living standard until his deportation.

[67] He changed his surname to Kornai in 1945.

János entered the German Imperial Highschool (*Német Birodalmi Gimnázium*), Budapest in 1933 where he studied every subject (including mathematics and physics) on a very high level in German language. Members of the Budapest intelligentsia sent their children there, this is how Kornai learned to know one of his best friends, Péter Kende who became a political scientist in Paris after the 1956 revolution. In 1941, Kornai had to switch to an ordinary highschool where the segregation of Jewish pupils was much stronger than in the German institution. After the occupation of Hungary by the German army in 1944, his father was transported to Auschwitz. János escaped from forced labor service and hid in a Jesuit Monastery until the Soviet army reached Budapest.

After his graduation in 1945, he entered the Hungarian Federation of Democratic Youth (*Magyar Demokratikus Ifjúsági Szövetség, MADISZ*) directed by the Communist Party. Kornai started studying the works of Stalin and Lenin and later the German original of Marx's Kapital with his friend Péter Kende. Kornai was impressed by these books and also by such charismatic communists as József Révai, editor in chief of the Party newspaper *Szabad Nép* and his later boss. Kornai had worked as an employee of MADISZ until 1947 when he was invited to be a journalist of the Party newspaper. In two years, he was appointed head of its economic section although he did not have a university degree[68]. Many of his articles were commissioned by head of the Economic Committee of the Party István Friss who became Kornai's superior at the Institute of Economics in 1955. Prior to that, Kornai, a follower of Imre Nagy, was fired from *Szabad Nép*. The dominant research methodology of the Institute could be labeled as naïve empiricism (Péteri 1997), and Kornai adhered to this approach by using empirical data for a simple but impartial description of economic phenomena. Before the 1956 revolution, Kornai was mostly influenced by György Péter who brought him textbooks and journals from the West and Péter Kende with whom he had long conversations about the consistency of Marxian political economy (Kornai 2004, 88). After the revolution, in a very disappointed state of mind, he set for himself a new goal to achieve: namely, joining Western economics (Kornai 2004, 144). He started reading mainstream literature on his own. First, he read the introductory books of Paul Samuelson (1948) and Erich Schneider (1958), both in German, and simultaneously learned to read English. Then, he studied Arrow (1951), Arrow-Karlin-Scarf (1958), Hicks (1946), Tinbergen (1949) and got acquainted with the "socialist calculation

[68] He entered the Faculty of Arts at the Eötvös University of Budapest but never finished his studies.

debate" by reading Hayek (1935), Lange (1936-37), Lerner (1948) and Bergson (1948) as well as the works of Eucken, Haberler, Pigou, Stackelberg, and Tinbergen (Kornai 2004, 134). He broke up with Marxism because of its inconsistency and unscientific character (Kornai 2004, 94).

Kornai's first scientific publication was his dissertation on overcentralization[69] (Kornai 1994 [1958])[70]. The defence of the dissertation took place one month before the 1956 revolution when Hungary sill seemed to be on her way to a major economic reform. Many economists and politicians endorsed Kornai's work. However, it was published after the Soviet invasion (Kornai 1957), and regarded as a 'revisionist' attack against the communist system. Not only leading party officials but also some former supporters, including the director of the Institute of Economics, and one of the most influential political manipulator of the Rákosi regime József Révai reconsidered their position. Kornai found himself in a difficult situation aggravated by the fact that he did not re-enter the Party after the revolution.

Following an investigation by a committee chaired by the rector of Karl Marx University László Háy, Kornai was fired from the Institute of Economics but, surprisingly, István Friss helped him continue research at the Planning Office of Light Industry (*Könnyűipari Tervező Iroda*) and later at the Research Institute of Textile Industry (*Textilipari Kutatóintézet*). Light industry provided him with the first evidence and motivation to deal with incentives and optimization. In that period, Kornai sympathized with mainstream ideas, and together with Tamás Lipták started working on the mathematical modeling of planning theory. Later, as an employee of the Computational Center of the Hungarian Academy of Sciences, he also tried to apply their model of two-level planning to the practice of central planning.

At the same time, an émigré took the Hungarian manuscript of the book on overcentralization and its English-language abstract to England. Anthony Jasay, a Hungarian-born economist read and sent it to John Hicks who proposed the book to Oxford University Press for publication (Kornai 1994 [1958]). While *Overcentralization* was not considered a scientific work by

[69] This dissertation earned him the degree of Candidate of Science, an equivalent of „PhD" in the Soviet educational system.
[70] The original Hungarian version was published as a book in 1957 (Kornai 1957).

Western standards, it was celebrated as the first credible description of how the command economy works.

After the publication of the book, Kornai was invited to LSE by head of the Economics Department Ely Devons. However, his application for a passport was refused several times. The first occasion for him to travel abroad came in 1962 when he took part in conferences in the GDR, Poland and Czechoslovakia. In 1963, Edmond Malinvaud, a main organizer of a conference of the International Economic Association invited him to Cambridge. The topic was 'Activity Analysis in Long Term Growth and Planning'. Kornai got the permission to participate but the secret police followed him closely (Kornai 2004, 175-180). At the conference he met Koopmans, Hurwicz, Dorfman, Hahn, Stone, Allais, Káldor, Robinson and many other authors of his previous readings. Moreover, Devons invited him again to the LSE to give a course on planning theory and practice. He spent a couple of months in London in 1964, where he met Alfred Zauberman and attended lectures by Phillips, Klein and Solow. Later, Arrow invited him to Stanford, Koopmans to the Cowles Commission, Hirschman to Princeton, and he spent one month in Washington at the World Bank in 1973.

When Kornai was in Stanford and at the Cowles, he showed the draft of his *Anti-Equilibrium* to Arrow and Koopmans. In this book, he intended to give a comprehensive criticism of general equilibrium theory. Although Arrow and Koopmans, two protagonists of the theory, helped strengthen his arguments, this book (Kornai 1968) caused a major break in Kornai's scientific career. The most conspicuous episode of the backlash was Frank Hahn's (1973) devastating review article, in which he criticized Kornai's naïve methodological standpoint, stressing that the critic failed to make a distinction between the consistency of a theory and its applicability. Seeing the fiasco of *Anti-Equilibrium*, Kornai turned to a research program that shows resemblance with the old institutionalist school, and became a highly esteemed expert of the economics of socialism but not of economic theory as such.

In 1967, István Friss took him back to the Institute of Economics. There Kornai organized a team following Western research standards and started working with mathematically well-trained younger economists. He was not allowed to hold official courses at the University of Economics until the collapse of communism but gave informal seminars and lectures to university students, for example, in the László Rajk College for Advanced Studies. In contrast

to the Robinson Crusoe-like research practice that characterized economic research in Hungary at the time, he instructed many younger scholars to read literature for him, to formulate his ideas in a mathematical form or to analyze empirical evidence whether it proves his hypotheses.

These joint efforts resulted in a number of projects and publications in the field of forced growth (Kornai 1972), control with non-price signals or 'vegetative control' (Kornai and Martos 1971, 1973 and 1981). The *Economics of Shortage* (Kornai 1980), a book he considers his magnum opus, introduced the concept of 'soft budget constraint'. This concept motivated by consumer's theory in microeconomics was intended to represent the situation where a socialist firm is bailed-out by the center when the revenues do not cover the costs. Kornai regarded this phenomenon as a basic building block of socialist economies. In 1984, he was appointed professor of Harvard University. Although he never cut his relations with Hungary[71], claiming that his research material lies on the Eastern side of the 'iron curtain', he had the chance again to work with mathematicians and mainstream economists. The mathematical model of the soft budget constraint was developed first by Weibull and later by Maskin and Dewatripont at Harvard.

In 1988 Kornai began to work on a synthesis of his all former studies of the socialist economy. However, the *Socialist System* (Kornai 1992) was published only after the 1989 revolutions. In 2002, Kornai returned to Hungary for good. Sometimes, he comments on changes in the Hungarian economy, gives advice in concrete questions but, similar to Bródy, never takes part in policy making.

Mathematical Theory of Planning

In his dissertation, which can be considered as the starting point for all his later works – in the field of both mathematical economics and institutional analysis of socialism --, Kornai provides a descriptive analysis of central planning based on mandatory planning targets. The book resulting from the dissertation (*Overcentralization*) is based on surveys and interviews with the managers of socialist firms. It summarizes the planning experiences of real production in light industry instead of providing an idealistic model of mandatory planning. Although there

[71] From 1984 to 2002, he spent half of the year in Cambridge (US) and the other half in Budapest.

are no reform proposals or explicit criticism in the dissertation, it contains some implicit value judgements on the overcentralized system. The book is intended to be a simple objective description of primary facts and hence, it does not use Marxian terminology.

The focus is on the incentives of the firms to fulfill the plan. Kornai points out that the most influential manual of production is the quarterly plan, which is determined by the branch ministries, thus, firm's decisions are never independent of politics. The conditions of decisions are embedded in a huge ambiguity and uncertainty. Since the planned system of reward and punishment always motivates the firms to manipulate the 'value of production', which is an exclusively quantity-based index, there are no incentives to increase the quality or to make innovations, just the other way round, a simple increase in material-intensive products in the plan is much more advantageous for the firm. Moreover, firms are never motivated to increase production over the planned quantities because of the 'ratchet effect'.

