Classic Prisoner's Dilemma: A Quasi-Experimental Test during the Great Terror[1]

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Abstract

This study provides an empirical assessment of the prisoner's dilemma model. It examines political prosecution and behavior of intellectuals during the Great Terror in the Soviet Union in the 1930s. This paper analyzes whether political prisoners confessed voluntarily as the prisoner's dilemma model predicts. It focuses on the prosecution of Mykhailo Krawtchouk, an internationally renowned Ukrainian mathematician, and more than 100 other political prisoners, who were connected to his case. Krawtchouk's case is selected because of its unintended effects on the invention of the electronic computer in the United States and the development of rocket technology in the Soviet Union. This study shows that only a small fraction of political prisoners confessed voluntarily. However, rational choice theory, on which the prisoner's dilemma model is based, is helpful in solving a puzzle pertaining to the electronic computer invention and patent.

Classic prisoner's dilemma model

This paper investigates behavior of prisoners who were arrested on political charges in the Soviet Union during the Great Terror in the 1930s. It analyzes the role of prisoner's dilemma incentives to confess in the mass terror. By examining the Great Terror, which affected millions of people, this study provides a unique empirical test of the prisoner's dilemma model that now gains wide currency in the social sciences.

The classic prisoner's dilemma predicts that it is rational for utility maximizing individuals, who are charged with a crime and are given a choice, to confess and implicate others in order to get lower sentences. The Great Terror in the Soviet Union presents an example of the prisoner's dilemma situation. According to one telling of the prisoner's dilemma, NKVD (Soviet Ministry of Internal Affairs) officers notice a conductor of an orchestra reading the music score and arrest him for being a spy. They believe that the music notation was a secret code. The arrested man tells the NKVD interrogators that the music score was written by Tchaikovsky. In a couple of days, the NKVD officers notify the music conductor that they have arrested his friend named Tchaikovsky. (See Dixit and Nalebuff, 1991, pp. 11-12).

The prosecutors give each prisoner a choice of one-year sentence if he confesses and implicates another and 25 year sentence if he does not. If one prisoner confesses and implicates the other, and the other one does not confess, the person who has voluntarily helped the prosecutors will get 1 year sentence, while the other person will get 25 year prison term. If they both do not confess, the two men will get 3-year sentences even though they are both innocent. (Table 1).

[Table 1 about here]

The prisoners' dilemma model predicts that rational prisoners who are unbounded by morality and friendship and are given a choice by a NKVD prosecutor will both confess and get 10 year sentence even they individually would be both better off not confessing. (Table 1). Assuming, as neoclassical economics and rational choice theory in political science do, that prisoners maximize their expected utility, confession is the optimal solution or the dominant strategy of the classic prisoner dilemma.

The logic and the outcome of the prisoner's dilemma game is essentially the same for large number of prisoners, or "players," and for other similar distribution of sentences, or pay-offs. Other solutions, involving cooperation between prisoners can arise only if they face repetitive choices, i.e. they presented with the dilemma multiple and indefinite number of times, or if external payoffs affect stakes faced by players. Tit for tat strategy beats other choices in nonfinite iterative prisoner's dilemma games. (See Axelrod (1984).

Research question, methodology and data

Many experimental tests of the prisoner's dilemma found that cooperation is a much more frequent outcome than that predicted by the model. (See, for example, Andreoni and Miller, 1993; Green and Shapiro, 1994, pp. 88-93). However, these experiments were often carried out among university students majoring in Economics. They involved artificial situations and small stakes. For example, Friedman and Savage (1952) explain gambling, lottery and other such empirical anomalies of the expected utility theory, e.g. the Allais (1953) paradox, by arguing that rational individuals have different degree of risk aversion and utility preferences when different levels of wealth are at stake.

The Great Terror in the Soviet Union comes closest to the real-life prisoner's dilemma situation. It involved large numbers of individuals arrested on political charges that carried capital punishment or sentences of varying length. Several million people were arrested at the height of the terror in 1937-1938. It is estimated that approximately 80 percent of Ukrainian writers, 50 percent of Soviet engineers, and 30 percent of astronomers were arrested during the Stalinist terror. (See Conquest, 1990, Graham, 1993). About 43 percent of legal scholars, 41 percent of ethnic and folk culture studies scholars and anthropologists, 37 percent of historians, 36 percent of archeologists, 33 percent of geologists, 31 percent of specialists in study of literature and language, 27 percent of economists, 25 percent of physicists, 22 percent of librarians, 20 percent of physicians, and 14 percent of mathematicians at the research centers of the All-Ukrainian Academy of Sciences were arrested in the 1930s.

Soviet prosecutors demanded from the prisoners to confess to political crimes and name associates in exchange for more lenient punishment. The confessions were used to convict arrested individuals, as well as to arrest others. Confession was a necessary and sufficient proof of guilt. Punishment for counterrevolutionary activity in the Soviet Criminal code ranged from execution to 3 years or more if there were softening circumstances.[2] Investigators promised less severe punishment to political prisoners who cooperated with them and implicated others. Trials were carried out without jury and witnesses by specially appointed courts and commissions. They overwhelmingly resulted in automatic convictions that were rarely overturned on appeal. The totalitarian political system and the protracted sentences or executions meant that possibilities of external enforcement and repeated interaction were minimal. The same logic applied to

denunciation of other individuals to the NKVD and the Bolshevik party. (See Conquest, 1990).

The question is whether political prisoners during the Great Terror cooperated with prosecutors and voluntary confessed as the prisoner's dilemma predicts. This paper analyzes behavior of more than 100 political prisoners arrested in the Soviet Union in the 1930s. These cases are linked to the political persecution of Mykhailo Krawtchouk, an internationally renowned Ukrainian mathematician who was arrested in 1938. Mykhailo Krawtchouk was an academician of the All-Ukrainian Academy of Sciences (VUAN). He held mathematics chair at the National Technical University of Ukraine, headed a mathematical statistics division in the Institute of Mathematics of the VUAN, and taught at several universities in Kyiv. Krawtchouk's contributions to different areas of mathematics, mathematical physics and statistics are still widely used. (See Parasyuk and Virchenko 1992, Seneta, 1997, 2001).

This paper analyzes behavior of Mykhailo Krawtchouk, individuals mentioned in the materials of his prosecution, and people connected to his academic and personal networks. They include Krawtchouk's colleagues and students arrested on various political charges in the All-Ukrainian Academy of Sciences (VUAN), the Institute of Mathematics of the VUAN, The Institute of Physics of the VUAN, National Economic University in Kyiv, Ukrainian Physico-Technological Institute (UFTI) in Kharkiv, and the Jet Propulsion Research Institute (RNII) in Moscow. These cases present a large N prisoner's dilemma with several sub-dilemmas.

The Krawtchouk's case is selected because it involves externalities (unintended effects) pertaining to the invention and patent on the electronic computer in the US and

rocket technology development in the Soviet Union.[3] His case and related cases include scientists and engineers, who played significant roles in the invention of the electronic computer, theory of space flight and the Soviet space program.

This study provides a new answer to a long-standing puzzle in the history of the computing. Namely, as to why John Atanasoff was reluctant to claim credit and accompanying large benefits for his invention of the electronic computer, until Honeywell lawyers discovered his pioneering work in this area and approached him in the end of the 1960s. Atanasoff's testimony in one of the largest federal trials in the US history not only successfully backed Honeywell challenge to the ENIAC computer patent held by Sperry Rand but it also resulted in an uncontested decision by a US Federal Judge Earl R. Larson that declared Atanasoff as the inventor of the electronic computer. (See Burks, 2003, Burks and Burks, 1988, Mollenhoff, 1988).

Previous studies explain this puzzle by Atanasoff's modesty and his switch to war related and non-academic work. (Mackintosh, 1987, 1988, Mollenhoff, 1988). However, Atanasoff received several dozen of patents for his other inventions, as well as major honors and awards, for example, U.S. Navy Distinguished Service Award, the highest honor given by the Navy to civilians. My hypothesis is that John Atanasoff did not publicize his work on the computer because he suspected that his contacts with Mykhailo Krawtchouk had led to the persecution of the Ukrainian scientist. Materials that I discovered in the National Museum of American History and Iowa State University archives show that John Vincent Atanasoff used Mykhailo Krawtchouk's works and translated his book when he invented and build the electronic computer (ABC) at Iowa State University in 1937-1942. (See Katchanovski, 2002, 2003).

This study combines political science approaches and experimental economics approaches and uses the quasi-experimental conditions of the Great Terror to test the prisoner's dilemma model. It analyses the role of prisoner's dilemma incentives in the behavior of the large number of political prisoners in the Soviet Union in several related cases. In using history to test rational choice models, this paper builds on works by Bates, Greif, Levi, Rosenthal, and Weingast (1998), Elster (2000), Greif (1994), and Olson (2000).

The data for this study are obtained from recently declassified materials of prosecution and rehabilitation of political prisoners in the former Soviet Union. This paper employs archival materials of interrogations and trials in the 1930s as well as legal reviews and judicial rehabilitation of political prisoners in the 1950s-1990s. It also uses secondary sources, interviews with people involved in the cases and computer patent trial materials in the United States.

