

PRELIMINARY VERSION

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Risk Aversion during World War II: Evidence from Belgian Lottery Bond Prices

Abstract

Using the market prices of two Belgian lottery bonds, this paper analyzes how the investors' risk preferences changed during the Second World War. The estimates suggest that risk aversion dramatically changed during the Occupation period. Before 1943, investors showed strong signs of risk aversion; yet, in 1943 and 1944, they exhibited a risk-seeking attitude. This puzzling result is attributed to the euphoria brought by the prospect of the war's end.

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Risk Aversion during World War II: Evidence from Belgian Lottery Bond Prices

1. Introduction

Understanding how risk preferences of financial markets' participants change over time is crucial to analyze the dynamic of financial markets. An investor's risk attitude partially determines his asset allocation between risky and non-risky assets, the premium he will require for bearing risk, and hence, the price he is willing to pay for a specific asset. As a result, on an aggregate level, changes in investors' attitude toward risk have a major impact on asset prices. Understanding the mechanism through which these risk preferences are formed, and how they change in extreme situations, such as during wars or financial crises is therefore key for analyzing past behaviors on the financial markets.

The present paper investigates the risk attitude of Belgian financial markets' participants during the Second World War. The aim of the paper is to determine to which extent risk preferences changed over time and to enhance the understanding of how extreme events impact financial behavior. The main idea is to extract a measure of risk aversion from the financial market, then study its evolution over the period. Intuitively, in front of such circumstances, one could expect investors to exhibit a high degree of risk aversion. The empirical evidence presented in this paper is however mixed. Risk attitudes clearly varied across the period, as if investors went through different behavioral phases. The most surprising result is that during the second part of the Occupation, Belgian investors exhibited risk-seeking attitudes on the lottery bond market. This observation could be attributed to the euphoria created by the prospect of the end of the war.

To elicit investors' risk preferences, we use the market prices of two lottery bonds issued by the Belgian government during the first half of the 20th century. Thanks to their specifications, these securities allow extracting evidence on investors' risk behavior. Indeed, a lottery bond mixes features of traditional bonds and lotteries. As a classical bond, the bearer receives a coupon every year until the bond is recalled. However, the date and the value at which the bond will be recalled are uncertain since they are determined via a monthly lottery. For each lottery, a pre-determined number of bonds are randomly drawn and each drawn bond provides a monetary prize. The holder of the drawn bond receives the cash prize. In counterparty the bond is retired. This setting provides an ideal environment to study risk behavior. The specifications of the lotteries are determined and publicized upon the issue of the bond. For each lottery, any investor knows the *a priori* probability of being drawn and the value of the prize pool. Therefore, lottery bonds are close to a market traded lottery ticket. Comparing the subjective price one is willing to pay on the market for this asset, to its theoretical value enable to draw conclusions on risk preferences.

Various techniques have been developed in the literature to analyze risk preferences and extract risk aversion estimates. Different types of data have been used: household data (Friend and Blume 1975; Morin and Suarez 1983), laboratory experiments (Harrison, List, and Towe 2007; Holt and Laury 2002), consumer survey (Guiso and Paiella 2008; Malmendier and Nagel 2011), option prices (Bliss and Panigirtzoglou 2004; Jackwerth 2000). In this paper, we are interested in the change in risk aversion, rather than its magnitude. Analyzing how risk aversion varies over time is however challenging. First, it requires having access to a frequent and continuous source of observable data. Second, it is sometimes difficult in practice to distinguish change in risk attitudes from change in risk preferences. An agent's attitude toward risk might vary, for example due to changing investment opportunities, even though his underlying risk preference

remains stable. In other words, observing the choices made by investors is not enough to infer conclusions on their risk preferences, there should be some kind of control on the states of nature.

Time-varying risk aversion has been a topic largely discussed in the literature. By incorporating this feature, several asset pricing models (Campbell and Cochrane 1999; Constantinides 1990) succeed in replicating the mean and counter-cyclicity of asset return data. For example, Brandt and Wang (2003) build a model in which aggregate risk aversion varies in response to news about inflation. Estimating their model, they find a positive correlation. From an empirical point of view, several studies have tried to analyze the stability through time of risk taking behaviors. Andersen et al. (2008) used repeated field experiments to study the temporal stability of risk preferences among a sample of the Danish population over a 17-month period. They find that risk attitudes are remarkably stable, whether or not they control for changes in certain major states of nature. On the other hand, several studies bring evidence on changing risk attitudes. M. Weber, E. Weber, and Nosić (2012) repeatedly surveyed online-brokerage customers about their expectations and their risk attitude during the recent financial crisis of 2008. They report a shift in risk taking behavior due a change in their return and risk expectations. For the same period, Guiso, Sapienza, and Zingales (2011) also report a significant increase in risk aversion. Since they do not find any correlations with change in wealth or consumption habit, they hypothesize that the cause is psychological. This explanation is coherent with the many studies arguing for the role of emotions, feelings and beliefs on financial decisions (Daniel, Hirshleifer, and Teoh 2002; Kuhnen and Knutson 2011; Loewenstein et al. 2001; Nofsinger 2005). As a result, change in psychological mindsets might trigger change in risk preferences. For example, Eckel, El-Gamal, and Wilson (2009) study the impact of the occurrence of a natural disaster on risk preferences. They conduct an experiment with hurricane Katrina evacuees and report a strong risk loving bias

when the experiment is run shortly after the catastrophe compared to when it is run a few months later.

To recover risk preferences, we opt in this paper for a quite unusual methodology. Using lottery bond prices to analyze risk preferences allows overcoming some of the limitations usually encountered by the previous methods. First, there is no need to make assumptions about the return distribution, the consumption growth or the investors' subjective probability beliefs. With lottery bonds, the probability and the payoff distributions are known from the outset by all investors. Therefore, the risk preferences embedded in the market prices are based on objective figures. Furthermore, because lottery bonds are continuously traded on the secondary market over a long period, it is possible to continuously monitor the evolution in risk attitudes by using high frequencies time series.