In doing research on planning in the light industry, Kornai kept on dealing with the role of incentives but turned to abstract modelling from descriptive analysis. At that time, increasing the share of profit in total revenue implied rewards for the managers and workers. This was a reformist attempt to ameliorate incentives. Kornai recognized that this program would have different outcomes as compared with that of simple profit maximization, which he thought to be the optimal solution. Allegedly, he tried to illustrate the difference by formulating two rudimentary linear programming models (Kornai 2005) but he was not sufficiently trained in mathematics to accomplish his purpose. Then, he started working with a mathematical genius Tamás Lipták who helped Kornai in correctly formulating his research problems and also to examine their mathematical properties. Moreover, Lipták gave him private courses in mathematics, which grounded his later research activities in the field of mathematical economics.

The formulation of incentive compatible optimization models led to very complicated nonlinear programming problems where the solution methods and even the analysis of solvability are not trivial. Although Lipták was arrested[72] in 1957, Kornai managed to publish their research results (Kornai and Lipták 1958) with the support of the Ministry of Light

[72] He took part in printing an underground paper (*Hungaricus*) on the 1956 revolution, spent one year in prison where he made an unsuccessful suicide attempt.

Industry (*Könnyűipari Minisztérium*). When Lipták came out from the prison, they wrote an English-language paper and, without asking their colleagues to check it, sent it by mail to *Econometrica*. The co-editor of the journal Edmond Malinvaud proposed the paper for publication in an unchanged form (Kornai and Lipták 1962).

The paper was written in the style of a Western journal article in mathematical economics since Lipták was familiar with the formal requirements of mathematics journals in the West. The authors stressed that they focused on a very special problem that cannot be generalized to interpret the whole socialist system, not even the Hungarian economy (Kornai and Lipták 1962, 161). They used both linear and nonlinear methods to clarify the differences between the "sum incentive" and "ratio incentive" settings with an additional analysis of price regulations and concluded that in the case of ratio incentives "firms never raise total output above normal capacity and often stay under it. On the other hand, it is worthwhile for the firms to produce whatever prices are". (Kornai and Lipták 1962, 160); the sum incentive setting is much simpler in terms of programming properties because the problems can be solved by decomposition and simple ordering while the ratio incentive setting needs much more complicated iterative methods of computation; and finally, the sum incentive setting is also easier to be implemented by the administration.

Parallel to theoretical research, Kornai – inspired by the works of Koopmans (1957) and Dorfman, Samuelson and Solow (1958) – launched an applied project to use linear programming methods in planning practice. First, he organized a group of light industry planners, engineers, experts of international trade and mathematicians/IT experts to model the choice between different technologies in cotton industry. More concretely, they investigated the most important exogenous variables of the outcomes, such as interest and exchange rates, technological parameters, etc. The emergence of this group generated competition between 'linear programmers' and 'input-output analysts'. The latter group led by András Bródy and later by Mária Augusztinovics had already had experience in this field, but Kornai emphasized that endogeneity of technology should be the key concept, which was not incorporated in the input-output models with fixed technological coefficients (Kornai 2005, 150).

The success of using these optimization models in planning of light industry motivated Kornai to extend this approach to that of the whole economy by decomposing the principal planning problem into linear programming subproblems. However, he recognized soon that the daily practice of the National Planning Bureau is different. There macro-indices are planned and then decomposed into sectorial indices. The sectoral ministries analyze these figures and a bargaining process between the sectors modify them. During this process the Central Planning Bureau reallocates the resources among the sectors and re-optimizes the planning targets.

This phenomenon of iterative bargaining served as the basic idea of two-level planning. Kornai constructed an economic model where the central planner allocates input and output quantity requirements among the sectors. Then, the sectoral planners solve their own optimization problem with some programming technique and send a feedback to the central planner in the form of shadow prices received from the solution of the dual problem. The feedback signals serve to balance the initial quantity allocations following the principles of market clearing process by price adjustment. The reallocation of quantities is followed by a new round of sectoral optimization and a second phase of feedback iteration. The iteration continues until the optimal plan is reached on both macro and sectoral levels.

The mathematical model for these procedures was built by Tamás Lipták again. He proposed to reformulate the bargaining part of the problem in a game theoretical framework. This was a really innovative idea because in the early 1960s game theory was not widely used in Western mathematical economics either. The paper containing this combined programming and game theoretical method was once again sent to *Econometrica* that published it in 1965.

In the paper the authors introduce, on the one hand, the "over-all central information problem (OCI)" (Kornai and Lipták 1965, 144) represented by a primal-dual pair of linear programming models:

$$\mathbf{Ax} \leq \mathbf{b}, \mathbf{x} \geq \mathbf{0}, \mathbf{c}'\mathbf{x} \rightarrow \boldsymbol{max} \qquad \mathbf{y}'\mathbf{A} \leq \mathbf{c}', \mathbf{y} \geq \mathbf{0}, \mathbf{y}'\mathbf{b} \rightarrow \boldsymbol{min}$$

where **x** denotes the vector of gross production of each product, **y** denotes the shadow prices, **A** is the matrix of technological coefficients and **a**, **b** are the vectors of policy parameters. Let us denote the set of feasible programs X and Y and optimal programs X* and Y* in a way that

$$\mathrm{X} = \{\mathbf{x}: \mathbf{Ax} \leq \mathbf{b}, \mathbf{x} \geq \mathbf{0}\} \qquad \mathrm{Y} = \{\mathbf{y}: \mathbf{y}'\mathbf{A} \leq \mathbf{c}', \mathbf{y} \geq \mathbf{0}\}$$

$$\mathrm{X}* = \{\mathbf{x}*: \mathbf{x}* \in \mathrm{X}, \mathbf{c}'\mathbf{x}* = \mathbf{max}\ \mathbf{c}'\mathbf{x}\} \qquad \mathrm{Y}* = \{\mathbf{y}*: \mathbf{y}*'\mathbf{b} = \min \mathbf{y}'\mathbf{b}\}.$$

On the other hand, Kornai and Lipták introduce the sectoral programming problem analogously to OCI for every sector *i* in a way that

$$\mathrm{X}_i(\mathbf{u}_i) = \{\mathbf{x}_i: \mathbf{A}_i\mathbf{x}_i \leq \mathbf{u}_i, \mathbf{x}_i \geq \mathbf{0}\} \qquad \mathrm{Y}_i(\mathbf{u}_i) = \{\mathbf{y}_i: \mathbf{y}_i'\mathbf{A}_i \leq \mathbf{c}_i', \mathbf{y}_i \geq \mathbf{0}\}$$

$$\mathrm{X}_i*(\mathbf{u}_i) = \{\mathbf{x}_i*: \mathbf{x}_i* \in \mathrm{X}_i, \mathbf{c}_i'\mathbf{x}_i* = \mathbf{max}\ \mathbf{c}_i'\mathbf{x}_i\} \qquad \mathrm{Y}_i*(\mathbf{u}_i) = \{\mathbf{y}_i*: \mathbf{y}'_i*\mathbf{u}_i = \min \mathbf{y}_i'\mathbf{u}_i\}.$$

The feasibility relation between the sectoral programs and OCI is given by the following equation:

$$\mathbf{u_1} + \cdots + \mathbf{u}_n = \boldsymbol{b}.$$

If one denotes the optimum values of the sectoral problems by $\varphi_i(\boldsymbol{u}_i) = \mathbf{c}_i'\mathbf{x}_i* = \mathbf{y}'_i*\mathbf{u}_i$ and $\varphi(\boldsymbol{u}) = \varphi_1(\mathbf{u}_1) + \cdots + \varphi_n(\mathbf{u}_n)$. Let *U* denote the set of feasible **u** central programs and $U* = \left\{\boldsymbol{u}*: \varphi(\boldsymbol{u}*) = \max_{\boldsymbol{u}\in U} \varphi(\boldsymbol{u})\right\}$ the set of optimal central programs.

In the first step of the two-level planning procedure the central planner determines $U*$, the set of optimal central programs. In the second step at the sectoral level every sector solves its problem for each optimal central program $\boldsymbol{u}*$. The third step is the composition of the central problem's solution set as a combination of the sectoral solution sets.

Thereafter, the authors reformulated the level planning problem as a "polyhedral game" (Kornai and Lipták 1965), in which the agents are the central planner and the sectoral planners. The strategy set of the central planner is *U*, the set of feasible central programs and the strategy sets of the sectoral planners are the Y_i sets of sectorial dual vectors (shadow prices). If $\boldsymbol{v} \in Y_1 \times \cdots \times Y_n$ is a strategy profile of sectors, then $\boldsymbol{v}'\boldsymbol{u}$ can play the role of payoff function of the whole game.

Lipták proved first that there exists a bounded nontrivial solution for the two-level planning problem if the corresponding OCI problem is solvable. He claimed that the optimal strategy in the polyhedral game coincides with the optimal central program in the two-level planning problem and the optimal sectoral strategies, in which all sectoral components are equal, forming an optimal shadow price system in the two-level planning problem.