Mykhailo Krawtchouk's Prosecution

Mykhailo Krawtchouk was arrested on February 21, 1938. He was charged with a membership in an underground Ukrainian nationalist and terrorist organization and spying. The accusation of a membership in such fictitious organizations was a typical charge against the country's intellectuals during the Great Terror. The allegations of stemmed from the fact that Krawtchouk closely identified with Ukrainian culture, playing a major role in developing Ukrainian mathematical terminology and mathematical education. Mykhailo Krawtchouk published his works in French, German, Italian, and Russian, but he wrote most of his books and articles in Ukrainian. It did not help that Krawtchouk had relatives and students people from a variety of ethnic and religious backgrounds: not only

Ukrainian, but also German, Jewish, Polish and Russian. He pointed out this fact to his interrogators but it had no effect

The NKVD prosecutors wanted Mykhailo Krawtchouk to confess about his subversive activity and to implicate others, e.g., his coworkers, students, and acquaintances. Krawtchouk wrote in his appeal to the Supreme Procurator of the USSR in 1940:

> They demanded from me, first of all, to give a written confession of being a member of this organization. They also demanded from me to name the upper leadership of this organization and persons who recruited me and whom I recruited, and who instructed me and whom I instructed on the matters of the organization within the Academy of Sciences. They demanded to describe the evolution of my counter-revolutionary convictions, my counter-revolutionary work, participation in the White Armies, my counter-revolutionary agitation among students, creation of insurgent detachments by the members of the organization, my spying activity, etc.[4]

The materials of his prosecution show that Mykhailo Krawtchouk did not confess and implicate others voluntarily. He was charged with being "an active member and a leader" of an organization established by former *borotbisti. Borotbisti* was a party established in 1918 by a left wing of the Ukrainian Party of Socialist Revolutionaries, which advocated a socialist and populist program as well as the independence of Ukraine.[5] Mykhailo Hrushevsky, the first president of Ukraine during its brief independence in 1918 and the leading Ukrainian historian, was politically close to the party of Ukrainian socialist revolutionaries. In contrast to most socialist revolutionaries, *Borotbisti* leaders advocated cooperation with the Bolsheviks. They joined the Bolshevik party in 1920 when it prohibited the existence of all other political parties.

Mykhailo Krawtchouk was never a member of *Borotbisti* or any other party. But evidence such as his official contacts with some of the former *Borotbisti* and Hrushevsky's history book that the NKVD confiscated during Krawtchouk's arrest were sufficient to link the Ukrainian mathematician to the prosecution of the fictitious organization of former *Borotbisti*.

Despite demands of a NKVD interrogator, Krawtchouk refused to confess and implicate the former leaders of *Borotbisti* whom he knew in their capacity as high-ranking government officials. The NKVD prosecutors tried to link Krawtchouk to Andrij Khvilya, Panas Lubchenko and Volodymyr Zatonsky, alleged leaders of this organization. They were charged in 1937 after the NKVD obtained incriminatory testimonies during interrogation of other political prisoners. Krawtchouk was charged with establishing connection with this fictitious organization in 1933. (Urbansky, 2002, pp. 189-192. 223-256).

At that time, Khvilya was deputy minister of education in Soviet Ukraine. When he was arrested on August 13, 1937, Khvilya was the head of the Directorate for the Arts. In his official positions and earlier as the head of the Communist party propaganda department, Khvilya publicly accused many intellectuals of political deviations. Most of these intellectuals were arrested on political charges. In one of the most notable examples, Khvilya denounced Mykola Khvylovy, a Ukrainian writer, for suggesting the slogan, "Away from Moscow." Khvylovy committed suicide in 1933 because of the public campaign against him and arrests of other Ukrainian intellectuals. In turn, Khvilya was denounced by some of his colleagues. (See Shapoval, 1993, p. 228).

During the interrogation, Khvilya confessed to being a leader, along with more than dozen of other top government officials, of the underground organization. On August 18, 1937, Khvilya wrote a declaration addressed to Stalin and other top party and NKVD officials. The declaration presented cultural and academic contacts with foreign countries, as communication with anti-Soviet Ukrainians in Poland and with foreign spies. Khvilya described visits of Western Ukrainian intellectuals from Poland as contacts with emissaries of foreign intelligence services. These visits were organized by the Ukrainian Association for Cultural Relations with Abroad. (See Shapoval, 1993, pp. 225-226).

However, during his interrogation and confrontation with Panas Lubchenko in Moscow a few days later, Khvilya renounced his confession. Khvilya told Stalin that he and other alleged members of the organization were not guilty. Stalin, along with other members of the Soviet Communist party leadership, was present during this interrogation and confrontation. Later the same day, Khvilya changed his testimony and repeated his earlier confessions. However, during his closed trial on February 5, 1938, he again renounced his confessions. Such reversals indicated that the NKVD interrogators used torture to extract confessions from Khvilya. (See Shapoval, 1993, pp. 228-229)

Panas Lubchenko was another alleged leader of the organization to which Krawtchouk was linked by the NKVD interrogators. In fact, Lubchenko was the head of the government of Soviet Ukraine and a member of the Political Bureau, the governing body of the Ukrainian branch of the Soviet Communist party. However, his membership in *Borotbisti* party twenty years earlier as well as confessions obtained from political prisoners led to his dismissal from the top party position. He faced an inevitable arrest. In his various prior capacities, Lubchenko took part in denouncing many government officials

and Ukrainian intellectuals. He did the same during a meeting of the central Committee of the Ukrainian branch of the Soviet Communist Party in the end of August 1937. This meeting reviewed incriminating testimonies against Lubchenko that the NKVD had obtained from interrogating prisoners such as Khvilya. Lubchenko denounced Khvilya and other members of the alleged underground organization, but he denied his own involvement. (See Shapoval, 1993, pp. 232-237). In another example, Lubchenko served as the main public prosecutor during the 1930 show trial of 45 intellectuals falsely accused in membership in SVU (Union for Liberation of Ukraine). In contrast, Krawtchouk declined to serve as a public prosecutor at the SVU trial despite strong possibility that this would be held against him. This did, in fact, happen.

Volodymyr Zatonsky was arrested on November 3, 1937. He was the Minister of Education of Soviet Ukraine, a member of Communist party leadership, and an Academician of the VUAN. He studied and then taught physics at Kyiv University around the same time that Krawtchouk did in the 1910s. Zatonsky was a Menshevik before the revolution. He later became one of the founders of the Ukrainian branch of the Bolshevik Party. Like many other party officials, he was involved in political denunciations, and was denounced himself.

Soon after his arrest, Zatonsky, mentioned Krawtchouk's name, along with many other names, during his interrogation by the NKVD. Some scholars argue that the short length of time (6 days) between his arrest and detailed confession, as well as the large number of individuals named by Zatonsky, indicated a voluntary nature of his confession. (See Kiyak and Proskura, 1997, pp. 256-257). However, an official review of his case in 1956 concluded that he was tortured.

During Krawtchouk's interrogation, NKVD prosecutors tried to present his meetings with Zatonsky as contact between members of an underground organization. A protocol of Krawtchouk's interrogation stated that he informed Zatonsky about "his anti-Soviet nationalist work at the Institute of Mathematics" and received new tasks. These tasks included "promoting young nationalist cadres on the educational front," "supporting the old reactionary professorate," and "directing it against young Soviet scientists" (Syta, 1993, pp. 107-108).

Mykhailo Krawtchouk visited Volodymyr Zatonsky several times in 1937 to counter accusations that he was giving low grades to students at the Kyiv Polytechnic Institute. Some of his students and colleagues denounced Krawtchouk's teaching despite numerous testimonies to the contrary. This was not simply an academic matter. Poor quality of work was considered sabotage in Stalin's Soviet Union.

The behavior of Mykhailo Krawtchouk, Andriy Khvila, and Volodymyr Zatonsky during their interrogations contradicts the prisoner's dilemma model. They did not confess voluntarily in exchange for a more lenient punishment. Their sentences reaffirmed the high stakes involved in their choices not to confess voluntarily. On September 23, 1938, in a trial lasting one half-hour, the Military Collegium of the Supreme Court of the USSR sentenced Krawtchouk to 20 years in prison and 5 years in exile. Mykhailo Krawtchouk was assigned to perform heavy manual work in a gold mine in Kolyma region, one of the coldest and most uninhabitable places on the planet. Like a large proportion of political prisoners, Krawtchouk did not survive the Kolyma camps. (Conquest, 1990). He died there in March 1942.

Khvilya and Zatonsky, who as alleged leaders of the counterrevolutionary organization faced more severe punishment, were executed in 1938. Only Panas Lubchenko voluntarily implicated others during a party leadership meeting that heard his case. Facing an imminent arrest, he committed a suicide after the meeting. In contrast to Krawtchouk, though, Lubchenko, Khvilya, and Zatonsky voluntarily participated in political denunciations before their arrests. In turn, others denounced them in a similar fashion.

Because Krawtchouk did not cooperate voluntarily with the prosecution and refused to confess and implicate others, the NKVD interrogators switched their method to torture. In his appeal letter, Krawtchouk summarized methods used by the NKVD investigators in his case as follows:

> I was devastated by these wild accusations, physically broken by the night interrogations, in particular, by complete sleep deprivation for 11 days and nights, worsening of my heart disease, and means of direct physical force. They were coercing me morally by screams and moans of the people being tortured in the neighboring rooms.[6]

The NKVD frequently used such methods of interrogation to force political prisoners to confess (See Conquest, 1990, Weissberg, 1951). In addition to beatings and psychological intimidation, Krawtchouk described a torture method called "conveyer." It involved constant interrogation of political prisoners by NKVD interrogators and deliberate sleep deprivation that could last up to several weeks. While prisoners were not allowed to rest or sleep, the interrogators rotated daily.