Despite the opportunity offered by lottery bonds, their use to assess risk aversion has been scarce. Schilbred (1973) extracts the market price of risk from bonds whose redemption dates were decided via a lottery. Green and Rydqvist (1997) study the Swedish lottery bonds. Although the lottery risk is diversifiable because an equally weighted portfolio of all the outstanding bonds could be purchased, they find that investors require a lottery risk premium. Florentsen and Rydqvist (2002) analyze the ex-day returns of Danish lottery bonds. The authors report that prices around the lottery dates fall by more than the mean of the lottery. Surprisingly, these price drops decrease with the lottery variance. The authors interpret this observation as a sign that investors actually dislike the lottery feature of the bond. Lobe and Hölzl (2007) attempt understanding the success of the British Premium bonds. Despite the fact that these bonds are non-tradable securities with a very uncertain payoff, their monthly return being based on a lottery, they are very popular among the population. They argue that the success is due to the prize skewness and fiscal motives. Ukhov (2010) uses the Russian lottery

bonds to analyze investors' risk preferences. He extracts absolute risk aversion parameters from the bond market prices and shows that a positive correlation exists between risk aversion and the price of the risk-free asset. Bühler and Herzog (2011) use a dynamic equilibrium model to estimate the size of the relative risk premium and the relative risk aversion coefficient from German lottery bond prices. They find relative risk aversion coefficients that are of a lower magnitude than those estimated from the stock markets. In addition, the values of the coefficients significantly vary over time, peaking during the 1980/1981 oil crisis, and are in line with the interest rates.

This paper brings an original point of view in the literature. It is the first to specifically analyze risk attitudes during WWII, and more globally risk aversion in time of war. Borrowing on the methodology from Ukhov (2010), we price the lottery bonds and build an index based on the ratio between the fair value of the lottery bonds and their market price. The paper is organized as follows: Section 2 gives an overview of the economic context of the period. Section 3 describes the data. Section 4 provides the methodology used for pricing lottery bonds and extracting risk aversion parameters. Section 5 presents the results whereas section 6 concludes.

2. Belgian economy under the Nazi boot¹

Since the aim of the paper is to analyze the risk preferences of Belgian financial markets' participants, it is crucial to understand the context in which they operated. The data used in this paper range from 1938 to 1948, and can be divided into three distinct periods.

¹ See Conway (2012) and Oosterlinck and White (2013) for two detailed accounts of the war economy and the aftermath of the war.

The pre-war period, from October 1938 to May 10th 1940, date of the German invasion, was marked by the rising probability of the outbreak of the war. Although in September 1938, the Munich Agreement had brought a glimmer of hope, the German occupation of Bohemia, Moravia and Slovakia in March 1939, followed by the signature of German alliances with Italy and the Soviet Union, increased international tensions during the second half of 1939. The German invasion of Poland, on September 1st 1939, shattered any hope for peace. Despite repeated statements of neutrality, Belgium had no illusions: its geographical position made the country a strategic place for battle. As a result, the country began to prepare for war, by mobilizing its troops and building defenses. This weighed heavily on the public finances.

In addition to exceptional expenses linked to preparation for war, the government had to face a contraction in revenue. Baudhuin (1945) describes the pre-war situation as an *economic stagnation*, caused by the fact that people, in anticipation of the events, avoided all unnecessary expenses. Because the Belgian treasury needed to find 500 million BEF every month, the government resorted to new taxes and to massive issues of bonds and treasury notes. The public deficits of 1938 and 1939, in a framework of linguistic quarrels, caused an internal political crisis that led to the dissolution of the government in March 1939 (Banque Nationale de Belgique, 1939). This political crisis, which came to an end with the formation of the Pierlot government on April 18th 1939, contributed to fuel the general atmosphere of fear and incertitude. As a result, people began hoarding cash. Bank deposits melted and banknote circulation surged. Financial markets were paralyzed and capital flew outside the country.

On May 10th 1940, Germany invaded Belgium. After, 18 days of resistance, king Leopold III capitulated against the will of part of the government, which fled to London. The German occupation force had one major priority: exploit the

economic resources of the country to fuel the German war effort. As noted by Warmbrunn (1993, p. 113), "*most of the new organizations the Germans created were to perform economic rather than political functions*". Germans knew they needed the cooperation of the Belgian administration, businessmen and population to achieve that goal. A major instrument used to take advantage of Belgium was the clearing system, put in place originally to compensate the business transactions between Germany and Belgium. When a transaction occurred, the German buyer deposited the money to the Reichsbank, the Belgian seller was then paid in Belgian Francs by the *Banque d'Emission*², on the advances from the *Banque Nationale de Belgique (BNB)*. The reverse was supposed to happen for German exports. However, German purchases were unrestrained and largely overtook Belgium's, leading to a rising imbalance of the clearing account. This situation led to a dramatic increase in the amount of currency in circulation, + 236% according to the BNB, because the money earned could not be spent, given the scarcity of goods in the country. Increased taxes, and the issue of internal debt, helped to control the inflation, which impacted mostly the black market. To further exploit defeated Belgium, Germany imposed huge occupation costs. The original amount of 1 billion BEF per month was raised to 1.5 billion in September 1941, forcing the government to issue a massive amount of debt. As a result, the public debt was multiplied by three between 1940 and 1944 (Vanheurck, 1954).