This paper became Kornai's most influential work in mainstream economics. The reason for the success was due to the model's similarity to the mathematically reformulated Lange model of market socialism published by Malinvaud (1967). However, in the Lange-Malinvaud model top-down information from the center is mediated by prices, in contrast to the Kornai-Lipták model where it is communicated by quantities. The bottom-up information coming from the sectoral planners is transformed by quantities in the Lange-Malinvaud model to make the size of excess demand or supply transparent while in the Kornai-Lipták model this feedback is mediated by (shadow) prices.

Beyond theorizing, Kornai was also interested in the application of his new model. In the period of political thaw, in 1962-1963, he got a new job at the Computational Center of the Hungarian Academy of Sciences where the first mainframe computer had been installed in Hungary. There, in collaboration with the Research Institute of the Planned Economy (*Tervgazdasági Kutatóintézet*), he organized a team to implement the two-level planning concept. As a first step, they built one central and 18 sectoral models and created many sub-teams to work out the details of their own fields. In the most productive period of research about 200 employees worked on this project and Kornai edited information brochures to make the method popular among decision makers and funders.

He deliberately avoided confrontation with politics, and never questioned the legitimacy of weights assigned to different sectors. Instead, he treated them as constraints, and the objective function of the model was a neutral index such as the balance of current account (Kornai 2004, 165). Moreover, his purpose was to contribute only to the long- and medium-term plans and not to the yearly directives.

During the application of the two-level planning concept, it turned out that finding the solution of the original model is complicated in terms of computation, hence, one had to radically simplify the model and create a more simple version to illustrate its utility for decision makers. The results of the simplified version were much less precise, the input data were unreliable, and the policy makers always changed and never clearly declared the objectives and even the constraints. Moreover, the computation process was too slow to support decision making in such an environment and the impact of analysis was also ambiguous because policy makers took the results seriously only if those supported their preconceptions. Therefore, the

enthusiasm of the team decreased and following five years of hard work, Kornai abandoned leadership.

After 1965, the collaboration between Lipták and Kornai was interrupted. Lipták who suffered from a serious mental disease emigrated to the UK, and did not continue scientific research. Later Kornai summarized the experience of implementing their model (Kornai 1967) and tried the review the theory and practice of mathematical planning (Kornai 1965, 1973), but at the end of the 1960's he basically left behind mathematical economics forever.

Out of the Trap? Tentative Conclusions

To return to our working hypotheses, in the previous sections we witnessed how difficult it was for the adherents of optimal planning to leave this research program behind and release themselves from the trap that prevented them from becoming "regular" neoclassical theorists prior to 1989. In fact, they could not help facing[73] a long chain of serious shortcomings. They were shocked to realize that – despite improving the mathematical quality of their models and raising the capacity of computers to run them – their optimization efforts repeatedly stumbled upon the institutional/informational regime of the planned economy.

The optimal planners may have expected that, with the advent of the New Economic Mechanism in 1968, the termination of annual plans, and a shift from mandatory instructions to "indirect regulators," the "controlled market" would enhance transparency and accuracy by disciplining the actors through competition while some political taboos might disperse. Instead, they saw an even more chaotic system of planning arise, in which plan bargaining was replaced or complemented by "regulatory bargaining," to use the contemporary phrase. Apparently, capturing such a complexity of bargaining games by means of numerous small models of optimization instead of constructing a single Big Optimal Plan did not prove an attractive (or viable) scientific venture for mathematical economists in Hungary.[74] Yet, here

[73] Facing the difficulties was not tantamount to admitting and explaining the failure. Just like Bródy and Kornai, the other former champions of optimal planning in Hungary also have not given a detailed historical account to this date about how and why their project ceased to exist.

[74] Tardos (1968) tried to build a formal model for the regulation system of NEM, which was based on the Dorfman-Samuelson-Solow model of linear programming but did not test it by means of detailed calculations. Among those who started working on optimal planning at the turn of the 1950s and 1960s, just a very few (such as András Nagy and Tardos) anchored themselves in reform economics so firmly that, from the 1970s onward, they stopped building quantitative models. This also meant that their interest in new institutional economics did not result in authentic formal models describing the planned economy undergoing market reforms.

again, an exchange of ideas with new institutional economists in the West probably could have been beneficial for both sides and paved the way for the Hungarian experts to reconcile themselves with neoclassical ideas without having to fear from ignoring real-world problems.

Unfortunately, the empirically grounded insights in the imperfections of optimization were not condensed in elegant scholarly theses. Instead, they sank into the tacit knowledge of mathematical economists. The research community of optimal planning in Hungary did not rethink the Socialist Calculation Debate in the light of the dismal experience of mathematizing central plans, challenging the axiom of rational economic calculation under communism.[75] Many of its members continued to refine the methodology of planning and moderate the worst outcomes of the bargaining games. They relaxed the initial – often prohibitively strict – assumptions, eliminated some of the simplifications of their models requiring homogeneity, linearity, closedness, determinism, staticness, and so on, and fine-tuned the estimation of data. The remedies also included disaggregation and "monetization" of the models, incorporating human capital and foreign trade and decentralizing the planning procedures (Augusztinovics 1981; Réti et al. 1981; Augusztinovics 1984, 43–85; Augusztinovics and Bod 1985; Ámon and Ligeti 1987; Sivák 1987). At the same time, the mathematical economists did not suggest any substantial change to the planning regimes. They, including Bródy and Kornai, demand neither an irrevocable transition from imperative to indicative planning nor at least the dismantling of the central planning of capital investments, a major obstacle to marketization under the NEM.[76]

Those experts who were not locked up in the treadmill of the daily fabrication of plans turned to long-term planning,[77] which was much less exposed to the interplay of lobby interests than

[75] Kornai (1986b, 1725–28) accepted some of Hayek's views indirectly, through passing judgement on Lange. It was only in 1991 that, criticizing state-led privatization, Kornai (1992a) referred to the Hayekian stance against "constructivism" approvingly the first time. In his book *The Socialist System* he admitted that "Hayek was right on every point in the debate [on socialist calculation]" (Kornai 1992b, 476).

[76] For example, as shown earlier, Kornai (1967a [1975])was still optimistic about centrally planned investments, and a total abolition of directive planning did not feature even in his writings on market reform during the second half of the 1980s (e.g., Kornai 1986b). Here, he rejected the attraction of "Galbraithian socialists" to large-scale state intervention but avoided to suggest the termination of five-year plans or at least of the gigantic central development programs. In his opinion, "*ex-ante* coordination" (whatever it may have meant) should have remained an important task of the central planner (1710, 1730–32).

[77] For example, Augusztinovics played a leading role in modeling long-term plans for 1970–85, 1975–90, and 1980–2000. These were the least risky types of central plans: they were regarded as futurological visions rather than regular plans that had to be endorsed by the Politburo and fulfilled by the economic actors at all levels of the hierarchy.

five-year plans. True, it was with diminishing hope that they were waiting for the arrival of an enlightened technocratic elite, to which they could have handed over a Great Plan of modernizing the Hungarian economy during the 1970s and 1980s. While planning became a less popular scientific undertaking, input-output models were prepared even in the 1990s (e.g., Halpern and Molnár 1997), and the perfection of I-O theory was not terminated for good. Besides Bródy, one of his followers, Ernő Zalai (1997, 2014), kept on publishing in this field during the 2000s. As to Augusztinovics, she closed the story of the research program by saying that "the heyday of Input-Output as a simple, transparent, deterministic, static linear model is […] certainly over." She added though that its "subject matter has not been lost, […] it has merely been transformed, incorporated into more complex structures. The subject matter […] is the dual and circular nature of the economy in general" (Augusztinovics 1995, 275).

What about the two pioneers? Did the bifurcation of their research programs result in differences in their assessment of neoclassical theory? As suggested above, Bródy chose another way out of the trap. He lost faith in educating the communist decision-makers through planning models early on, and did not trust in market reforms either since he had second thoughts about both the efficiency of market coordination and the altruism of communist bureaucracy that was supposed to manage marketization – something that probably would jeopardize its own integrity.[78] Therefore, he elevated his research program to a higher level of abstraction and made efforts to identify organic links between the Marxian theory of labor value and input-output analysis (later even claiming that neoclassical theory is a special case of them) – not quite the best rite de passage to become a neoclassical economist. Remaining in the realm of mathematical economics, Bródy strived to prove that all economic systems suffer from cycles, any convergence toward market equilibrium is actually a cyclical oscillation around that, and economic dynamics can best be explained through a combination of classical (including Marxian) theory of labor value and marginalism – a contention again that did not really match standard neoclassical principles. As for his self-image, Bródy (1994, 325) liked to characterize himself as an heir of the classical tradition.

[78] Bródy's (1978, 180) opinion about state planning in both the East and the West was more than skeptical: planning "can be hardly left to the usual sort of politicians who will promise whatever is popular […] and have a time horizon much shorter than the horizon considered in an economy-wide plan. […] A plan is actually conserving the very power structure that gave rise to it."