By means of torture in prison and by threats to arrest his family, prosecutors forced Krawtchouk to sign confession statements. Before his trial, new NKVD investigators threatened Krawtchouk not to retract his confession because he would remain

under control of the Soviet organs.[7] However, Krawtchouk did retract his confession after the trial ended.

Interrogation of Other Mathematicians

Mykhailo Krawtchouk was convicted for being a member of the Ukrainian nationalist and terrorist organization, which "included" three of his former students. Volodymyr Mozhar, a researcher at the Institute of Mathematics and a mathematics professor at the Kyiv Technologic Institute of Food Production (now National University of Food Technologies), was one of them. He was arrested on May 1, 1937, and charged with being an active member of the Ukrainian nationalist terrorist organization.[8] Mozhar was a researcher at the Division of Mathematical Statistics at the Institute of Mathematics. Krawtchouk headed this division. They also co-authored two books on mathematics. (See Krawtchouk and Mozhar, 1934, Martynenko and Vasyanovich, 2001).

Mykhailo Krawtchouk refused to describe Mozhar as an "enemy of the people" in an academic article he published in 1937. This fact was used to initiate a public campaign of his denunciation that led to his dismissal from the academic positions and the eventual arrest. *Kommunist*, the main official newspaper in Soviet Ukraine, published on September 14, 1937, an editorial titled "Academician Krawtchouk Advertises Enemies." The editorial was signed by Dmitry Grave, the director of the Institute of Mathematics of the Ukrainian Academy of Sciences, and Kindrat Breus, the academic secretary of the Institute. The article stated that in his piece in the journal *Uspekhi Mathematicheskich Nauk (Progress in Mathematical Sciences)*, Krawtchouk gave a favorable review of the work of "enemies of the people" who were uncovered by the NKVD. The letter noted that Mykhailo

Krawtchouk had enough time to withdraw his article or to make "appropriate corrections," but he chose not to. (Grave and Breus, 1937).

Volodymyr Mozhar did not cooperate with the prosecutors. He refused to confess in his membership in the fictitious underground Ukrainian nationalist organization and to implicate Krawtchouk and others during his interrogation. His first interrogation after being transported from Moscow, where he was arrested, to a prison in Kyiv, is dated May 10, 1937. The protocol of his interrogation stated that Mozhar categorically denied his membership in the organization. He was specifically asked by Gaponov, a NKVD interrogator, to implicate Mykhailo Krawtchouk: "You are a student of Krawtchouk, a known nationalist." Mozhar confirmed that he was Krawchouk's student but said that he did not know about his nationalist views.[9]

Volodymyr Mozhar's membership in 1919 in the *Borotbisti party* as well as books found during his arrest served as evidence for nationalist charges. NKVD documents characterized books confiscated during Mozhar's arrest, as "counterrevolutionary and ideologically dangerous." The NKVD also used Mozhar's earlier contacts with several anarchists and a confiscated book by Kropotkin, a famous 19th century Russian anarchist, to accuse him of membership in an underground anarchist organization. It relied on testimony obtained from several other individuals to corroborate these charges. During his interrogation on June 22, 1937, a NKVD interrogator told Mozhar that the investigation had detailed evidence about his "participation in a counterrevolutionary organization" and persons with whom he "jointly conducted counterrevolutionary activity." Mozhar again refused to confess in the membership in the underground organization.[10]

Testimonies of three other imprisoned individuals and one witness provided the NKVD with incriminatory evidence against Mozhar. Confessions by two of these political prisoners were not voluntary. Circumstances of the confession of the third prisoner cannot be established because archival materials and publications about Mozhar's prosecution include incomplete materials regarding this prisoner, who was arrested in Leningrad (now St. Petersburg) in April 1937. [11]

The confession of Israel Dubinsky, who was arrested on June 12, 1937, and whose case had the same number as Mozhar's case, was obtained by the NKVD by means of torture. In 1956, Dubinsky testified to a KGB investigator who was reviewing his case, that "all my confessions that I furnished in 1937 were given as result of unbearable physical coercion; investigators reached the point when they were throwing a cat on my head and on my face." [12] In 1939, Dubinsky lodged a complaint with the Prosecutor General of the USSR about his conviction. He wrote that the interrogator distorted his testimony, in particular, by presenting a gathering at Mozhar's apartment as a meeting of counterrevolutionary organization.[13]

The prosecution case of Mozhar and Dubinsky contains testimony of Bentsion Aisenberg, arrested in April of 1937 on charges of membership in an anarchist-trotskyist terrorist organization. In his letter to the head of the NKVD in August 1937, Aisenberg named Mozhar and Dubinsky as members of the same organization, but he also stated that he abandoned his earlier refusal to confess.[14] Such sudden change in behavior is an indication that torture was used to extract this confession.

Mozhar's critical statements about the Communist party's role in the artificial famine in Ukraine and the situation of peasants in collective farms in the beginning of the

1930s were classified by prosecutors as "counterrevolutionary agitation." It is worth noting that the Soviet government and the Communist party denied the artificial famine, which claimed lives of at least three million people in Soviet Ukraine. (See Conquest, 1986, Kulchytskyi, 1995). Other evidence against Mozhar included his work in *Prosvita*, a Ukrainian educational organization, during short period of existence of independent Ukraine in the end of the 1910s.[15]

Mozhar refused to confess during the interrogation and trial to all charges except "anti-Soviet agitation" and was given a capital punishment. Obviously, the refusal to confess was contrary to his self-interest, as the prisoner's dilemma shows. Mozhar paid the ultimate price for non-cooperation with the NKVD, even though he had the chance to incriminate Mykhailo Krawtchouk and others. Mozhar was executed immediately after the verdict was announced on the 9th of November in 1937.[16] Israel Dubinsky, who signed a confession under torture, was sentenced to 10 years. [17] The behavior of both prisoners in this case contradicts the prisoner's dilemma model. Despite incentives to confess offered by the NKVD, neither prisoner chose to cooperate with the prosecutors voluntarily and implicate others.

David Topolyansky, a mathematics professor and Krawtchouk's colleague at Kyiv University and the Division of Mathematical Statistics at the Institute of Mathematics, was arrested on June 11, 1937. Krawtchouk and Topolyansky (1936) co-authored an article in a mathematical journal. In another article published less than a year later, Krawtchouk (1937) mentioned his joint work with Topolyansky at the Institute of Mathematics of the VUAN. As in the case of Mozhar, this fact was held against Krawtchouk during the public campaign against him which began in September 1937. During his interrogation and trial,

Krawtchouk did not implicate Topolyansky in membership in fictitious underground organizations.

Similarly, David Topolyansky refused to cooperate with the prosecutors and implicate Mykhailo Krawtchouk and others. A summary statement of the prosecution in October of 1938 concluded that "the investigation conducted in this case established that Topolyansky, while being a member of anti-Soviet Trotskyist organization, was connected with Sachnovsky and Krawtchouk (sentenced), members of this organization, and conducted anti-Soviet activity.[18] However, the testimony about Krawtchouk came not from Topolyansky, but from two witnesses. These witnesses, who were graduate students at Kyiv University, informed the NKVD that Krawtchouk and Sachnovsky defended Topolyansky against accusations of poor teaching quality and helped to promote him to the position of a professor. [19] A summary statement of the prosecution accused Topolyansky of using "bourgeois methods in teaching in order to harm communist education of the youth." According to the NKVD charge, Topolyansky said that only talented people could quickly learn mathematics.[20]

Although charges of Trotskyism were typically leveled against Jews such as Topolyansky, the substance of accusations was not of primary importance to the NKVD. Many Ukrainians were charged with Trotskyism and spying for Poland. Similarly, many Jews were charged with Ukrainian nationalism and spying for Nazi Germany. For example, several dozen of Jewish and Ukrainian intellectuals, including Sachnovsky, were convicted in the case of the "Trotskyist Terrorist Organization" in 1936. Semen Semkovsky, Trotsky's cousin and an academician of the All-Ukrainian Academy of Sciences, allegedly led this organization. Yuri Kotsubinsky, the head of the State Planning

Committee in Soviet Ukraine and a son of Mykhailo Kotsubinsky, a noted Ukrainian writer, was presented as another leader of this organization. (See Rozhenko, 1996, pp. 134-135).

David Topolyansky was released in the end of December, 1938, after about a year and a half in prison, due to the lack of evidence against him. His refusal to confess was a major factor. Another major factor, though, was that Krawtchouk and Mozhar did not implicate him during their interrogation, even though it was in their self-interests, as the prisoner's dilemma model shows. The NKVD documents stated that testimony obtained from Sachnovsky and used to arrest Topolyansky was not incriminating enough to convict him. The testimony of Grygory Lozovik, a professor of ancient history at Kyiv University, against Topolyansky was discounted because it relied on words of Sachnovsky.[21] This was not for lack of effort by the NKVD. Sachnovsky and Lozovik, who were arrested as a part of the fictitious "Trotskyist Terrorist Organization" in the beginning of 1936, were already sentenced and executed. (See Shapoval, 1993, pp. 197-201). Two witnesses in the case did not provide enough evidence about "anti-Soviet activity" of Topolyansky. After his release, Topolyansky taught at Dnipropetrovsk University. (Tsigankova, 1994).