Belgian stock exchanges were closed on May 10th, 1940. Given the circumstances of life under the occupation, many people needed to realize their investments. Without a regulated official stock exchange, these people had to turn to unofficial circuits, where unscrupulous intermediaries were eager to take advantage of them. In this context, stolen securities were also likely to be sold. To avoid this situation, a reopening of the stock exchanges was needed. As Buelens

² The *Banque d'Emission* was created at the beginning of the Occupation. It was supposed to take on the role of the *Banque Nationale de Belgique* (see Van der Wee and Van der Wee-Verbreyt, 2010 for an in-depth description of the workings of the National Banks during the occupation).

and Willems (2006) report, this was one of the arguments the Brussels stock exchange commission put on the table. The German military command agreed, also because it knew that Belgian authorities were likely to have to rely on the financial markets to meet the occupation costs. At the end of August 1940, Belgian stock markets reopened, under strict conditions³. Stocks immediately registered an impressive upward movement. Baudhuin (1945, p. 190) attributes it to a correction of the huge depreciation that happened before the war.

When the situation stabilized, people who had made liquidity provisions before the war began to look for secure investments. They feared the monetary consequences of the war and the impact of inflation. This concern was also shared by those who were seeking a discrete way to hide the illegal profits they had made during the occupation. Moreover, many firms had realized their stocks and needed to find a way to reemploy their liquidities. Banks faced the same investment problem. Bank deposits had surged because of capital repatriation in the country and the increasing money circulation. Yet, during this period, businesses had no need for credit, which forced banks to find other investments. Despite the huge inflation, many investors turned to state securities, particularly short term ones, because they allowed for major liquidity in case their customers needs' for credit re-appeared (Baudhuin, 1945, Oosterlinck, 1999). Overall, Belgian financial markets experienced a boom during the first phase of the occupation. Real assets and artworks in particular experienced an even greater boom (David and Oosterlinck, 2011). This financial boom can be explained by the lack of investment opportunities, especially after 1943 when people began to fear the withdrawal of high value banknotes⁴, the uncertainty about the Belgian Franc, the financial

³ No futures market, no foreign or colonial stocks, no access for the public, limited opening hours, presence of a German controller. See Buelens and Willems (2006) for more details.

⁴ As Baudhuin (1945), this fear was very lively in 1942-1943 among the population. Given the always increasing money circulation, they feared that the government might decide to retire a fraction of the country's banknotes. In March 1943, when it happened in Holland, Belgian financial markets witnessed a very violent boom.

repression and the constantly increasing monetary circulation. During this period, the same situation was observable in occupied France (Oosterlinck, 2003).

Banks had considerable liquidities to invest during the period. Following the banking reforms of 1934 and 1935⁵, the share invested by Belgian banks in Belgian state securities had been slightly growing. During the occupation, this share rocketed. Deposit banks had powerful means of action, but the private sector had no need for credit. At the same time, the government had to issue a tremendous amount of debt to face the occupation costs. Both parties found there a natural match. In 1944, credits to the public sector were representing more than 80% of total Belgian banks' credit. They invested 74% of their total asset in state securities (Cassiers et al., 1998). Nevertheless, even though banks were massively buying the Belgian debt, they had only appetite for the short term debt. Their target were the so-called *certificats de trésorerie*, a short term and low return security, but with an almost unlimited liquidity (Baudhuin, 1945). This could enable banks to move quickly in case opportunities in the credit to the private sector reappeared.

In 1944, 35 on the 39 billions of francs of Belgian debt held by Belgian banks were short term. The Belgian National Bank noted in its report about the 1940-1944 period: "To preserve the liquidity of its assets, banks almost exclusively affected the capital raised from deposits to the purchase of *certificats de trésorerie*. This is confirmed looking at the structure of new debt emission during the war: on the 40.250 billion of francs of issue, 31.100 were raised with *certificats de trésorerie*" (BNB, 1945). From 1946 on, Belgian banks were lawfully required to hold at least 65% of the total value of their short term liabilities in cash or short term

⁵ The most important one being the reform of the mixed banking model. This forced banks to split their activities in an investment bank and a deposit bank. Deposit banks could no more invest in commercial and industrial securities, and were therefore forced to turn to government securities. See Vanthemsche (1997)

government securities⁶. Since they already had to keep a large part of their assets in short term Belgian debt, banks did not want to hold in addition other kind of securities issued by the Belgian government, probably limiting their holdings of lottery bond (Vanthemsche, 1997).

Most of the population had however other concerns. The cost of life had surged during the occupation. Official prices had somehow been kept under control. After having been multiplied more or less by two in 1940-1941, they remained stable until the end of the war (Launay and Offergeld, 1982). However, given the scarcity of goods on the official market, many had to turn to the black market to live decently. Taking 1938 as standard, prices on the black market had increased by 1600% in January 1943 (Launay and Offergeld, 1982). For the same period, wages had on average only risen by 8%, with an average revenue increasing between 10 and 28% thanks to extra-hours and indirect compensations (Jacquemyns, 1950). As a result, the majority of the population had not much money to save, and those who had financial investments were probably tempted to sell them in order to keep a decent living standard. Mentioning inflation as a major driver of the period is especially worth given the kind of securities we study. First, lottery bonds are very long term asset with a fixed coupon. As such inflation makes them tend to make them unattractive. Furthermore, these securities were designed to attract the public thanks to the high prizes it offers. The rising cost of life however undermined the subjective value of these prizes, which could have affected the lottery bond appeal⁷.

⁶ The goal of this measure was to force Belgian banks to keep buying the country's debt. Indeed, after the war, when opportunities in the private sector reappeared, the government became afraid to see one of its biggest lending source shrinking.

⁷ Skewness is often pointed out as the major ingredients of a lottery success. A lottery should offer many small prizes, but also a small number of very large prizes ((Golec and Tamarkin 1998; Lobe and Hölzl 2007). In our case, inflation could have lowered the appeal of the lotteries by lowering their skewness.