Kornai's was perhaps a more complicated case. It was neither an attraction to Marxism nor a high-level mathematical understanding of economic dynamics that prevented him from subscribing to the neoclassical paradigm. Unlike Bródy, he was not animated by abstract concepts of economic development ranging from the Neumann model to chaos theory, and distanced himself from both Marx (tacitly, quietly) and the neoclassical school (openly, loudly). Rather than finding the institutional architecture of the communist economy responsible for the failure of optimal planning, he blamed – with a dose of self-criticism – the "neoclassical illusions" blinding mathematical economists like himself. In passing, he alluded to the Socialist Calculation Debate and – while Bródy did not defy the legacy of Lange – Kornai disliked the Lange tradition as an unfortunate mix of Marxist and neoclassical thought and dropped skeptical remarks on Lange's "naiveté" in postulating a fruitful cooperation between the state plan and the regulated market. Here, he made no distinction between Hayek's classical liberalism and the neoclassical view of the market: both of them were rejected as laissez faire doctrines. After having left optimal planning behind, he continued to define himself as a mathematical economist but insisted on many of his former doubts about neoclassical thought. [79] Being "one foot out," however, prevented him from building new mathematical models as powerful as earlier.

Arguably, the failure of optimal planning did not prompt the two pioneers to critically examine the deep layers of the institutional world of the planned economy, no matter how knowledgeable they were about not only the economic sociology but also the social anthropology and psychology of central planning's main actors.[80] Refraining from thorough institutional studies could be justified by (self-)censorship and – until the mid-1960s – by the hopelessness of far-reaching economic reforms. Nevertheless, with the New Economic Mechanism appearing on the political agenda, ideological cautiousness did not require persistent skepticism toward the efficiency of market control, particularly not a frontal attack on neoclassical theory. As presumed in the first pages of our chapter, such attitudes and

[79] Augusztinovics (2000, 17) was even more mistrustful: "the neoclassical theory does not want to understand but to cover up the reality of the capitalist economic system."

[80] As young scholars in the 1950s and 1960s, Bródy and Kornai did empirical research in numerous firms (engineering and textiles, respectively) and gathered ample insider experience also about how the Planning Office and various branch ministries worked.

actions can hardly be explained if the historian solely focuses on political fears and ignores scientific preferences.[81]

It is our hope that the story we have told about the evolution of planning concepts in Hungary shed light on a whole series of sources of those preferences: Marxist indoctrination, misinterpretation of neoclassical theory as a bundle of abstract (unrealistic) ultra-liberal ideas, seeking a modus vivendi between communist and capitalist fundamentalisms, pride felt for authenticity and equality with the West in terms of scholarly discoveries, inertia of a large and initially promising research program, self-deception promoted by Western peers, and so on. Let us leave aside the questions of how justified and coherent these motives were and which author was inspired by which of them the most. Rudimentary answers to them were scattered in the notes attached to this chapter. Be as it may, it was the same motives (fixations?) that helped the former adherents of optimal planning avoid entering other dead-end streets, favored much too long in a number of communist countries, such as the decentralization of planning (e.g., on the basis of workers' self-management or on that of mega-enterprises) or, on the contrary, the organization of vast – centralized and automated – planning systems spirited by a sort of "computopia."

The I-O analysts and the optimal planners had to accept the inevitable: what they once thought would become a hegemonic discourse and planning technique remained a negligible, auxiliary tool in the hands of the top apparatchiki of the party-state. Over time, hegemony was attained by another group of economists, the market reformers, by far the largest segment of the research community in Hungary. Witnesses to the failure of rationalizing the plan, they were comforted in their conviction that the agenda of marketization of the planned economy had no real alternative: depending on the boldness of their project, they claimed that central planning must be tamed or dismantled – but not optimized. The failure of optimal planners strengthened the pre-existing suspicion of many institutional reformers toward

[81] The trauma of the post-1956 retributions had a long afterlife. Kornai was not fully rehabilitated by his return to the Institute of Economics in 1967; the secret police did not stop harassing him from time to time. The last time Bródy had to undergo a disciplinary procedure in the communist party was in 1988. Yet, their fears stemmed increasingly from concerns about losing their jobs and privileges such as relative freedom of thought and travel as well as proximity to top decision-makers in the reformist camp while their worries about violent repression dwindled. Nevertheless, forced emigration (like in the case of some members of the Budapest School in the 1970s) remained a credible threat.

mathematical analysis as such, which in turn blocked their road leading to neoclassical economics.[82]

Postscript on Econometrics

The examples of Bródy and Kornai as well as their disciples demonstrate another comparative advantage vis-à-vis their colleagues in many communist countries. During the 1970s and 1980s, a growing number of mathematical economists in Hungary turned their backs on the normative strategy of improving central plans.[83] Although this turn was unspectacular, the program of producing a sound analysis of the planned economy (not just planning as such) with the help of mathematical instruments eventually replaced the intention of enlightening the nomenklatura and supporting the communist regime through "science-based" plans. While it was not always clear where optimal planning ended and where econometrics started,[84] many of the younger experts refused to construct overarching planning models and shape countrywide economic policies any longer. They indulged in econometric research and – after experiencing the imperfections of their own simultaneous macro-models – contented themselves with smaller-scale research projects that were to comprehend the real world of certain segments of the planned economy. The econometricians' scholarly choices stemmed neither from a deep sociological/political critique of planning under communist rule nor from a devotion to neoclassical principles. Nevertheless, they nolens volens kept a larger door open for Westernizing their research programs than I-O experts and optimal planners earlier (Kőrösi 1996).

Their role was controversial in other respects as well. In the field of quantitative economic research in general, empirical analysis was neglected for a long time. In retrospect, this may be surprising because in Hungary empirical studies served as a bridge connecting pre- and post-communist economic sciences. Subdisciplines such as labor and educational economics,

[82] For more on this, see Kovács (2012, 2016).

[83] For example, Gács and Lackó (1973) was a promising attempt to examine the behavior of central planners (instead of helping them improve planning) but their early initiative was hardly followed by their colleagues.

[84] Kornai, for example, abandoned optimal planning, in which he had relied on econometric analyses, continued to apply econometric research in his later works, was active in the Econometric Society, but – as mentioned – insisted on the broadest possible designation and preferred to call himself a mathematical economist. This is how he remembered mathematical economics in Hungary during the 1960s: "we <two-levelers> formed one faction, but other groups emerged as well, such as the <input-outputters,> the econometricians, and the operations researchers. They often overlapped" (Kornai 2007, 153).

health economics, financial economics, and empirical industrial organization, which applied econometric methods extensively, progressed more rapidly during the past decades. The roots of neglect stretch back to the early period of communism.

Back in the 1950s and early 1960s, empirical works containing statistical arguments were sporadic in Hungarian economic research. As mentioned, the foundation of the Econometric Laboratory at the Central Statistical Office brought some fresh wind into quantitative studies although its econometric investigations were not concatenated with models of mathematical economics in a way suggested, for instance, by the Cowles Commission's slogan of "theory and measurement."[85] Mathematical economists mostly avoided confronting their models with empirical data; therefore, the stage of verification was absent in their research agendas. This cannot be explained simply by the lack or bad quality of empirical information. Data served as a source of inspiration to generate a model (cf. Bródy's theory of cycles and Kornai's concept of overcentralization) or to support economic policy arguments (cf. the Laboratory's model series) rather than to precisely corroborate or falsify scientific hypotheses.[86]

During the 1970s, the situation changed slightly. The I-O models started including stochastic blocks (e.g., Hulyák 1972). The parameter estimations of production functions and the regression analyses of macro data began to infiltrate, quite unsystematically, the theoretical arguments instead of only helping solve practical problems and fill the input-output tables and SAM matrices. The authors were mostly self-made econometricians who chose their topics and methods often accidentally.[87] In the late 1970s and the 1980s, macro-econometric models still used the already outdated method of simultaneous equations (Kőrösi 1996, 359). The critique of simultaneous macro-econometric models (Lucas 1976; Sims 1980) did not affect this attitude for a while.[88]

[85] In the beginning, it was only Ede Theiss who worked in the spirit of this slogan in Hungary. He died at the end of the 1970s.

[86] Kornai later became an exception in this regard when his disciples helped him verify the empirical relevance of his concepts.

[87] For instance, at the Institute of Economics Mária Lackó investigated investment cycles, Miklós Ördög worked on the estimation of consumption functions, and György Simon on that of sectorial production functions. The example of László Hunyadi is revealing. As a self-taught econometrician, he had worked on planning models until – completing a large project on the impacts of change in energy prices on the Hungarian economy – he realized that the Planning Office ignored such econometric analyses, and in the mid-1980s he decided to move to Karl Marx University to teach instead of struggling for recognition within the economic administration (Hunyadi 2014).

[88] Yet, the first article in Hungary on the "Lucas critique" was published by Kamilla Lányi as early as 1977.

A turn to more professional econometric research came only in the second half of the 1980s and in the 1990s. Younger researchers left I-O analysis and optimal planning for fields that were less macro-oriented and required robust evidence-based reasoning. To use the example of the Institute of Economics again, Halpern and Molnár started studying household statistics and corporate data that led them to so diverse research projects as the analysis of subjective welfare and industrial organization. Labor economists such as István Gábor, Károly Fazekas, János Köllő, and Gábor Kertesi explored employment and educational data and drew conclusions also with regard to gender and race economics.[89] A detailed case study made in the textile industry introduced some of them to both empirically and theoretically grounded procedures of neoclassical research.