Twelve political prisoners, who named Krawtchouk during their interrogation, did this involuntarily.[22] They included Mykhailo Ptukha, Director of the Institute of Demography, Volodymyr Ivanushkin, Director of the Library of the Academy of Sciences, Fedir Polonski, a researcher at the Institute of Geology, Maxim Lukovsky, secretary of the party committee of the Academy of Sciences, Leonid Levitsky, Deputy Director of the Institute of Experimental Biology, Oleksandr Goldman, Director of the Institute of

Physics, Josip Hermaize, history professor at Kyiv University, Volodymyr Durdukovski, director of a school in Kyiv, Grygori Kholodny, Director of the Institute of Ukrainian Scientific Language, Grygori Ivanitsya, professor of Ukrainian language at Kyiv University, Petro Suprunenko, Director of the Institute of Transportation Mechanics, and Arnold Krister, professor of law at the National Economic University in Kyiv. They all refused to confess voluntarily and were tortured.[23]

Defection

There were other people who behaved as the prisoner's dilemma predicts. They "defected" by voluntarily denouncing Krawtchouk and others. Stepan Feshchenko, a researcher at the Institute of Mathematics and a Communist party candidate, who was arrested in December of 1937, voluntarily denounced Mykhailo Krawtchouk during the interrogation. Feshchenko disliked Krawtchouk, who thought him lacking in mathematical knowledge and ability. A NKVD operative testified that Feshchenko wrote a letter in the beginning of 1936 to the NKVD informing them about the "anti-Soviet feelings and nationalist views" of Academician Krawtchouk.[24]

Stepan Feshchenko stated that Mozhar and Topolyansky were arrested because of his denunciation to the NKVD. He also said that Mykhailo Orlov, the academic secretary of the Institute of Mathematics and his friend, was arrested in 1936 because of his denunciation. Feshchenko stated that he wanted to denounce others. He was released on February 22, 1938, as a reward for his denunciations. [25]

Mykhailo Orlov was charged in the membership in the "Trotskyist Terrorist Organization. In addition to his position at the Institute of Mathematics, Orlov was a high-ranking Communist party official. Archival materials of his prosecution indicate that he

confessed voluntarily. Three days after his arrest, Orlov admitted his membership in this fictitious organization and implicated others.[26]

Konstantin Shteppa, professor of ancient history at Kyiv University, was also involved in Krawtchouk's case and voluntarily cooperated with the NKVD. He was arrested in March of 1938 and charged with participation in an underground Ukrainian nationalist organization and spying for Japan. However, archival documents and research by historians show that Konstantin Shteppa was one of the *seksots*, or secret informers, who denounced people to the NKVD. (See Prystaiko and Shapoval, 1996, 337-338, Verba, 1999, p. 101). At the special session of the military tribunal on April 16, 1939, Shteppa stated that the NKVD gave him especially important tasks in uncovering Ukrainian nationalist organizations and that he provided much material to accomplish these tasks. He also clamed credit for uncovering "the nationalist group" headed by Sachnovsky, Lozovik, and others at Kyiv University.[27]

Reports of secret informers to the NKVD in Krawtchouk's case are not yet opened for researchers. However, indirect evidence points towards Konstantin Shteppa as one of the secret informers in this and other related cases. In the mid 1930s, Shteppa established close ties with Krawtchouk, even though they worked in different fields. As Shteppa himself confessed during the trial, the NKVD officials installed secret informers close to people they considered politically suspicious. (See Verba, 1999).

Steppa's behavior during the Great Terror fits the prisoner's dilemma model. He is a perfect example of a rational self-interested individual, unconstrained by any ethical values. Throughout his life, Konstantin Shteppa constantly changed his behavior and political stance according to changes in incentives. He fought the Bolsheviks during the

Civil War, but turned into "a non-party Bolshevik" after they won the war. Archival documents recently uncovered by historians show that during the Nazi occupation of Ukraine, Shteppa became a German secret police informer. He became the chief editor of the main pro-German newspaper in Kyiv in the end of 1941, after the Nazis executed the paper's previous editors for their association with a radical Ukrainian nationalist organization. He published many pro-Nazi and anti-Semitic articles, and earned praise for his active collaboration from the commander-in-chief of the German Army stationed in Ukraine (See Kosik, 1993, pp. 227-228). However, after the war ended with the Nazi defeat, Shteppa again conveniently changed his behavior and public views. For instance, he used support from Niels Bohr and Alexander Dallin, Jewish scholars, in publishing his books. (See Dallin, 1962, Popov, 2003, Verba, 1999).

In his books, Konstantin Shteppa portrayed himself as a victim of the Great Terror (See Beck and Godin, 1951, Shteppa, 2003). He described several secret informers but failed to acknowledge his service to the NKVD. Contrary to his claims in the book, Shteppa provided distorted accounts of his own behavior and behavior of other people involved in his case. Konstantin Shteppa (2003, p. 36) called Georgy Lozovik, a history professor at Kyiv University, his close friend. But, as noted, Shteppa voluntarily stated during his trial that he denounced Lozovik to the NKVD. Georgy Lozovik a former Menshevik, a member of the faction of the Russian social democratic party which split with Bolsheviks before the 1917 revolution. After he left the Soviet Union, Konstantin Shteppa established close ties with Boris Nikolaevsky, one of the leaders of émigré Mensheviks in the US. Shteppa received assistance from Nikolaevsky in obtaining a US visa and a Ford Foundation grant for his book on Soviet historians. (See Popov, 2003).

Externalities Pertaining to the Invention and the Patent of the Electronic Computer

John Atanasoff did not mention in his extensive trial testimony and oral history interviews that he used and translated Krawtchouk's mathematical works. He referred to several other mathematicians whose work was relevant to his education, research, teaching, and the electronic computer project (See Atanasoff's Materials, 2000). Publications on the Atanasoff-Berry computer did not mention Krawtchouk either. Lawyers who represented Honeywell and Atanasoff during the ENIAC trial were not aware of Mykhailo Krawtchouk, Atanasoff's translation of his book and his contacts with the Ukrainian scientist.[28] The same applied to Arthur Burks, an engineer who was involved both in the ENIAC project and the ENIAC trial and published a book on the Atanasoff-Berry computer.[29] Similarly, Atanasoff's wife was not aware of Mykhailo Krawtchouk.[30]

However, Krawtchouk's work was very relevant to the Atanasoff's computer project. Atanasoff worked on approximate solution of differential equations in the second half of the 1930s. In the end of 1937, Atanasoff decided to create an electronic computer based on a binary number system in order to speed up solution of systems of linear algebraic equations. Approximate methods, including methods that Krawtchouk developed, involved solutions of large systems of linear equations. In order to handle numerical calculations with high degree of precision, Atanasoff made his computer digital (See Atanasoff, 1984, Burks and Burks, 1988, Grier, 2000).

Atanasoff was motivated by problems of mathematical physics, statistics, and other fields. Atanasoff (1940/1982) described potential applications of his computer to various mathematical tasks that required the solution of systems of linear algebraic equations. These mathematical problems included multiple correlation, curve fitting, method of least

squares, and approximate solution of problems of elasticity and quantum mechanics. Atanasoff (1940/1982) wrote that "this list could be expanded very considerably, for linear algebraic systems are found in all applications of mathematics which possess a linear aspect." He stated that "approximate methods using large systems of linear algebraic equations constitute the only practical method of solving many problems involving linear operational equations" and that "this point of view is well substantiated by an examination of the literature." Atanasoff (1940/1982, p. 316) mentioned differential and integral equations as examples.

John Atanasoff used Krawtchouk's work on approximate solution of linear differential and integral equations and on the method of moments. Mykhailo Krawtchouk researched approximate methods that had applications in physics, statistic, and engineering. He discovered new ways to extend application of the method of moments and the method of least squares, which he regarded as a special case of his generalized method of moments, from statistics to other areas.

Essentially, approximate solution methods made it possible to solve many problems which had practical importance in science and technology. However, these methods required long and tedious mathematical calculations. These calculations were often done by human beings with help of mechanical instruments. These people, usually women, were then called "computers." Atanasoff sought a way to speed up such mathematical computations, and he invented his computer in winter 1937 for this purpose. He built the electronic digital computer with help of Clifford Berry, a graduate student, in 1938-1942. (See Burks and Burks, 1988, Grier, 2000).

John Atanasoff tried interest IBM in application of his ideas to its business machines, but the company responded that electronic computing would have no future. (See Gustafson, 2001a, p. 74). However, his work attracted attention of John Mauchly, a physicist at the University of Pennsylvania. Atanasoff disclosed to Mauchly his computer project at a meeting of the American Association for the Advancement of Science in 1940 and later invited him to visit Ames, where he lived and worked at Iowa State University. During Mauchly's visit in June of 1941, Atanasoff showed him his computer and revealed many of the ideas that he used in its design and construction. (See Mollenhoff, 1988, pp. 55-61).