Although fighting continued in some part of the country until 1945, Brussels was liberated in September 1944 and the Pierlot government returned immediately to the capital. Belgium managed in 1947, to be the first occupied country to restore its pre-war industrial level. Nonetheless, the situation at the Liberation was difficult. Belgian authorities had to face a series of internal policy issues which divided the public opinion: the dismemberment of the resistance, the linguistic issues, the debates about the fate of collaborationists, and the future of King Leopold III, the so-called *Question Royale*. In addition to these political issues, the economic situation was also preoccupying. Because of the enormous clearing imbalance and because investment possibilities had been low during the war, the fiduciary circulation had tripled during the war. Inflation was a clear threat to the economic recovery (Eyskens, 1954). To address the problem, Camille Gutt, the minister of finance, designed a program of monetary purge. Known as the *Plan Gutt*, it had as objective the withdrawal of excess money from the economy. In practice bank deposits were blocked, in order to decrease the fiduciary circulation to a level corresponding to the real needs of the economy. 60% of these assets were definitively blocked and converted into a forced debt; the rest was temporarily blocked and released as the need of the economy grew (Banque Nationale de Belgique, 1945 and 1946). The *Plan Gutt* enabled to dramatically slow down the expansion of the money supply. As a consequence of the plan, the stock exchanges were closed in September 1944, and reopened only after a long break, the 4th June 1945, under special conditions.

3. Data

Lottery bonds (*emprunts à lots*) were a common feature of Belgian public finances at the eve of the Second World War. Already in the 19th century cities and districts had used lottery bonds to finance their activities (e.g.: Anvers 1887, Gand, 1896, Schaerbeek 1897, Liege 1897). Even though lotteries were forbidden by the law of the 31st December 1851, lottery bonds, providing they met certain ethical

criteria, were authorized upon approval by the government⁸. The government turned to lottery bonds for massive public financing after World War I. The first nation-wide issue took place in 1921 and was at the heart of a passionate parliamentary debate. Its goal was to finance the country's reconstruction via a dedicated body: *La fédération des coopératives pour dommages de guerre*. On December 23rd 1920⁹, Georges Theunis, minister of finance, defended the issue in the Belgian Chamber of Representatives. According to him, the country desperately needed to raise 1 billion Francs to finance the reconstruction and a lottery bond was the only way to achieve this objective, "The human nature being as it is, it has been demonstrated that prizes, in addition to interests, are powerful to ensure the success of a bond issue"¹⁰. He added that the demand from Belgian investors for this type of asset was huge. Consequently, if investors' demands were not met, they were going to invest their money in foreign lottery bonds (for example in France, where the *Crédit National français* offered a lottery bond). The issue faced a tough opposition from liberal deputies. Paul Van Hoegaerden stressed the immorality of such an issue stating that "*People should not be encouraged to gamble and believe that wealth can be acquired through gambling, whereas only labor can provide it.*"¹¹ Eventually, the issue was authorized, and similar issues followed in 1922 and 1923.

Lottery bonds were again issued, with fewer debates however, in 1932, 1933, 1938 and 1941¹², to finance public deficit. At the end of the 1930s, a wide variety of lottery bonds coexisted on the Belgian stock exchanges. These bonds accounted for

⁸ Cf. Law of the 30th December 1867, description in Levy-Ullman, H., *Lottery bonds in France and in the principal countries of Europe*, Harvard Law Review, Vol.9, No.6 (Jan. 25, 1896), pp. 386-405

⁹ Belgian Chamber of Representatives, Plenary session of 23 December 1920, proceeding of the plenary session p. 21., online consultation: plenum.be, University of Antwerp

¹⁰ Translated from French. Original quote « *Il a été prouvé, la nature humaine étant ce qu'elle est, que les lots, ajoutés à l'intérêt accordé au porteur, sont un puissant stimulant pour la réussite d'un emprunt* ».

¹¹ Ibid. « *il est mauvais d'inciter le public belge au jeu et de lui laisser croire que la fortune peut s'acquérir par le jeu, alors que c'est le travail seul qui peut lui la procurer* »

¹² Lottery bonds issued by cities (e.g.: Brussels 1905), by public companies (Société nationale des Chemins de fers) or by banks (Crédit Communal) were also traded.

a small but significant part of Belgian public finance¹³. Knowing the exact repartition of the lottery bonds among the different categories of investors is extremely hard. According to Davin (1945), in 1942, the Belgian public debt repartition was as follow: 44.5% to public banking institutions, 26.6% to private financial investors and 28.9% to the general public. Cassiers et al. (1998) estimate the share of Belgian debt held by Belgian banks at 25%. .

Lottery bonds were specifically designed to appeal to the general public. Therefore the figures mentioned by Davin (1945) probably represent a lower bound for the share of lottery bonds held by the population. Bonds were issued with different denominations ranging from 500 BEF (1932 and 1938) to 1,000 BEF (1933 and 1941). In order to concentrate on bonds most likely to be held by a large part of the population, this paper focuses on the 1932 and 1938 bonds. Both bonds were issued before the war and thus were not facing the specific risk of repudiation of the bonds issued by the *Secrétaires Généraux*, which are known to have specific price dynamic (Oosterlinck, 1999).