The recognition of the problematic aspects of old-fashioned macro-econometric analysis discouraged some of the experts and micro-data methods became more popular. However, during the 1980s, there was no institution of higher education in Hungary to teach economists applied econometrics. Econometrics at the universities was regarded as part of the "high theory" of mathematical statistics. Symptomatically, the first generation of new-school econometricians like Gábor Kőrösi and László Mátyás learnt cutting-edge methods while teaching abroad (in Australia) in the 1990s, and returned to Hungary to cooperate with economists whose interest in micro-data analysis was greater than their knowledge of econometric methodology.

However, prior to 1989, this process of catching up with the West was not yet accompanied by a large-scale takeover of neoclassical principles and by a profound reconsideration of former assumptions and axioms of mathematical modeling, although a few young scholars (e.g., Imre Csekő, Júlia Király, János Vincze) decided to build their scientific careers on cultivating mainstream micro- and macroeconomics and finance.[90] A good example for the inertia of economic thinking was the way in which the computable general equilibrium (CGE)

[89] Interestingly enough, a main motivation of this group came from sociologists (such as László Füstös and Róbert Manchin) who already applied first-generation statistical software (e.g., Socprog) in their empirical surveys, launched by István Kemény, on poverty and ethnicity (Köllő 2021).

[90] The attraction of neoclassical concepts for certain econometricians survived Kornai's attack on general equilibrium theory. For example, when Ziermann (1977) reported on the annual meeting of the Econometric Society she presented not only the new results in times series analysis (to which she also contributed in the field of dynamic factor analysis) and multivariate regression but also in research on Pareto efficiency and decentralized allocation mechanisms.

approach was received in macro-level modeling (Zalai 1983). Due to the flexibility of this approach, it could be used in input-output tables and SAM matrices without subscribing to the underlying philosophy of general equilibrium theory.91 Similarly, the real business cycle (RBC) model proved too neoclassical to be adopted by Hungarian economists before 1989.

In sum, Hungarian econometricians built new pillars to support the bridge that input-output analysts and optimal planners had begun to erect in the late 1950s but only a few of them proved able to reach neoclassical economics situated on the opposite side of the abyss separating them. No matter how robust and sophisticated the new quantitative models became in comparison to those formulated by optimal planners, econometrics in communist Hungary (a) did not excel with significant original discoveries, and (b) failed to evolve into a compact discipline in close cooperation with micro- and macroeconomic theories. Unlike their peers beyond the Iron Curtain, Hungarian econometricians indulged in applied rather than basic research, the applications were scattered over a random variety of topics and were not underpinned by a tightly woven net of neoclassical concepts. In a sense, they moved ahead too quickly in the 1980s: they had to wait for the breakthrough of the other two core disciplines of neoclassical thought, micro- and macroeconomics, to progress further.

[91] Interestingly, the inertia was not overcome by some of promising international ventures (such as the LINK project, in which András Simon represented Hungary and the IIASA (International Institute for Applied Systems Analysis) where Ernő Zalai spent years in the first half of the 1980s) since these research communities were more pluralistic and did not exclusively favor the idea of general equilibrium.

Bibliography

Ámon, Zsolt, and István Ligeti. 1987. “A tervezés kvantitatív módszereinek fejlesztése.” *Tervgazdasági Fórum* 3 (3): 101–10.

Andorka, Rudolf, Béla Martos, and György Szakolczai, eds. 1967. *Dinamikus népgazdasági modellek*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Andorka, Rudolf. 1970. *Mikromodellek*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Arrow Kenneth. 1979. *Egyensúly és döntés*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Augusztinovics, Mária. 1964. “Ankét a matematikai módszerek gazdasági alkalmazásáról.” *Az MTA Társadalmi-Történeti Tudományok Osztályának Közleményei* 14 (1–2): 65–68.

———. 1975. “Integration of Mathematical and Traditional Methods of Planning.” In *Economic Planning, East and West*, edited by Morris Bornstein, 127–48. Cambridge: Ballinger.

———, ed. 1979. *Népgazdasági modellek a távlati tervezésben*. Budapest: Közgazdasági és Jogi Könyvkiadó. 1984. *Long-Term Models at Work*. Budapest: Akadémiai Kiadó.

———. 1981. “Népgazdasági modellszámítások a VI. ötéves terv kidolgozásához.” *Szigma* 14 (4): 229–38.

———. 1995. “What Input-Output Is About.” *Structural Change and Economic Dynamics* 6 (3): 271–77 (1996. “Miről szól az input-output modell?” *Közgazdasági Szemle* 43 (4): 313–20).

———. 2000. “Pénz és terv – modellek és emberek.” Interview by Krisztina Megyeri. In *Racionalitás és méltányosság*, edited by Júlia Király, András Simonovits, and János Száz, 7–20. Budapest: Közgazdasági Szemle Alapítvány.

———. 2008. “Beszélgetés Augusztinovics Máriával.” Interview by Miklós Lakatos. *Statisztikai Szemle* 86 (12): 1163–70.

———. 2012. Interview with Mária Augusztinovics by András Pinkász, May 30, 2012. Manuscript.

Augusztinovics, Mária, and Péter Bod. 1985. “Practical Linear Programming in Macroeconomic Planning: The Case of Hungary.” *European Journal of Operational Research* 22 (2): 204–15.

Balassa, Ákos. 1979. *A magyar népgazdaság tervezésének alapjai*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Bauer, Tamás. 1981. *Tervgazdaság, beruházás, ciklusok*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Baumol, William. 1968. *Közgazdaságtan és operációanalízis*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Bihari, Péter, Lajos Bokros, Júlia Király, and András Vértes. 2018. “A Kornai-hatás.” *Köz-Gazdaság* 13 (1): 29–44.

Bod, Péter et al., ed. 1962. Az ágazati kapcsolati mérlegek összeállításának és felhasználásának kérdései. Budapest: Akadémiai Kiadó.

Bornstein, Morris, ed. 1975. *Economic Planning, East and West*. Cambridge: Ballinger.

Bródy, András. 1956. “A hóvégi hajrá és gazdasági mechanizmusunk.” *Közgazdasági Szemle* 3 (7–8): 870–73.

———. 1957. “Input-output: Módszer a nemzetgazdasági folyamatok elemzésére.” *Közgazdasági Szemle* 4 (2): 145–65.

———. 1958. “Az ágazati kapcsolatok mérlegének elméletéhez.” *Közgazdasági Szemle*, 5 (8–9): 823–36.

———. 1960a. “Az ágazati kapcsolatok mérlege és a közvetett beruházások.” *Közgazdasági Szemle* 7 (5): 561–80.

———. 1960b. “A közgazdasági <modellek> kérdéséhez.” *Közgazdasági Szemle* 7 (8–9): 954–63.

———. 1962a. *Matematikai programozás: 1. Lineáris programozás*. Budapest: Tankönyvkiadó.

———. 1962b. *Matematikai programozás: 2. Sztochasztikus programozás*. Budapest: Tankönyvkiadó.

———. 1962c. “The Unicity of the Prices of Production and of the Average Rate of Profit.” In *Input-Output Tables: Their Compilation and Use,* edited by Ottó Lukács et al., 243–49. Budapest: Akadémiai Kiadó.

———. 1964. *Az ágazati kapcsolatok modellje: A felhasznált absztrakciók, azok korlátai és a számítások pontossága*. Budapest: Akadémiai Kiadó.

———. 1966. “A Simplified Growth Model.” *The Quarterly Journal of Economics* 80 (1): 137–46.

———. 1969. “The Rate of Economic Growth in Hungary, 1924–1965.” In *Is the Business Cycle Obsolete?*, edited by Martin Bronfenbrenner, 312–27. New York: Wiley.

———. 1970. *Proportions, Prices, and Planning: A Mathematical Restatement of the Labor Theory of Value*. Budapest–Amsterdam: North-Holland. Originally published as 1969. *Érték és újratermelés: Kísérlet a marxi értékelmélet és újratermelési elmélet matematikai modelljének megfogalmazására*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1973. “Szabályozási modellekről.” *Szigma* 6 (2): 93–103.

———. 1978. “Planning and Planning: Some Comments on Professor Wassily Leontief's Proposals.” *Acta Oeconomica* 20 (1–2): 179–81.

———. 1980. *Ciklus és szabályozás: Kísérlet a klasszikus piac- és cikluselmélet matematikai modelljének megfogalmazására*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1981. “Készletről és nyereségről vezérelt zárt gazdaság.” In *Szabályozás árjelzések nélkül*, edited by János Kornai and Béla Martos, 135–46. Budapest: Akadémiai Kiadó.

———. 1985. *Slowdown: Global Economic Maladies*. Beverly Hills: SAGE Publications.

———. 1990. “Prices and Quantities.” In *The New Palgrave: Problems of the Planned Economy*, edited by John Eatwell, Murray Milgate, and Peter Newman, 218–26. London: Macmillan.

———. 1994. “Beszélgetés Bródy Andrással.” Interview by János Mátyás Kovács. In *Miért hagytuk hogy így legyen? Tanulmányok Bródy Andrásnak*, edited by Aladár Madarász and Judit Szabó, 271–348. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1995. “Truncation and Spectrum of the Dynamic Inverse.” *Economic Systems Research* 7 (3): 235–47.