More than three decades later, this visit would be examined in detail in a large federal trial. At the end of the trial, Judge Earl Larson ruled that John Mauchly borrowed many of Atanasoff's ideas and used them in creating the ENIAC (Electronic Numerical Integrator and Computer). Mauchly built the ENIAC along with Presper Eckert in the mid 1940s at the University of Pennsylvania for the US Army. The judge concluded that "Eckert and Mauchly did not themselves first invent the automatic electronic digital computer, but instead derived that subject matter from Dr. John Vincent Atanasoff." (See Mollenhoff, 1988, p. 265).

Other computers which were created before or simultaneously with the ABC were either completely or partly mechanical. In contrast, Atanasoff's computer relied on vacuum-tubes. Most of the other computers at that time were analog devices for mathematical computations. Atanasoff's computer, like all modern computers, was digital. It relied on binary numbers (zeros and ones) to process information and handle mathematical equations. It was the first computer which used capacitors to temporarily

store information. Dynamic Random-Access Memory (DRAM) in modern computers uses this idea invented by Atanasoff. (See Burks and Burks, 1988, Gustafson, 2001b).

The ABC worked during tests, but a flawed mechanism for punching holes made accuracy of calculations not good enough for mathematical problems which required a very high degree of precision. This prevented the ABC from becoming fully operational. However, this problem was not an issue for purposes of granting a patent. The US patent law required only demonstration of ideas and principles of an invention. Atanasoff could have obtained separate patents for different new ideas and principles that he discovered. The ENIAC inventors successfully did this years later. (See Burks and Burks, 1988, pp. 277-278).

From a perspective of *homo economicus*, on which the prisoner's dilemma is based, it was a major anomaly that John Vincent Atanasoff was reluctant to claim his patent rights, and potential multi-million dollar benefits, as well as public recognition for the invention of the electronic digital computer. He was eager to publicize his computer to fellow scientists, a big company, and the media when he invented and built the ABC computer from 1937 to 1942, but only few years later his behavior in this regard started to change into the diametrically opposite direction. In 1942, Atanasoff moved to defense-related research and left the computer at ISU, but he continued for a year or two to be involved in the patent application. However, from mid-1940s to about 1966, Atanasoff demonstrated extreme reluctance not only to claim potential benefits, but even talk about his computer.

John Atanasoff did not pursue the patent application on the ABC, after he learned in 1946 that ISU failed to file a patent on the computer. He was reluctant to contest

computer patent applications filed by the ENIAC inventors even though IBM lawyers in 1954 invited him to back their legal challenge and expressed confidence that his testimony would invalidate one of the key ENIAC patents. (See Mollenhoff, 1988, pp. 82-89). This behavior stands in sharp contrast to 32 patents Atanasoff received for his other inventions.

Similarly, John Atanasoff did not discuss the ABC during his work on a computer for the US Navy in 1946, even though a project team which he headed was supposed to review all previous work on computers. Mooers (2001, p. 58.), who was involved in the Navy computer project at the Naval Ordinance Laboratory, recalled:

> It was only well into the project when we staff members first heard the rumors, which surprised us, that Atanasoff had already constructed some kind of computer while he was at Iowa State University. The information in these rumors had apparently trickled down from higher management at the Laboratory. Most definitely, from the outset of the project, Atanasoff provided absolutely no mention of his earlier work on a computer or that there was such a computer. In the non-technical social interactions with Atanasoff, he quite often referred to his Iowa State activities and his trusted aides out there. Some of these trusted aides were brought to the Laboratory and became employees in Atanasoff's divisions. On not one but several occasions, I and other members of the computer project inquired, first tentatively, and later bluntly and insistently, for information about any such project. We were consistently stonewalled…

Similarly, in his deposition in a court case regarding a patent on computer regenerative memory, John Mauchly testified that John Atanasoff did not want to talk about the ABC when they both worked at the Naval Ordinance Laboratory in the mid 1940s. (See Burks, 2003, pp. 75-76). John Atanasoff declined an invitation to return to ISU in 1946 to become chairman of the Physics Department. After visiting him at the Naval Ordinance Laboratory in Washington, DC, Dean R. Buchanan from the Iowa State University wrote an inter-office memo concerning the patent situation of the Atanasoff-Berry computer. The memo stated that Atanasoff, during their Washington meeting,

declared that his computer "was probably largely obsolete." The computer was dismantled in 1948. (See Atanasoff, 1995, p. 38, Mollenhoff, 1988, pp. 73-74).

With Atanasoff's cooperation, Iowa newspapers published stories about the Atanasoff-Berry computer in 1941. Iowa State University issued a press release about the ABC in 1942. However, from the mid-1940s until the ENIAC trial several decades later, John Atanasoff did not make any significant efforts to publicize his computer. During this time there was, apparently, no other publication on the ABC, with exception of few paragraphs in the Eckert (1953) article. The first reference on the ABC, as an ancestor of modern electronic digital computers, appeared in R.K. Richards' (1966) book on the history of electronic digital systems. Richards, who remembered the ABC from his studies at Iowa State University, contacted Atanasoff in 1963. However, Atanasoff was reluctant to provide details and referred him to Clifford Berry. Berry gave a description of the ABC, but died several months later as a result of an apparent suicide. (See Mollenhoff, 1988, pp. 93-105).

In 1967, after they learned about the ABC from Richards' book and materials they obtained from Iowa State University, lawyers representing the Honeywell company located Atanasoff and managed to convince him to testify in their legal challenge to the ENIAC patent. Sperry Rand acquired this patent from the ENIAC inventors. Sperry Rand asked Honeywell for $250 million in royalties for the right to build computers. The company demanded almost $150 million in royalties from other companies. Atanasoff was a key witness in the trial involving 156 other witnesses. After a 135-day long trial in 1973, a US district judge ruled that Atanasoff was the inventor of the electronic computer and invalidated the ENIAC patent. (See Mollenhoff, 1988, Burks, 2003).

Because of the time that had passed since the time of the invention, Atanasoff was not eligible to receive the patent or royalties on his computer. The outcome of this case meant that no one owned a patent on the electronic computer and on many of its components, such as memory. This trial ended the monopoly of the IBM, which established cross-license agreement with Sperry Rand for $11 million in 1956. As result, competition began to flourish in the computer industry, which enjoyed rapid growth since the mid-1970s. The invalidation of the patent on the electronic computer and the end of the monopoly in the computer industry benefited both computer entrepreneurs and consumers.

Although media attention was focused on "Saturday Night Massacre" when the Judge announced his decision in the computer patent case, John Atanasoff enjoyed growing public recognition for his invention. He and his computer are now honored at the history of the Information Age exhibit at the Smithsonian Museum of American History, which attracts millions of visitors from the US and around the world. Iowa State University provided $300,000 to complete reconstruction of the Atanasoff-Berry computer. President George W. Bush presented John Atanasoff with the National Medal of Science and Technology for 1990. Atanasoff received honorary doctorates and many other distinctions in the US and Bulgaria, where his father was from. Not only Mykhailo Krawtchouk did not receive any benefits for his contribution to the invention of the electronic computer, he was punished instead. His role in both the invention of the ABC and the rapid growth of the computer industry remained unrecognized until very recently.

The link between Mykhailo Krawtchouk' persecution and Atanasoff's work on the computer explains Atanasoff's pattern of behavior as it appears to contradict the theory of rational self-interested individual. In fact, the theory remains intact when this missing

link is taken into account. The pattern of his behavior and indirect evidence suggests that John Atanasoff did not want to confess his contacts with Krawtchouk, about use of Krawtchouk's work, and translation of his book. A realization that his letters to the Ukrainian scientist in 1937 might have led to the prosecution of Mykhailo Krawtchouk is a logical explanation for both Atanasoff's reluctance to pursue benefits from his invention of the computer and for his failure to reveal Krawtchouk's connections.

Atanasoff's work on the ABC from 1937 to 1942, his correspondence, as well as his and his students' mathematical publications and graduate theses on the approximate solution of mathematical equations were considered in great detail during the ENIAC trial. His memory about the events of winter 1937, when Atanasoff had the idea for electronic computer on his trip to Illinois, and a 1941 visit and correspondence with Mauchly, proved to be crucial in the outcome of the ENIAC trial. However, as noted, John Atanasoff did not publicly mention his letter to Mykhailo Krawtchouk, use of Krawtchouk's mathematical work, and the translation of his book.

His own actions and words in the end of the 1930s showed that this was not an accidental omission. Atanasoff wrote to Mykhailo Krawtchouk on September 9, 1937, five days before the public persecution of the Ukrainian scientist started:

> I have found your series of papers on the approximate solution of differential equations very useful in my work. I would like to receive reprints of any of your papers which you have available. I am particularly interested in obtaining copies of those papers which you have published in Ukrainian journals, as these papers are almost inaccessible to me.[31]

On November 16,1937, John Atanasoff followed up with a letter to the Ukrainian Association for Cultural Relations with Abroad, which in fact was under the control of the

NKVD. He wrote that the library of the Iowa State University ordered monographs published by Krawtchouk's in 1932 and 1936 "as well as all future issues" from a German intermediary but received nothing.[32] The records at the ISU library indicate that this two-volume book was in the library in March of 1938.