The 1932 Lottery Bond

The nominal amount of the 1932 Lottery Bond issue was 1 billion BEF with a 5% coupon payable on March 15th. The face value of the bond was 500 BEF (200,000 series of 10 bonds worth 500 BEF). But the thrilling feature was that the series were to be redeemed within 70 years, randomly, via monthly lotteries. These monthly lotteries not only decided when the bonds were to be recalled, but also decided on their redemption value. These redemption values were equal to the prizes of the lottery. Thus, investors could neither know the maturity nor the recall payment of the bond. The drawings took place every month on the 25th. The prize values and the number of bonds to be recalled at each drawing were scheduled at

¹³ In 1938 lottery bonds represented more than 11% of Belgian long term sovereign debt (Baudhuin, 1945, p .398)

issue. The drawing plan and the associated prizes were thus public information. For each outstanding series, a corresponding token was put into a ballot. Then, for each prize to be attributed at the lottery, a token was drawn, and the prize value was divided between the 10 bonds of the series. If drawn, a bond was immediately retired, and ceased to participate in further lotteries; however, holders of these bonds kept the right to receive the coupon payment of the year. During the 10 first years, drawn bonds were providing prizes ranging from 25,000 to 5 million BEF. After this date, the total monthly value of the prizes slightly decreased, with the highest prize worth only 500,000 BEF. The “prize” could even fall to only 50 BEF to be added to the face value. This was the fate of most of the bonds, the probability of winning a thrilling prize was very small. Eventually, coupons and prizes were both tax-exempt.

The 1938 Lottery Bond

The 1938 Belgian lottery bond was issued on the 15th October 1938¹⁴ in order to cover the extraordinary expenses of the previous year, which were linked to the preparation of the country in prevision of a war with Germany. It consisted of 2 000 000 bonds of 500 BEF face value¹⁵. The issue price was set at 485 BEF. In order to simplify the drawings, the bonds were grouped in 200 000 series of 10 bonds. The lottery bond paid a variable interest rate: 3.5% from 1938 to 1948, then 4% from 1948 until maturity. The annual coupon was paid on the 15th October. As in the case of the 1932 bond, the bond was to be amortized in 70 years. Both the maturity and the recall payment were random because of the lottery feature. The drawings were taking place publicly at the Belgian National Bank in Brussels, on the 5th of each month, or the day before in case of public holiday.

¹⁴ Following a Royal Decree (*Arrêté Royal*) published in the *Moniteur Belge*, 10-11 October 1938, p. 6067-6074

¹⁵ It was possible to buy whole series. A part of the issue was meant to be sold as such. Therefore two 1938 lottery bonds coexisted on the market, a small one of 500 BEF, and a larger one of 5000 BEF. The latter being much less frequent, the analysis relies on the 500 BEF bond.

The prize values and the number of bonds to be recalled at each drawing had been scheduled when the bond was issued. The drawing plan and the associated prizes were thus public information. For each outstanding series, a corresponding token was put into a ballot. Then, for each prize to be attributed at the lottery, a token was drawn, and the prize value was divided between the 10 bonds of the series. All prizes were to be paid on the 15th October following the drawing date, no matter the month of the drawing. If drawn, a bond was immediately retired, and ceased to participate in further lotteries; however, holders of these bonds kept the right to receive the coupon payment of the year. Eventually, coupons and prizes were both tax-free.

The value of the prizes varied depending on the month of the drawing, inducing seasonality in the public attention. The total yearly value of the lottery also changed over the years. The biggest prizes were distributed during the first years to attract the public. However, a guiding principle remained for all drawings. For each monthly drawing, there was one big prize, ranging from 250,000 to 3,000,000 BEF which was attributed to one series, and a smaller prize of 25,000 BEF to be allocated to a number ranging from 11 to 30 series. There was of course no guarantee that investors would eventually win one of these prizes. Indeed, from 1949 on, in addition to the lottery prizes, a fraction of the outstanding bonds was randomly recalled at face value. For an individual bond, this was equivalent to “winning” a 500 BEF prize and therefore, will be treated at such in the remainder of the paper. The number of bonds that experienced this fate far exceeded the number of bonds that won big prizes: for example, in 1949, 144 series received a *true* prize, and 682 were reimbursed at par. The number of par-redeemed bonds increased every year. Thus, the odds of winning the jackpot were rather poor. Even though they offered a higher coupon than other state bonds, lottery bonds were still risky assets. Lottery bonds often traded much above par, therefore a buyer

faced the risk of paying a high price for a security that could be drawn at the next lottery and redeemed at face value.

Clearly, for both bonds, the prizes were significant and had the power to attract a large panel of investors. For a low-middle class family with an average income of 1,897 BEF in 1940, the prizes must have been perceived as a fortune (Jacquemyns, 1950, p. 16).

The Dataset

The dataset is composed of the daily market prices of the 1932 and the 1938 lottery bonds. The market prices were retrieved from two newspapers: *Le Soir* and *La Dernière Heure*. For the 1932 bond, the data series begins on January 1st, 1936 and ends on July 31st, 1947 (2,409 observations). Regarding the 1938 bond, the sample contains 1,815 daily observations, ranging from November 17th, 1938 to July 31st, 1947. The series suffers however from two large breaks due to the war. The Belgian stock exchanges were closed, first during the German invasion and the beginning of the occupation (from May 10th, 1940 to August 21th, 1940), secondly at the Liberation (from September 1st, 1944 to June 4th, 1945). Although transactions occurred unofficially, there are no market prices for this period (Baudhuin, 1945).

4. Methodology

This section shows first how to find the theoretical price of the 1932 and the 1938 lottery bonds. The methodology used is borrowed from the work of Ukhov (2010), to which adjustments are made to take into account the specificities of the Belgian lottery bonds.

The pricing of lottery bonds¹⁶

Belgian lottery bonds were made of two components: the first giving the right to claim an annual coupon until the bond was recalled, the other, determining the timing and the value of the recall payment. Pricing the lottery bond can be achieved by pricing separately these two components. The theoretical price of the bond at time t is equal to the sum of the present values of all the coupons to be received between t and the uncertain recall date, plus, the present value of the expected lottery prize.