———. 1997a. “A kétszáz éves ciklus és az Egyesült Államok I: A növekedési ráták alakulása.” *Közgazdasági Szemle* 44 (2): 113–23.

———. 1997b. “A piac és az egyensúly: A neumanni és a kvázi-hamiltoni rendszer.” *Közgazdasági Szemle* 44 (9): 738–55.

———. 1999a. “A kétszáz éves ciklus és az Egyesült Államok II: A kamatráták alakulása.” *Közgazdasági Szemle* 46 (1): 35–44.

———. 1999b. “Rövid vagy hosszú ciklus? Új előrejelzés az ezredfordulóra.” *Közgazdasági Szemle* 46 (7–8): 701–8.

———. 2004a. “Leontief zárt dinamikus modellje: Megoldások és értelmezések.” *Közgazdasági Szemle* 51 (10): 924–35.

———. 2004b. *Near Equilibrium*. Budapest: Aula Könyvkiadó.

Bródy, András, and Alfréd Rényi. 1956. “Az árrendezés problémája.” *Az MTA Matematikai Kutatóintézetének Közleményei* 1 (3): 325–35.

Bródy, András, and Anne Carter, eds. 1970a. *Contributions to Input-Output Analysis*. Amsterdam: North Holland.

———. 1970b. *Applications of Input-Output Analysis*. Amsterdam: North Holland.

Bródy, András, and Miklós Farkas. 1987. “Forms of Economic Motion.” *Acta Oeconomica* 38 (3–4): 361–70.

Bronfenbrenner, Martin, ed. 1969. *Is the Business Cycle Obsolete?* New York: Wiley.

Csató, Katalin. 2019. “Az akadémiai közgazdasági gondolkodás formálódása a politika bordásfalán.” IEHAS Discussion Papers No. 18, Hungarian Academy of Sciences, Institute of Economics, Budapest.

Csekő, Imre. 1996. “Választás és mechanizmus: Felületes ismerkedés az implementáció-elmélettel.” *Közgazdasági Szemle* 43 (5): 420–30.

Csontos, László. 1996. „Túl jón és rosszon: a racionális döntések elméletének recepciója Magyarországon.” *Közgazdasági Szemle* 43 (4): 326–31.

Davis, Christopher, and Wojciech Charemza, eds. 1989. *Models of Disequilibrium and Shortage in Centrally Planned Economies*. London: Chapman and Hall.

Debreu, Gerard. 1987. *Közgazdaságtan axiomatikus módszerrel*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Dewatripont, Mathias, and Eric Maskin. 1995. “Credit and Efficiency in Centralized and Decentralized Economies.” *Review of Economic Studies* 62 (4): 541–56.

Farkas, Katalin. 1973. “Ágazati terv-modell kísérletek (IV. ötéves terv).” *Szigma* 6 (1): 86–92.

Forgó, Ferenc, and Sándor Komlósi. 2015. “Krekó Béla szerepe a magyar közgazdászképzés modernizálásában.” *Szigma* 46 (3–4): 137–58.

Friedman, Milton. 1986. *Infláció, munkanélküliség, monetarizmus*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Frisch, Ragnar. 1974. *Dinamikus és kvantitatív közgazdaságtan*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Gács, János, and János Köllő, eds. 1998. *A túlzott központosítástól az átmenet stratégiájáig: Tanulmányok Kornai Jánosnak*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Gács, János, and Mária Lackó. 1973. "A Study of Planning Behavior on the National-Economic Level." *Economics of Planning* 13 (1–2): 91–119.

Ganczer, Sándor. 1973. *Népgazdasági tervezés és programozás*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Goldfeld, Stephen, and Richard Quandt. 1988. "Budget Constraints, Bailouts, and the Firm under Central Planning." *Journal of Comparative Economics* 12 (4): 502–20.

Goldmann, Josef. 1977. *Makroökonómiai elemzés és előrejelzés*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Gomułka, Stanisław. 1985. "Kornai's Soft Budget Constraint and the Shortage Phenomenon: A Criticism and Restatement." *Economics of Planning*, 19 (1): 1–11.

Grosfeld, Irena. 1992. "Reform Economics and Western Economic Theory: Unexploited Opportunities." In *Reform and Transformation on the Threshold of Change*, edited by János Mátyás Kovács and Márton Tardos, 62–79. London: Routledge.

Hahn, Frank. 1973. "The Winter of Our Discontent." *Economica* 40 (159): 322–30.

Halabuk, László. 1971. "The Activities of the Econometric Laboratory of the Central Statistical Office." *Acta Oeconomica* 6 (4): 381–85.

———. 1976. "Econometric Models and Methods: Research and Applications in Hungary." *Acta Oeconomica* 16 (1): 81–102.

Halabuk, László, Zoltán Kenessey, and Ede Theiss. 1965. “An Econometric Model of Hungary.” *Economics of Planning* 5 (3): 30–43.

Halpern, László. 2020. Interview with László Halpern by Gergely Kőhegyi, January 7, 2020. Manuscript.

Halpern, László, and György Molnár. 1997. “Equilibrium and Disequilibrium in a Disaggregated Classical Model.” In Simonovits and Steenge 1997, 149–60.

Hámori, Balázs, ed. 1986. *Politikai gazdaságtan 3*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Havass, Miklós, ed. 2011. *A SZÁMALK és elődei*. Budapest: Számalk Kiadó.

Hicks, John. 1978. *Érték és tőke: A keynesi gazdaságtan válsága*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Hoch, Róbert, ed. 1968. *Piac és vállalati árpolitika*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Horváth, Róbert. 1963. “The Development and Present Status of Input-Output Methods in Hungary.” *Economics of Planning* 3 (3): 209–20.

Hulyák, Katalin. 1972. “Plan of an Econometric Model Based on Input-Output Tables.” *Acta Oeconomica* 8 (4): 433–43.

———. 2014. “Ötven éve alakult meg a Központi Statisztikai Hivatalban az Ökonometriai Laboratórium.” *Statisztikai Szemle* 92 (1): 71–72.

Hunyadi, László. 2012. “Gondolatok Theiss Ede <A makroökonómiai modellek statisztikai problémái> című cikkével kapcsolatban.” *Statisztikai Szemle* 90 (11–12): 1130–42.

———. 2014. “Beszélgetés Hunyadi Lászlóval.” Interview by Gábor Rappai. *Statisztikai Szemle* 92 (6): 594–600.

Huszár, István. 2008. “Beszélgetés Huszár Istvánnal.” Interview by Miklós Lakatos. *Statisztikai Szemle* 86 (3): 293–99.

Jánossy, Ferenc. 1963. *A gazdasági fejlettség mérhetősége és új mérési módszere*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1966. *A gazdasági fejlődés trendvonala és a helyreállítási periódusok*. Budapest: Közgazdasági és Jogi Könyvkiadó. 1971. *The End of the Economic Miracle*. White Plains, New York: International Arts and Sciences Press.

———. 1969. "Beszélgetés Jánossy Ferenccel." Interview by Varga Domonkos. *Valóság* 12 (5): 49–56.

Juhász, András, and Tamás Morva, eds. 1982. A jövő tervezése – A tervezés jövője. Budapest: OT Tervgazdasági Intézet.

Kaase, Max, and Vera Sparschuh, eds. 2002. *Three Social Science Disciplines in Central and Eastern Europe (1989–2001)*. Bonn: GESIS/Social Science Information Centre (IZ).

Kádas, Kálmán. 1980. "Emlékezés Theiss Ede professzorra." *Statisztikai Szemle* 58 (10): 1022–27.

Káldor, Miklós. 1989. *Gazdaságelmélet – gazdaságpolitika*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Kalecki, Michał. 1980. *A tőkés gazdaság működéséről*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1982. *A szocialista gazdaság működéséről*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Kantorovich, Leonid. 1965. *The Best Use of Economic Resources*. Oxford: Pergamon Press. Originally published as 1959. *Ekonomicheskii raschet nailuchshego ispolzovaniia resursov*. Moskva: Akademiia Nauk SSSR.

Kapitány, Zsuzsa, János Kornai, and Judit Szabó. 1984. "Reproduction of Shortage on the Hungarian Car Market." *Soviet Studies* 36 (2): 236–56.

Kenessey, Zoltán. 1959. "A magyar népgazdaság ágazati kapcsolatainak mérlege." Statisztikai Szemle 37 (12): 1174–90.

Khachaturov, Tigran. 1966. *A beruházások gazdasági hatékonysága*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Klaus, Václav. 1997. “Review of János Kornai’s The Socialist System.” In *Renaissance: The Rebirth of Liberty in the Heart of Europe*, 163-70. Washington DC: Cato Institute.

Klein, Lawrence. 1986. *Mérés és prognózis a gazdaságban*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Kornai, János. 1959. *Overcentralization in Economic Administration: A Critical Analysis Based on Experience in Hungarian Light Industry*. Oxford: Oxford University Press. Originally published as 1957. *A gazdasági vezetés túlzott központosítása*. Budapest Közgazdasági és Jogi Könyvkiadó.

———. 1967a. *Mathematical Planning of Structural Decisions*. Amsterdam: North-Holland. Originally published as 1965. *A gazdasági szerkezet matematikai tervezése*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1967b. “Mathematical Programming of Long-Term Plans in Hungary.” In *Activity Analysis in the Theory of Growth and Planning*, edited by Edmond Malinvaud and M. O. L. Bacharach, 211–31. London: Macmillan.