The NKVD treated many contacts with foreigners as spying, and therefore monitored foreign correspondence. For example, Volodymyr Ivanushkin, director of the library of the Ukrainian Academy of Sciences, was accused of corresponding with foreigners and ordering scientific publications and newspapers from Germany, Italy, and the US. He did not confess voluntarily but denounced Krawtchouk under torture in the beginning of 1937. A protocol of Ivanushkin's interrogation mentions personal contacts and exchange of publications between Director of the Institute of Archeology of the VUAN and Henry Field, a leading US anthropologist as an illustration of international ties of the fictitious underground organization.[33]

Lev Velichko, the head of the Ukrainian Association for Cultural Relations with Abroad, was arrested in July of 1937 on charges of "spying activity on behalf of German and Polish intelligence services." He was also charged with being an active member of a Ukrainian counterrevolutionary nationalist and Trotskyite organization. A short period between his arrest and admission of guilt as well as detailed testimony that implicated more than 50 people in spying and political crimes indicate voluntary nature of his confession. Protocols of Velichko's interrogation describe visits of foreigners, including American and Norwegian writers, book exchanges with foreign countries, and other activity of the Ukrainian Association for Cultural Relations as counterrevolutionary actions and spying.[34]

NKVD interrogators queried Mykhailo Krawtchouk about his foreign ties in order to present these contacts as spying activity. Krawtchouk described his contacts with West Ukrainian, French, and German mathematicians but refused to confess in spying.[35] Krawtchouk stated that he suspended his foreign correspondence and publication of his papers abroad in 1936 to avoid any repercussions.[36] Before 1936, Krawtchouk maintained academic and personal contacts with many foreign mathematicians including Hadamard, Hilbert, Courant, Levi-Civita, and Tricomi. He received job offers from leading US universities, but he declined them. According to recollections of people who knew Krawtchouk, he received the first job offer from the US in 1923 or 1924. His biographers mentioned offers to work at Princeton, Stanford, or Harvard Universities, and the American Mathematical Society was noted as source of these job offers.[37] Krawtchouk was a member of French, German, and Italian (Palermo) Mathematical Societies and the Shevchenko Scientific Society, a Ukrainian scientific organization which was based in Poland at that time. As noted, he published his articles in French, Italian, and German mathematical journals before 1936. (Soroka, 1991, Virchenko and Syta, 1992).

However, such academic and personal contacts with mathematicians from abroad were sufficient for the NKVD to accuse Mykhailo Krawtchouk of spying. The NKVD charged Krawtchouk with helping Mykhola Tchaikovsky to spy for Poland. Tchaikovsky, a Ukrainian mathematician, was born in the Galicia province, then part of Austria, and was educated at the University of Vienna. After World War I, Galicia became part of Poland and the Polish authorities restricted Ukrainian-language education in universities and schools. Krawtchouk helped Tchaikovsky immigrate to Soviet Ukraine and found him an academic position in Odessa. This fact was used as evidence for spying charges.

Tchaikovsky was arrested in 1933 and he was charged with being a spy and a member of an underground military organization (UVO). The NKVD interrogators tried to use the fact that he once lived in Poland and visited France as an evidence that he was either Polish or French spy. Tchaikovsky did not confess voluntarily during his interrogation.[38]

Another point of accusations involved Krawtchouk's correspondence with Volodymyr Levytsky, long-time head of the mathematics-physics section of the Shevchenko Scientific Society in Lviv in Galicia.[39] In his letters to Levytsky, Krawtchouk discussed publication of mathematical papers and academic cooperation between scholars from Soviet Ukraine and Polish Ukraine. (See Krawtchouk, 2000, pp. 202-218, and MacTutor, 2000). Krawtchouk lobbied the education officials to invite Levytsky to work in Soviet Ukraine. In 1938, this fact was used to convict the Ukrainian mathematician.

The special commission of the All-Ukrainian Academy of Sciences denounced Krawtchouk's conversation with wife of Tullio Levi-Civita, a visiting Italian mathematician, as a political offence. Tullio Levi-Civita visited the Institute of Mathematics in Kyiv in 1935 on Mykhailo Krawtchouk's invitation. Levi-Civita's wife asked Mykhailo Krawtchouk to recommend her a book on Ukrainian history. He suggested a German translation of Hrushevsky's *History of Ukraine*. The Academy commission accused Krawtchouk in recommending this book because it was written by the "nationalist historian" and published in a foreign language, not in the language of "comrades Lenin and Stalin, geniuses of the mankind" (Visnovki, 1994, p. 122).

Since Atanasoff's letters preceded Krawtchouk's persecution and arrest and detailed accounts about the Great Terror in the West in the mid-1940s, it would have been logical for Atanasoff to conclude that his contacts with Krawtchouk in 1937 contributed to

the political persecution of the Ukrainian scientist. There were many ways for Atanasoff to discover the possible implications to Mykhailo Krawtchouk of his letters in 1937.

In 1944, Victor Kravchenko, a Ukrainian engineer defected to the US. Kravchenko was an official in the Soviet lend-lease office in Washington, DC, where Atanasoff had worked during and after the war at the Naval Ordnance Laboratory. This defection was front-page news in the US. His case involved top government officials including President Franklin Delano Roosevelt as the Soviet Government demanded the extradition of Kravchenko, who faced capital punishment in the USSR for his decision to stay in the US. Kravchenko's (1946) book "I Chose Freedom," described the Great Terror in Soviet Ukraine. The book was published in the beginning of 1946 and became a bestseller in the US. It sold 5 million copies around the world. (See Liebich, 1997).

Kravchenko's last name is a variation of Mykhailo Krawtchouk's last name. A common English transliteration of Krawtchouk's last name is "Kravchuk". The last name of the Ukrainian mathematician became mostly known in its French transliteration, because his most cited paper was published in French. John Atanasoff used an English transliteration of Krawtchouk's name in his September 9, 1937 letter.

Two Western physicists, arrested in the UFTI case, but expelled to Nazi Germany in 1939, published accounts of the political terror against scientists in Soviet Ukraine (See Beck and Godin, 1951, Weissberg, 1951). They described how physicists from the Ukrainian Physico-Technological Institute (UFTI), like many others who had contacts with foreigners, were accused of being foreign agents. The arrests of UFTI scientists on spying charges and other similar stories became first known to Western physicists and

mathematicians in 1938, when several of them, including Albert Einstein and Bohr, wrote letters to Stalin on the behalf of the imprisoned.

One of these books was co-authored by Friedrich Houtermans, a physicist who worked at the UFTI and was arrested as "a German spy," and Konstantin Shteppa under the pseudonyms of Beck and Godin (1951). They were sharing one cell in a Kyiv prison. As noted, Shteppa was involved in Mykhailo Krawtchouk's case, although he did not reveal his own role. The book specifically mentioned people who had contacts with foreign countries as one of the principal categories singled out by the NKVD for prosecution as spies.

Formal and informal academic contacts provided another source from which John Atanasoff could have learned about potential unintended consequences of his letters to Mykhailo Krawtchouk and the Ukrainian Association for Cultural Relations with Abroad in 1937. The mathematical and physical academic communities, to which John Atanasoff belonged, were very small in the 1930s as compared to present time. For instance, participants of the International Mathematical Congresses, which attracted many leading mathematicians from around the world, numbered in hundreds. Iakov Frenkel, a Soviet physicist, described physicists at that time as "a narrow cast, members of which are well known to one another in all parts of the globe." (See Holloway, 1994, p. 26).

Stephen Kulyk, Krawtchouk's graduate student and colleague moved to Germany in the end of World War II and emigrated to the United States in the beginning of the 1950s. He knew first hand about Krawtchouk's persecution. In spite of demands of NKVD interrogators, Krawtchouk refused to provide evidence that could have led to an arrest of Kulyk. Stepan (Stephen) Kulyk became a mathematics professor at Claremont McKenna

College, University of South Carolina in Colombia, and California State University in Long Beach. He published his articles in the US journals and attended conferences of American mathematicians. (See *Encyclopedia*, 1988, p. 708).

Nathan Rosen, a physicist and Einstein's research assistant from the Institute for Advanced Study at Princeton University, also knew of Mykhailo Krawtchouk's persecution. They worked together at the department of mathematics and physics before and during Krawtchouk's persecution. Rosen became a professor of physics at Kyiv University in 1936. He returned to the US in 1938 and resumed his academic career there.

It was possible to infer the prosecution of scientists by looking into citations of their works, because both their publications and references about their works were prohibited in the Soviet Union during the Great Terror. After his arrest, Mykhailo Krawtchouk's works were transferred into special library collections, closed for researchers, and his formulas were removed from mathematical journals in the Soviet Union. For example, Krawtchouk's name and the description of his contributions disappeared from Chebotaryov's (1937) article when it was republished in a festschrift dedicated to Grave in 1940. Shohat, mathematics professor at University of Pennsylvania noted in his review of a 1940 article on orthogonal polynomials by Geronimus, Soviet mathematician, that the reference should have been given to an earlier article by Krawtchouk.

The same reasoning that made John Atanasoff reluctant to publicize his computer explains his failure to publish the translation of Krawtchouk's book. As noted, Atanasoff translated Krawtchouk's monograph on the method of moments, which appeared in 1932 and 1936, in two volumes from Ukrainian into English, but he did not publish it.