Let's consider an investor buying the 1938 bond when issued. Between the issue and the bond maturity, 70 years later, 836 lotteries will take place¹⁷. $k = \{1, 2, 3, \dots, 836\}$ corresponds to the k -th lottery. Each lottery has a specific pool of prizes. On the day of the first lottery, there are two alternatives for the investor. If the bond is drawn, he wins one of the p - prizes of the lottery; he keeps the right to receive the coupon of the year, but the bond is retired and ceases to participate in the future lotteries. If the bond is not drawn, the holder receives nothing. On the second drawing, conditional to not having been drawn at the first lottery, the same logic applies; and henceforth until the 836th lottery.

Generalizing, the theoretical price of the bond, at any time t , is the sum, for each lottery k remaining, of all the cash-flows to be received if the bond is drawn at a the lottery k , multiplied by the conditional probability of being drawn at the lottery k . The cash-flows are the sum of a) the present value, at t , of the expected value of

¹⁶ The pricing methodology is presented for the 1938 lottery bond. The pricing of the 1932 lottery bond follows exactly the same principle. Of course, the prize values, the drawing dates, and the discount factor are adapted.

¹⁷ There were only 836 lotteries, not 840, because no lottery was scheduled in November 1938, January 1939, September 1939 and October 1939. In addition, it is reasonable to assume ex ante that during the life of the bond, all scheduled lotteries would take place, even during the war.

the prize if drawn at the lottery k , and b) the present value, at t , of all the coupons to be received between t and k . In other words:

$$P_t = \sum_{k=1}^{836} [\mathbb{P}\{Drawn\ at\ lottery\ k\ | Outstanding\ at\ time\ t\} \cdot (L(t, k) + C(t, k))] \quad (3.1)$$

where $L(t, k)$ is the present value in t of the expected value of the winnings of the lottery k , $C(t, k)$ is the present value in t of the sum of the annual coupons between t and k , and $\mathbb{P}\{k | t\}$ is the probability, for a bond outstanding in t , to be drawn at the lottery k .

In the event that a bond is drawn at the lottery k , $L(t, k)$ represents the expected value of the recall payment that the holder is expecting to receive, discounted at time t . Every bond outstanding has the same probability of receiving one of the p_k prizes of the lottery. If there are p_k prizes to be attributed at lottery k , $z_k(i)$ denotes the prize i of the lottery k , and Z_k the total value of the prize pool of the lottery k , the expected value of the drawing k is:

$$L(t, k) = Df(t, k) \frac{\sum_i^{p_k} z_k(i)}{p_k} = Df(t, k) \frac{Z_k}{p_k}$$

where $Df(t, k)$ is the discount factor between t and the 15th October that follows the lottery k .

$C(t, k)$ is the sum of all the coupons that the holder in t , of a bond drawn at the lottery k , is expecting to receive. The coupon is paid annually on the 15th October and if a bond is drawn it still receives the coupon that is due for the year. The value of the coupon varies depending on the year. If y denotes the year in which a coupon is paid, j the year in which the lottery k takes place, and y_t is the year of the first coupon to be paid after time t :

$$C(t, k) = \sum_{y=y_t}^J Df(t, y) \cdot \begin{cases} 17,5 & \text{if } 1938 \leq y \leq 1948 \\ 20 & \text{if } 1949 \leq y \leq 2008 \end{cases}$$

with $Df(t, y)$ the discount factor between t and the 15th October of the year y .

Finally, the recall probability $\mathbb{P}\{k \mid t\}$ is the probability for a bond outstanding at t to be drawn at the lottery k , conditional on not being drawn in the previous lotteries occurring between t and k . For the first lottery that follows time t , denoted k_1 , the probability of being drawn is simply the number of bonds to be drawn, n_{k1} , which is equal to the number of prizes to be attributed, divided by the number of bonds outstanding before the lottery, O_{k1} . For the second drawing, the recall probability is similarly n_{k2} / O_{k2} , yet because the probability of being drawn at this second lottery is conditional of not being drawn at the first lottery, it has to be multiplied by n_{k1}/O_{k1} . And henceforth for all the following lotteries. Of course, for all the lotteries before t , the recall probability is 0. Therefore:

$$\mathbb{P}\{k \mid t\} = \begin{cases} 0 & \text{for the lotteries occurring before } t \\ \frac{n_{k1}}{O_{k1}} & \text{for the lottery that follows } t : k = k_1 \\ \frac{n_k}{O_k} \cdot \prod_{i=k1}^{k-1} \left(1 - \frac{n_i}{O_i}\right) & \text{for the rest of the drawings} \end{cases}$$

Since $L(t, k)$, $C(t, k)$, and $\mathbb{P}\{k \mid t\}$, can be found using the bond specifications, which are public information, the theoretical price P_t can be calculated for any date t using the equation (3.1)

The findings of the previous section are used to build an index that will be used to analyze the daily changes in risk attitudes. The price index is simply the ratio of the

market price of the lottery bond divided by the theoretical price calculated through (3.1.):

$$PI = \frac{\text{market price in } t}{P_t}$$

When PI is above 1, investors pay more than the risk neutral value of the bond, and inversely. An increase in PI reflects a diminution of investors' risk aversion.

A way to test the pricing methodology is to look at the PI at the date of issue. If the pricing and the methodology are correct, when issued the bonds should have had a PI close to 1. According to our metric, the 1938 bond was almost perfectly priced at issue, the issue price was 485 F and the bond had an actuarial value of 483.5 BEF. This is equivalent to a PI equal to 0.997.

5. Results

5.1. Lottery bonds overview

Prices of lottery bonds greatly varied over the periods. Figure 1 shows the price evolution of the 1932 and the 1938 lottery bonds.