———. 1969. “A tervezés matematikai modelljeinek osztályozása.” In *Népgazdasági tervezés és irányítás*, edited by Géza Kovács, 43–54. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1971. *Anti-equilibrium*. Amsterdam: North Holland. Originally published as 1971. *Anti-equilibrium*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1972a. *Rush versus Harmonic Growth: Meditation on the Theory and on the Policies of Economic Growth*. Amsterdam: North-Holland.

———. 1972b. “Mathematical Programming as a Tool of Socialist Economic Planning.” In *Socialist Economics: Selected Readings*, edited by Alec Nove and Mario Nuti, 475–88. Harmondsworth: Penguin Books.

———. 1973. “Some Intersectoral and Intertemporal Choice Problems: Hungarian Experience in Long-Term Planning.” In *Economic Structure and Development*, edited by H. C. Bos, H. Linnemann, and P. de Wolff, 201–14. Amsterdam: North-Holland.

———. 1975. *Mathematical Planning of Structural Decisions*. Amsterdam: North-Holland. Second edition. Originally published as 1973. *A gazdasági szerkezet matematikai tervezése*. Második kiadás. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1979. “Bevezetés.” In *Egyensúly és döntés*, by Kenneth Arrow, 7–17. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1980. *Economics of Shortage*. Amsterdam: North-Holland. Originally published as 1980. *Hiány*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1981. “On the Difficulties and Deficiencies of Mathematical Economic Research in Hungary.” *Acta Oeconomica* 26 (1–2): 175–98.

———. 1986a. “The Soft Budget Constraint.” *Kyklos* 39 (1): 3–30.

———. 1986b. “The Hungarian Reform Process: Visions, Hopes, and Reality.” *Journal of Economic Literature* 24 (1): 1687–747.

———. 1992a. “The Principles of Privatization in Eastern Europe.” *De Economist* 140 (2): 153–76.

———. 1992b. *The Socialist System: The Political Economy of Communism*. Oxford: Oxford University Press.

———. 1996. “Nagy András 70 éves.” *Közgazdasági Szemle* 43 (3): 266–69.

———. 1998. “In Memoriam: Tamás Lipták.” *Acta Oeconomica* 49 (3–4): 461–63.

———. 2000. “Tíz évvel a Röpirat angol nyelvű megjelenése után: A szerző önértékelése.” *Közgazdasági Szemle* 47 (9): 647–61.

———. 2007. *By Force of Thought: Irregular Memoirs of an Intellectual Journey*. Cambridge MA: The MIT Press. Originally published as 2005. *A gondolat erejével: Rendhagyó önéletrajz.* Budapest: Osiris Kiadó.

———. 2018. "A Közgazdaságtudományi Intézet 1990 előtti történetéről." Lecture 2, edited version of the lecture given at the Institute of Economics, Budapest, April 12, 2018. https://www.mtakti.hu/wp-content/uploads/2018/10/Kornai2018-KTI-1990-elotti-torteneterol2.pdf.

Kornai, János, Zsuzsa Dániel, and Judit Rimler. 1972. "Macrofunctions Computed on the Basis of Plan Models." *Acta Oeconomica* 8 (4): 375–406.

Kornai, János, Zsuzsa Dániel, Anna Jónás, and Béla Martos. 1971. "Plan Sounding." *Economics of Planning* 11 (1–2): 31–58.

Kornai, János, and Tamás Lipták. 1959. A nyereségérdekeltség matematikai vizsgálata. Mimeo, Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1962. "A Mathematical Investigation of Some Economic Effects of Profit Sharing in Socialist Firms." *Econometrica* 30 (1): 140–61.

———. 1965. "Two-Level Planning." *Econometrica* 33 (1): 141–69.

Kornai, János, and Béla Martos. 1973. "Autonomous Control of the Economic System." *Econometrica* 41 (3): 509–28.

Kornai, János, Eric Maskin, and Gérard Roland. 2003. "Understanding the Soft Budget Constraint." *Journal of Economic Literature* 41 (4): 1095–136.

Kornai, János, and Ágnes Matits. 1987a. "The Softness of Budgetary Constraints: An Analysis of Enterprise Data." *Eastern European Economics* 25 (4): 1–33.

———. 1987b. *A vállalatok nyereségének bürokratikus újraelosztása*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Kornai, János, and András Simonovits. 1977. “Decentralized Control Problems in Neumann Economies.” *Journal of Economic Theory* 14 (1): 44–67.

———. 1981. “Bródy András <Ciklus és szabályozás>.” *Közgazdasági Szemle* 28 (1): 115–20.

Kovács, János Mátyás. 2002. “Business as (Un)usual: Notes on the Westernization of Economic Sciences in Eastern Europe.” In Kaase and Sparschuh 2002, 26–33.

———. 2009. “*Ex Occidente Flux*: A Debate on the Usefulness of Macroeconomics and the Responsibility of Economics.” *Közgazdasági Szemle* 56 (10): 881–912.

———. 2012. “Beyond Basic Instinct? On the Reception of New Institutional Economics in Eastern Europe.” In *Capitalism from Outside? Economic Cultures in Eastern Europe after 1989*, edited by János Mátyás Kovács and Violetta Zentai, 281–310. Budapest: CEU Press.

———. 2016. “Minden, amit tudni akartam a matematikai közgazdaságtanról, de nem mertem megkérdezni.” 2000 Irodalmi és Társadalmi Havi Lap. http://ketezer.hu/2016/11/minden-amit-tudni-akartam-matematikai-kozgazdasagtanrol-de-nem-mertem-megkerdezni/.

———. 2019. “An Attempt to Ground Central Planning on a Scientific Basis: János Kornai and the Mathematical Theory of Planning.” *Múltunk*, special issue: 210–27.

Köllő, János. 2021. Interview with János Köllő by Gergely Kőhegyi, January 15, 2021. Manuscript.

Kőrösi, Gábor. 1996. “Az átalakulás ökonometriája avagy az ökonometria átalakulása.” *Közgazdasági Szemle* 43 (4): 356–62.

———. 2020. Interview with Gábor Kőrösi by Gergely Kőhegyi, January 13, March 12, 2020. Manuscript.

Köves, Pál. 2005. “Beszélgetés Köves Pállal.” Interview by H. L. *Statisztikai Szemle* 83 (9): 878–84.

Krekó, Béla. 1972. *Optimumszámítás*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Lackó, Mária. 1989. “Sectoral Shortage Models.” In *Models of Disequilibrium and Shortage in Centrally Planned Economies*, edited by Christopher Davis and Wojciech Charemza, 263–82. London: Chapman and Hall.

Laki, Mihály, ed. 2006. *Egy délután Kornaival*. Budapest: MTA Közgazdaságtudományi Intézet.

Lampl, Tamás. 1971. “Az *Infelor Rendszertechnikai Vállalat gazdaságmatematikai munkái.” Szigma 4 (3):* 243–47.

Lange, Oskar. 1965. *Politikai gazdaságtan I*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1966. *Optimális döntések*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1967a. *Bevezetés a közgazdasági kibernetikába*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1967b. *Politikai gazdaságtan II*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Lányi, Kamilla. 1977. “Egy előrejelzési paradoxon.” *Szigma* 10 (1–2): 49–59.

Leontief, Wassily. 1953. *Studies in the Structure of the American Economy*. Oxford: Oxford University Press. Russian translation: 1958. Issledovaniia struktury amerikanskoi ekonomiki. Moskva: Gosstatizdat.

———. 1977. *Terv és gazdaság*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1984. *Gazdaságelmélet, tények és gazdaságpolitika*. Budapest: Statisztikai Kiadó.

———. 1997. “Foreword.” In Simonovits and Steenge 1997, VII.

Liska, Tibor. 1988. *Ökonosztát*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Lucas, Robert. 1976. “Econometric Policy Evaluation: A Critique.” *Carnegie-Rochester Conference Series on Public Policy* 1 (1): 19–46.

Lukács, Ottó et al., eds. 1962. *Input-Output Tables, Their Compilation and Use*. Budapest: Akadémiai Kiadó.

Malinvaud, Edmond. 1967. “Decentralized Procedures for Planning.” In *Activity Analysis in the Theory of Growth and Planning*, edited by Edmond Malinvaud and M. O. L. Bacharach, 170–208. London: Macmillan.

Malinvaud, Edmond and M. O. L. Bacharach. 1967. *Activity Analysis in the Theory of Growth and Planning*. London: Macmillan.

———. 1974. *Az ökonometria statisztikai módszerei*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Martos, Béla. 1975. *Nonlinear Programming: Theory and Methods*. Amsterdam: North Holland.

———. 1990. *Economic Control Structures: A Non-Walrasian Approach*. Amsterdam: North-Holland.

Martos, Béla, and János Kornai. 1973. “Tervszondázás: a modellek szerkezete.” *Szigma* 6 (1): 33–61.

———, eds. 1981. *Non-Price Control*. Amsterdam: North-Holland.

Maskin, Eric, and András Simonovits, eds. 2000. *Planning, Shortage and Transformation: Essays in Honor of János Kornai*. Cambridge MA: MIT Press.