One possible explanation is a decline of interest in the method of moments in statistics in the 1940s-1970s. At that time, R.A. Fisher won his debate with Karl Pearson on the theoretical superiority of his maximum likelihood estimation over the method of moments advocated by Pearson. Atanasoff attended Fisher's lectures when he visited Iowa State University in the mid-1930s, and was probably aware of this controversy. In recent years, a generalized version of the method of moments has made a comeback in econometrics and finance because its offers greater practical applicability than the maximum likelihood. (See Bera and Bilias, 2002).

However, John Atanasoff ordered and translated Krawtchouk's book from Ukrainian and French despite the debate on the method of moments at the time when he invented and built the electronic computer. In 1947, Atanasoff received letters from Solomon Lefschetz, head of the Mathematics Department at Princeton University, and from D. L. Holl, the head of Mathematics Department at ISU. They expressed interest by Princeton University Press in publishing his translation.[40]

The Library of Congress catalog search indicates that Atanasoff's translation would have been the first book in English on the method of moments. Several Russian books on the method of moments and related topics had been translated and published in the US since the late 1940s. The translation of Krawtchouk's book was of professional quality, because Eugene Victor Prostov, who was fluent in several Slavic languages, assisted Atanasoff. Prostov, who was born in the Polish part of the Russian Empire, worked as a translator for US Intelligence during World War II and headed the Bulgarian Unit of the Voice of America in the 1950s and 1960s. Many other works translated by Eugene Prostov

were published in the US, including studies of Soviet anthropologists done for Henry Field, and Slutsky's (1937) article in *Econometrica.*[41]

John Atanasoff could not have obtained complete information about Krawtchouk's prosecution until end of the 1980s or the beginning of the 1990s, shortly before his death. The first book length biography of Mykhailo Krawtchouk was published in Ukrainian in 1985 (Soroka, 1985). But at that time, its author was not able even to mention Krawtchouk's persecution. The book ended with a description of an incident in which Mykhailo Krawtchouk received $3,000 payment from a US company in 1934, arousing the suspicion of some of his colleagues. Publications about the tragic fate of Krawtchouk, including a second expanded edition of his biography, appeared only during Gorbachev's *glasnost* period and after Ukraine became an independent state following the collapse of the Soviet Union in 1991.

Declassified materials regarding Krawtchouk's prosecution do not mention John Atanasoff's name or his letters. However, reports by NKVD informers on Mykhailo Krawtchouk and secret materials from monitoring his correspondence are not yet declassified. Krawtchouk's foreign correspondence was confiscated by the NKVD during his arrest in February of 1938, has not been located.

During his interrogation, Mykhailo Krawtchouk refused to present his academic contacts with foreign mathematicians as spying, although the prisoners' dilemma predicts that this went against his self-interest. Krawtchouk told the prosecutors that spying charges were logically incompatible with accusations of being a Ukrainian nationalist and the prosecutors dropped the charges of spying.

SVU Case

Krawtchouk's name was mentioned in several testimonies obtained by the NKVD prosecutors from the accused in the 1930 SVU show trial. Materials of Krawtchouk's prosecution state that Yosip Hermaize recruited him in 1928 into a "counter-revolutionary and terrorist organization" that he headed. Krawtchouk and Hermaize studied together in Kyiv University in the 1910s, and taught together at the First Ukrainian Gymnasium in 1919-1920. Yosip Hermaize, a professor of Ukrainian history at Kyiv University and Agricultural University and head of Arheographic commission of the VUAN, was convicted as one of the leaders of the SVU (the Union of Liberation of Ukraine) in 1930.

Krawtchouk was appointed as a public prosecutor at the SVU show trial but he declined to participate despite significant risks that this decision entailed. During the public campaign against Krawtchouk, this fact was used as an evidence of his anti-Soviet activity. In 1930, 45 intellectuals were accused in forming an underground organization, Soyuz Vizvollenna Ukrainy (SVU). The accusations and the trial were masterminded by the Communist party leaders and the GPU, as the NKVD was then called. Stalin himself sent a secret letter to Kossior and Chubar, Communist Party leaders of Ukraine, with instructions on how to stage the SVU show trial and add new accusations of poisoning communist leadership to existing charges. (Mirsky, N.D.).

Hermaize was arrested first time on July 26, 1929 as part of the SVU case. He refused to give voluntary confession for several months.[42] In 1989, a review of the materials of the SVU case by a KGB commission concluded that 42 out of 45 accused did not confess voluntarily during their interrogations. (Prystaiko and Shapoval, 1995, p. 372).

Rocket Scientists

Sergei Korolev, former Krawtchouk's student at the Kyiv Polytechnic Institute, was arrested in Moscow in June 1938. Krawtchouk helped Korolev to get admission to the Kyiv Polytechnic Institute by waiving a two-year prior work requirement introduced for people of non-proletarian origin (Soroka, 1986). Korolev later transferred to a Moscow Institute and joined in the 1930s a rocket program headed by Tukhachevsky, a Red Army Marshall.

Korolev's was arrested after his imprisoned colleagues at the rocketry institute provided testimony which implicated him. However this testimony was not voluntary (Harford, 1997, p. 49, Golovanov, 1994). Korolev refused to confess voluntarily and was tortured. He confessed but later renounced his testimony. Korolev was implicated by testimonies of Langemak and Kleimenov, two leaders of the Jet Propulsion Institute (RNII).[43] Their testimony was obtained by means of torture. Langemak and Kleimenov were arrested on November 2, 1937 following arrest of Tukhachevsky and other top Soviet military officials who were accused of being German agents. Glushko, arrested in March 1938, also confessed of being a member of the anti-Soviet organization and a German spy. However, he renounced his testimony in letters to Vyshinsky and Stalin and stated that he was tortured during his interrogation. See (Harford, 1997, pp. 49-50).

The behavior of these four prisoners contradicts the prisoner's dilemma model. During their interrogations and trials they did not confess voluntarily in exchange for a more lenient punishment. Langemak and Kleimenov were executed. Korolev received 10 year sentence, while Glushko was given 8 years. The difference in length of sentences reflected primarily differences in their alleged roles in underground organizations.

This case had externalities pertaining to the Soviet space program. In the 1950s- and 1960s, Korolev became Chief Designer of the Soviet space program and he masterminded the development of the first artificial satellite (*Sputnik*), the first man and first woman in space, and the first space crafts to reach the Moon and Venus and fly by Mars (See Harford, 1997). Korolev's believe that he was prosecuted because of Glushko's testimony led to his tensions with Glushko who became a leading rocket engine designer. This had a negative effect on the Soviet manned flight program to the Moon in the 1960s, and is considered one of reasons for the failure of this program. Unexpected death of Korolev during a surgery in 1966, which was in part attributed to a broken skull during his interrogation by the NKVD, also negatively affected the Soviet space efforts, including the secret program of the manned flight to the Moon. (See Harford, 1997).

Prosecutors interrogated Krawtchouk about his acquaintances from the Volyn region, in particular about family of Kondratyuks. Oleksandr Shargei, who is now regarded as one of the founders of the theory of space flight, adopted documents and identity of Yuri Kondratyuk (Soroka (1991, pp. 216-224). Shargei did this to hide his service in the White Army from the Soviet authorities. Such service and adoption of fake identity documents were regarded as a political crime which carried a capital punishment. Krawtchouk personally knew Yuri Kondratyuk. He also knew Volodymyr Kondratyuk, Yuri's brother. Volodymyr Kondratyuk provided Shargei with the documents in the name of Yuri who died in 1921. During his interrogation Krawtchouk minimized his contacts with Kondratyuks and stated that they were people of Russian culture, even though Volodymyr Kondratyuk was an ethnic Ukrainian and worked as a teacher of Ukrainian literature in the 1920s.[44]

Similarly, Volodymyr Kondratyuk did not confess about the fact that he provided Shargei with identity documents of his brother. Volodymyr Kondratyuk was arrested in 1930 on political charges along with four other teachers of a high school in Kyiv. He and other teachers were accused in membership in a fictitious counterrevolutionary organization. Volodymyr Kondratyuk did not implicate his fellow teachers and Mykhailo Krawtchouk. Because the NKVD prosecutors could not obtain confessions from the arrested individuals, Volodymyr Kondratyuk was released after spending about 6 months in prison. [45] In 1932, he was arrested again on similar charges. However, Volodymyr Kondratyuk did not confess. He was released again after three months of interrogation.[46]

Oleksandr Shargei-Kondratyuk was arrested in Siberia in 1930 on charges of "sabotage" along with several other engineers. Materials of his prosecution show that he did not confess and implicate others during his interrogation. Similarly, Shargei did not disclose his real identity. This fact, which was uncovered in the 1970s as result of investigations by his biographers, as well as KGB, communist party and academic commissions, was made public only in the end of the 1980s.

The uncovering of real identity of Shargei and likely disappearance of his works from the public domain could have affected not only his fate but also the competition between the Soviet and US space programs, in particular, their efforts in the manned flight to the Moon. Shargei-Kondratyuk was the first to suggest a lunar orbiter rendezvous method of flying to the Moon. He proposed many other fundamental solutions, which were later used by the Soviet and American space programs, such as use of atmosphere to slow down descent of spacecraft. But because he feared that the NKVD would discover his true

identity and arrest him, Shargei-Kondratyuk refused to join Korolev and others in the Jet Propulsion Institute in Moscow. He worked as an engineer on designs of grain elevators and wind electricity-generating towers.