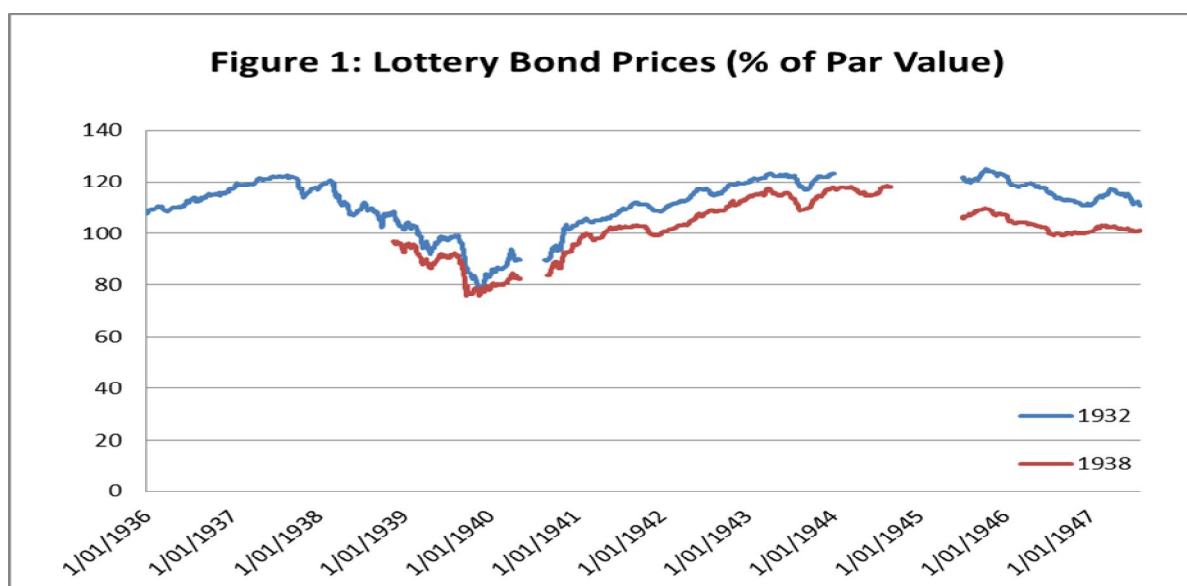
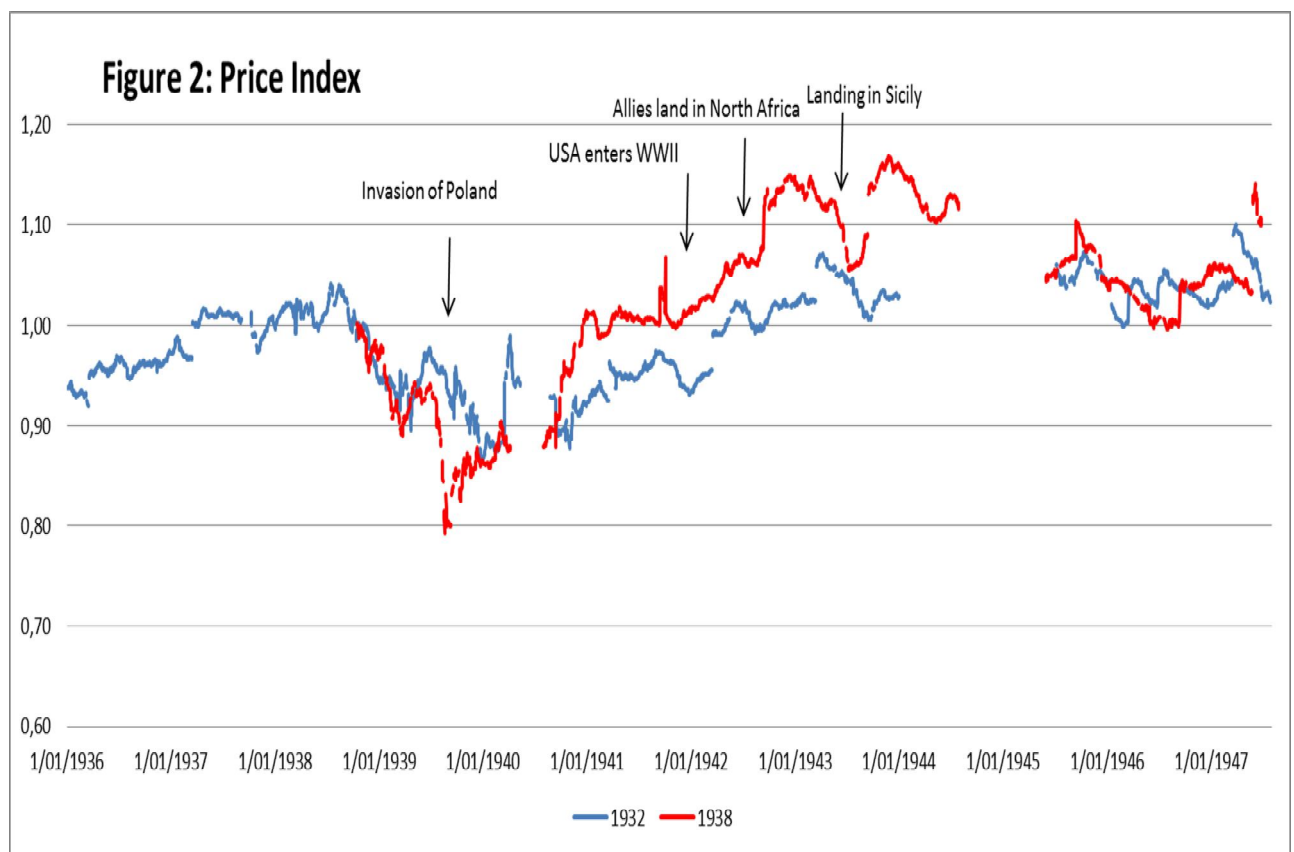


Figure 1 shows that prices of both bonds were highly correlated. Prices of both bonds nosedived at the war outbreak. But during the occupation, prices experienced an impressive growth. That does not necessarily mean as such that investors were favoring lottery bonds. Given the financial repression, the high inflation and the lack of investment opportunities, investors were forced to make some investment choices they would not do in normal times. Financial repression forced many investors to buy state bonds (Oosterlinck, 1999). As a matter of fact, other assets also experienced a large boom. For example, Baudhuin (1945) reports that a stock index based on the Belgian market capitalization was multiplied by 2.5 between 1938-1939 and 1943. This price increase is confirmed by the work of Willems and Buelens (2006).