Medvegyev, Péter. 1984. “A General Existence Theorem for von Neumann Economic Growth Models.” *Econometrica* 52 (4): 963–74.

———. 2015. “Augusztinovics Mária és a 20. századi magyar közgazdaságtan.” *Közgazdasági Szemle* 62 (6): 700–703.

Mihályi, Péter. 2017. “Kaldor and Kornai on Economics Without Equilibrium: Two Life Courses.” *Acta Oeconomica* 67 (S1):47–66.

Móczár, József. 1980. “A Marx Károly Közgazdaságtudományi Egyetem Népgazdasági Tervezési Intézetének tudományos munkássága.” *Szigma* 13 (3): 233–37.

Molnár, György. 2019. Interview with György Molnár by Gergely Kőhegyi ,December 4, 2019. Manuscript.

Morva, Tamás. 1965. “Tervgazdálkodás, tervezési és irányítási módszerek.” *Közgazdasági Szemle* 12 (4): 397–413.

———. 1966. “Tervszerűség és piaci mechanizmus a szocializmusban.” *Közgazdasági Szemle* 13 (3): 273–85.

Nagy, András. 1996. “A *déjà vu*-től a *what’s new*-ig.” *Közgazdasági Szemle* 43 (4): 335–42.

Nemchinov, Vasily. 1962. *A matematika alkalmazása a közgazdasági kutatásokban*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1966. *A népgazdasági tervezés és irányítás problémái*. Budapest: Kossuth Kiadó.

Nove, Alec, and Mario Nuti, eds. 1972. *Socialist Planning: Selected Readings*. Harmondsworth: Penguin Books.

Novozhilov, Viktor. 1971. *A ráfordítások és eredmények mérése*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Pawłowski, Zbigniew. 1970. *Ökonometria*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Pete, Péter. 1996. “Mi az általános az általános egyensúlyelméletben?.” *Közgazdasági Szemle* 43 (5): 437–42.

Péteri, György. 1993. “The Politics of Statistical Information and Economic Research in Communist Hungary, 1949–56.” *Contemporary European History* 2 (2): 149–67.

———. 1997. “New Course Economics: The Field of Economic Research in Hungary after Stalin, 1953–1956.” *Contemporary European History* 6 (3): 295–327.

———. 2002. “Purge and Patronage: Kádár’s Counterrevolution and the Field of Economic Research in Hungary, 1957–1958.” *Contemporary European History* 11 (1): 125–52.

———. 2017. “External Politics – Internal Rivalries: Social Science Scholarship and Political Change in Communist Hungary.” *East Central Europe* 44 (2–3): 309–39.

———. 2019. “By Force of Power: On the Relationship between Social Science Knowledge and Political Power in Economics in Communist Hungary.” *History of Political Economy* 51 (6): 30–51.

Petrakov, Nikolai. 1970. *A szocialista gazdálkodási módszerek vitatott problémái*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Pontriagin, Lev et al. 1968. *Optimális folyamatok elmélete*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Portes, Richard, and David Winter. 1980. “Disequilibrium Estimates for Consumption Goods Markets in Centrally Planned Economies.” *Review of Economic Studies* 47 (1): 137–59.

Prékopa, András. 2018. “Operációkutatás és alkalmazott matematika a SZTAKI-ban.” *Alkalmazott Matematikai Lapok* 35: 5–11.

Réti, János, György Boda, Tivadar Faur, and Judit Simon. 1981. “A KV (központi volumen modell).” *Szigma* 14 (4): 239–68.

Samuelson, Paul. 1976. *Közgazdaságtan*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Sík, György. 1966. “A tervezés tudományos színvonalának és a gazdaságirányítás reformjának kapcsolata.” *Közgazdasági Szemle* 13 (4): 405–16.

Simon, György. 1970. *Gazdaságirányítás és népgazdasági optimum*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1973. “A reflektorprogramozás elvei és algoritmusa.” *Szigma* (2–3): 115–26.

Simon, György, and György Kondor. 1962. “Kantorovics, L. V.: Az erőforrások legjobb felhasználásának gazdasági számítása.” *Közgazdasági Szemle* 9 (1): 121–27.

———. 1963. “A gazdasági optimumszámítások problémái Kantorovics és Novozsilov műveiben.” *Az MTA Közgazdaságtudományi Intézet tájékoztató közleményei* 2

———. 1965. *Gazdasági hatékonyság és árnyékárak*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Simonovits, András. 1975. “A Note on the Underestimation and Overestimation of the Leontief Inverse.” *Econometrica* 43 (3): 493–98.

———. 1978. “A Note on <Marx in the Light of Modern Economic Theory> by Morishima.” *Econometrica* 46 (5): 1239–41.

———. 1996. “A magyar matematikai közgazdaságtan múltja, jelene és jövője.” *Közgazdasági Szemle* 43 (4): 350–55.

———. 2003. “A magyar szabályozáselméleti iskola.” *Közgazdasági Szemle* 50 (5): 465–70.

———. 2018. “Mit tanultam Kornai Jánostól?.” *Köz-Gazdaság* 13 (1): 67–73.

———. 2019. Interview with András Simonovits by Gergely Kőhegyi, December 12, 2019. Manuscript.

Simonovits, András, and Albert Steenge, eds. 1997. *Prices, Growth and Cycles: Essays in Honor of András Bródy*. London: Macmillan Press; New York: St. Martin’s Press.

Sims, Christopher. 1980. “Macroeconomics and Reality.” *Econometrica* 48 (1): 1–48.

Sivák, József. 1987. “Illúzióvesztés vagy lépésváltás a modellezésben?.” *Tervgazdasági Fórum* 3 (2): 58–62.

Soós, K. Attila. 1985. “A hiányjelenségek magyarázatához: keresletmennyiség és strukturális rugalmatlanság.” *Közgazdasági Szemle* 32 (1): 86–98.

———. 1986. *Terv, kampány, pénz*. Budapest: Kossuth Kiadó – Közgazdasági és Jogi Könyvkiadó.

Stark, Antal, ed. 1981. *Tervgazdálkodás*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Szabó, Judit. 1988. "Preliminary and Incremental Softness of the Budget Constraint: A Comment on the Gomulka-Kornai Debate." *Economics of Planning* 22 (3): 109–16.

———. 2015. "Szemben a mainstream közgazdaságtannal." *Buksz* 27 (1): 3–10.

Szabó, Kálmán. 1960. *A szocialista tervszerűség elméleti kérdései*. Budapest: Kossuth Kiadó.

Szakolczai, György, ed. 1963. *A gazdasági fejlődés feltételei*. Budapest Közgazdasági és Jogi Könyvkiadó.

———. 1967. *A gazdasági növekedés feltételei*. Budapest Közgazdasági és Jogi Könyvkiadó.

———. 1972. "Activities of the INFELOR Systems Engineering Institute." *Acta Oeconomica,* 8 (4): 445–54.

Szamuely, László, and László Csaba. 1998. *Rendszerváltozás a közgazdaságtanban közgazdaságtan a rendszerváltozásban*. Budapest: Közgazdasági Szemle Alapítvány.

Szepesi, György, and Béla Székely. 1974. "Optimal Path of Economic Growth in a Controlled Economic System." *Jahrbuch der Wirtschaft Osteuropas* 5: 221–241

Tardos, Márton. 1968. "Az új gazdasági rendszer szabályozó rendszerének modellje." *Közgazdasági Szemle* 15 (10): 1185–95.

Theiss, Ede. 1947. "Dinamikai közgazdaságtudomány és társadalmi folyamat." *Közgazdasági Szemle* 70 (3–4): 129–55.

———. 1965. "A makroökonómiai modellek statisztikai problémái." *Statisztikai Szemle* 43 (4): 399–411.

Tinbergen, Jan. 1957. *Ökonometria*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Tobin, James. 1984. *Pénz és gazdasági növekedés*. Budapest: Közgazdasági és Jogi Könyvkiadó.

Váradi, Balázs. 2007. "Karl Marx Learns Microeconomics." Manuscript.

Varga, István. 1947. "A gazdasági élet fejlődése és a közgazdaságtan." *Közgazdasági Szemle* 70 (5–12): 257–74.

Vincze, János. 1996. "Van-e magyar út az elméleti közgazdaságtanban?." *Közgazdasági Szemle* 43 (4): 331–35.

Virág, Ildikó. 1973. "Az MTA Közgazdaságtudományi Intézetében folyó matematikai közgazdasági kutatásokról." *Szigma* 6 (1): 83–86.

Zalai, Ernő. 1983. "Egyensúly és optimum: A makrogazdasági modellezés két irányzatának összevetése." *Közgazdasági Szemle* 30 (2): 157–75.

———. 1989. *Bevezetés a matematikai közgazdaságtanba*. Budapest: Közgazdasági és Jogi Könyvkiadó.

———. 1997. "Production Prices and Proportions Revisited." In Simonovits and Steenge 1997, 280–301.

———. 2014. "Neumann versus Leontief: Két modell – két gazdaságkép." *Közgazdasági Szemle* 61 (11): 1245–78.

Ziermann, Margit. 1977. "ESEM 76." *Szigma* 10 (1–2): 106–8.