The LOR method, employed by the NASA during the Apollo program, had significant technological and economic advantages over the earth-orbit rendezvous method suggested by Von Braun and the direct descent method also considered by the NASA in the early 1960s. The LOR is credited by experts with enabling the US to achieve to land on the Moon by the end of the 1960s, a key political objective that Kennedy declared in 1961 to counter the Soviet lead in space. This method also saved several billions of dollars compared to other methods considered by the Apollo Program. (See Hansen, 1995, Kondratiuk, 1929/1947, Logsdon, 1971).

The arrest of Shargei-Kondratyuk in the 1920s and his disappearance during one of the battles of World War II in 1942 made not only him but also his ideas, like the LOR, politically dangerous in the Soviet Union. After the Nazi Germany attacked the Soviet Union, Kondratyuk became a soldier in the Red Army. He was either killed or was captured by the Nazis and perished as several million of Soviet POWs. (See Datsenko and Pristchepa, 1997). Captivity was considered as a treason by the Soviet government. Discovery of Kondratyuk's work in German territory captured by the Soviet troops in the end of World War II created suspicions that he might have worked for the Nazi missile program and joined along with most of Von Braun team the US program. Soviet rocket scientists initially preferred the Earth-orbit rendezvous method for their manned Moon program, and this depraved them of a key advantage compared to the US Apollo program

before its adoption of the LOR. They switched to the LOR concept only in 1964, more than two years after the Apollo program did.

Interrogations of Physicists

Oleksandr Goldman, director of the Institute of Physics in Kyiv, chaired the commission of the Ukrainian Academy of Sciences which investigated and denounced Krawtchouk. Mathematicians and physicists were members of the same division of the VUAN, and their research often intersected. Goldman was arrested in January 1938. He did not confess and implicate Krawtchouk and others during the interrogation and trial. (See Kiyak and Proskura 1997).

Sixteen people, including the most noted physicists, such as Lev Landau, were arrested in the case of the Ukrainian Physico-Technological Institute (UFTI) in Kharkiv. They were charged with counterrevolutionary activity, spying, and sabotage. The materials of the prosecution show that 3 individuals defected (confessed voluntarily) and 8 did not confess voluntarily. The cases of the others are unknown at this stage of the research. (See Pavlenko, Raniuk, and Khramov, 1998).

Conclusion

The prisoner' dilemma model applied to the Great Terror in the Soviet Union predicted that those arrested by the NKVD had an incentive to confess and implicate other prisoners. Since the other prisoners had similar incentive, they also confessed. As a result, all of the prisoners ended up worse off than if they all refused to confess.

The analysis of Krawtchouk's case and related ones, such as the Jet Propulsion Institute, SVU, and UFTI cases, finds weak support for the prisoner's dilemma model. Among 123 cases of scientists and other intellectuals arrested on political charges, 11

percent gave voluntarily confessions and implicated other prisoners. The absolute majority, 76 percent did not confess voluntarily. Their interrogators had to resort to other methods in the form of physical and psychological torture to extract confessions. Materials about behavior of 13 percent of the prisoners are either unavailable or are not sufficient to make a conclusion. (Table 2).

[Table 2 about here]

However, economic theory of rational self-interested individual, on which the prisoner's dilemma relies, is helpful in solving the puzzle of John Atanasoff's reluctance to claim credit and patent for the electronic computer. The study shows that this unwillingness is linked to the political prosecution of Mykhailo Krawtchouk.

Table 1. Classic prisoner's dilemma

		Prisoner B
Prisoner A	Do not confess	Confess
Do not confess	(3,3)	(25,1)
Confess	(1,25)	**(10,10)**

Table 2. Defection and cooperation in Krawtchouk's case and related cases, percent

	Cases
Confessed voluntarily/Defected	11
Did not confess voluntarily/Cooperated	76
DK/NS	13
Total	100
N	123

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Notes

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[2] Article 58 of the Russian Federation. Similar articles and punishments existed in other Soviet Republics, including Ukraine.

[3] The externalities pertaining to the outcome of World War II will be discussed in the book which is being written by the author.

[4] Krawtchouk Archival Investigative Case, Vol. 2, p. 109.

[5] The party name was derived from the name of its newspaper, which meant "struggle."

[6] See Syta (1994, p. 109) and Krawtchouk Archival Investigative Case, Vol. 2, p. 175.

[7] The reasons for the transfer of Krawtchouk's case to new investigators are not known, but a significant number of NKVD personnel, including leadership in Soviet Ukraine, were arrested or executed during the Great Terror and in its immediate aftermath.

[8] Mozhar and Dubinsky Archival Investigative Case.

[9] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, pp. 23-33.

[10] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, p. 34.

[11] Mozhar and Dubinsky Archival Investigative Case.

[12] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, p. 141.

[13] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, p. 100.

[14] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, p. 69.

[15] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, pp. 35, 48, 80.

[16] As in many other cases, the verdict was not made public. Only in the end of the 1980s, the family of Mozhar learned that he was executed.

[17] Mozhar and Dubinsky Archival Investigative Case, Vol. 1, pp. 84-88.

[18] Topolyansky Archival Investigative Case, p. 41.

[19] Topolyansky Archival Investigative Case, pp. 33-38.

[20] Topolyansky Archival Investigative Case, p. 41.

[21] Topolyansky Archival Investigative Case, pp. 43-50.

[22] Archival materials about interrogation of Mykhailo Killerog, a top party official and the former professor at the National Economic University, do not provide sufficient information to determine whether his confession was voluntary or involuntary. (See Killerog Archival Investigative Case and Naberukhin, 1995).

[23] See Archival Investigative Cases of Mykhailo Ptukha, Volodymyr Ivanushkin, Fedir Polonski, Maxim Lukovsky, Leonid Levitsky, Oleksandr Goldman, Petro Suprunenko, and Arnold Krister.

[24] Feshchenko Archival Investigative Case.

[25] Feshchenko Archival Investigative Case.

[26] See Killerog Archival Investigative Case, p. 42-78.

[27] Shteppa Archival Investigative Case, v. 2, p. 181; quoted in Shapoval (1996a, p. 347).

[28] Personal communication with Henry Hanson, Charles Call and Dennis Allegretti, November 2002.

[29] Personal Communication, December, 2002.

[30] Personal Communication, December, 2001.

[31] Atanasoff Papers, Box 14/1.

[32] Atanasoff Papers, Box 14/1.

[33] Ivanushkin Archival Investigative Case, p. 55.

[34] See Velichko Archival Investigative Case, and Mukomela and Romanyuk, 1995, pp. 22-23.

[35] Krawtchouk Archival Investigative Case, Vol. 2., pp. 25-124.

[36] The international conference on algebra that was organized by Krawtchouk in Kyiv in 1936 was cancelled for similar reasons.

[37] The details are sketchy because Krawtchouk's folder with foreign correspondence was confiscated by the NKVD during his arrest. It has not been located. Ulam (1991. p. 74), writes that most mathematics positions in the US were secured through recommendations of George Birkhoff, Oswald Veblen, and Arthur Coble. These scientists headed the American Mathematical Society during various times in the 1920s and 1930s. (See *MacTutor*, 2002).

[38] Tchaikovsky was released in 1943 after serving a 10-year sentence. He became a professor of mathematics at Lviv University.

[39] Levitsky was not arrested when Western Ukraine was incorporated into the Soviet Union in 1939.

[40] Atanasoff Papers, Box 8/10. Solomon Lefschetz translated and published a book by Krylov and Bogolyubov in 1943-1946. This work, along with several other books translated and published in the end of the 1940s, led to the rediscovery by American

scientists of a theory of stability developed by Lyapunov (Liapunov) several decades earlier. Neoclassical economists used this theory in the 1950s to provide mathematical foundations for stability of general economic equilibrium, a key element of modern economic theory. (See Weintraub, 1991).

[41] This article was translated and submitted before such practice was officially condemned during a public campaign against Luzin, a founder of Moscow School of Mathematics, in 1936. Slutsky taught mathematical statistics at the same time Krawtchouk was at the Kyiv Commercial Institute (now the National Economic University) and studied at the same mathematics and physics department at Kyiv University. In his paper which laid down mathematical foundations for the 1937 article in *Econometrica*, Slutsky (1960, p. 50) noted that Krawtchouk showed him how to prove a number of mathematical formulas. Following suggestions of Schultz and the editor of *Econometrica*, Slutsky (1937) published an updated version of his paper on stochastic processes and time-series analysis. Economists view this article as one of the earliest predecessors of the Real Business Cycles theory.

[42] On April 19, 1930, Hermaize was sentenced to 8 years. On December 8, 1937, *troika*, an extrajuditiary body created at the start of the Great Terror, in Saratov region of Russia sentenced Hermaize, who was released from prison, to 10 years. (See *Represovane Kraeznavstvo,* 1991, pp. 132-133).

[43] Korolev was sent to the same GULAG camp in 1939 where Krawtchouk was sent. However, after others intervened on his behalf, he was transferred from a Kolyma camp to *sharazka*, a blend of a prison and a research institute in 1940 to work on military projects, and released in 1944.

[44] Krawtchouk Archival Investigative Case, Vol. 2., pp. 1-7.

[45] See Pacharevsky, Petrushevsky, Lysenko, Kondratyuk and Manzhos Archival Investigative Case.

[46] Kondratyuk Archival Investigative Case.