5.2. Analyses of the price index

The indices provide valuable evidence on investors' risk preferences. More than their absolute value, it is their variation over time that we are interested in. Indeed, changes in the index reflect changes in risk preferences. Figure 2 shows the evolution during the Second World War of the price index (PI), the ratio of the market price of the bond by its theoretical price.



Indices witnessed a significant evolution over time. A first striking feature is the common evolution of both indices but also their difference in level. The common evolution is a consequence of the high correlation existing between the bond prices. The difference in level seems at first sight harder to account for. Two elements may explain this. First, the importance of the lottery varied from one bond to the other. In 1940, the first bond had already paid a substantial amount of prizes and the future prizes to be won were limited whereas for the 1938 bonds many big prizes were still to be had. The relative difference in terms of present value of the lottery may explain the observed difference. Second, bonds had different duration and thus had different reactions to interest rate changes.

Both indices behave differently during the pre-war, the war and the post-war period. At the beginning of the observation period, the indices plummeted. This is hardly surprising given the tense international context. The political crisis the

country went through during the months of March and April also had a major impact on investors. The indices experienced a further dramatic decline in September 1939, linked to the invasion of Poland and the consequent French and British declaration of war against Germany, on the 3th September. During the first 3 weeks of the month, the PI of the 1938 bond lost 10%, falling from 90% to 80%. This clearly shows a reluctance to buy the lottery bond, although it does not mean necessarily that it was caused by a change in risk attitudes. During the same period, stocks and other government bonds experienced the same kind of decline. Given the context of high uncertainty, people were accumulating liquidities, selling their positions and avoiding new investments. After this turmoil, the indices slightly increased until the invasion of Belgium.

As soon as the stock exchanges reopened, the indices rocketed, in line with the price of other securities. Lottery bonds were especially affected by this boom. All drawings had been suspended between May and August and to catch up with the amortization plan, these missing drawings took place in October and November, hence exciting investors. From January 1941 to March 1942, the 1938 index stabilized around the unit, then it experienced an impressive growth that lasted more or less until the end of the Occupation. From March 1942 on, both indices increased constantly, after a small break, they surged again in October 1942, to peak in January 1943. They then stabilized at this high value for the first semester of 1943. During the summer of 1943, both indices experienced a severe depression, but remained above unity. Both indices rose again from September 1943 on. It is tempting to attribute the significant growth that affected the indices in the second half of the war, to a change in investors' risk preferences.

5.3. Did investors become risk loving during the occupation?

The results of the previous sections point to the same direction. The indexes substantially increased during the second phase of the occupation. Taking these elements out of their context, we could interpret these results as an indication that risk-averse investors became risk-loving in 1943. However, the very specific market conditions faced by investors during this period need to be taken into account. Financial repression, monetary circumstances, lack of investment opportunities, inflation are factors to be taken into account. Alternative explanations thus deserve scrutiny. Fiduciary circulation dramatically increased during the war, and at the same time the opportunities of investments were very limited. Given this situation, it is possible that investors and Belgian banks particularly, bought the lottery bond, not because they were attracted by its features, but because they had no other choice for investing their money. The argument could be confirmed when looking at other type of securities, which experienced a similar growth.

If investors purchased the lottery bond because they were forced to, one would expect a decline in the indices after the war, when investment opportunities re-appeared. This is indeed the case. Another proof is that indices hugely dropped between June and September 1943. For Baudhuin (1945), during this period, many investors were anticipating a quick end to the war, and thus sold their assets to have enough liquidity for the post-war period. As a matter of fact, Struye (1945) reports an *unbounded optimism* among the population in May 1943. The Allied landing in Sicily, in July 1943, probably raised optimism to an even higher level. This view was also shared by contemporary financial journalists. Throughout 1943, movements in the Belgian financial market are determined by the agents' opinion of the length of the war. Every military event that seemed to favor a quick end or seemed to be a prelude to further destructions in the country had a negative impact on the

market¹⁸. Mid-1943, agents expected the war to end soon, but they were disappointed when they heard the advance of the allied troops in Italy was very slow. This would be consistent why the subsequent rise of both indices. These elements tend to prove that for many, lottery bonds were only a temporary investment, not a choice. Nevertheless, the previous argument fails to explain the violent upward movement of the indices in 1942. The monetary condition hardly changed between 1942 and 1943 (Baudhuin, 1945). The situation was globally worse, the money circulation still quickly increasing, yet the monetary expansion was of the same magnitude as in 1941 and 1942, 16 million BEF in 1942 versus 13 million BEF in 1943. Bank deposits increased more in 1943 than in 1942, showing that people had more liquidity to invest. But it is hard to see how these conditions should translate into a rise of the PI.

Alternatively the profile of the investors in lottery bonds may have changed. In 1941 and 1942, banks invested heavily in state bonds since their deposits grew and there was almost no other investments opportunity. Yet in 1943, Baudhuin (1945) reported that companies and businesses began to ask again for credits. This could have resulted in banks selling the assets they bought by default in 1941-1942 to serve their clients. Dujardin et al. (2010) also report that Belgian firms began to prepare the post-war in 1943. As a consequence, banks may have sold their lottery bonds and that these were bought by another class of investors with different risk preferences. War profiteers are for instance known to have had many funds to invest at that time. Jacquemyns (1950) argues that the economic situation of households slightly improved in 1943, thanks to a better organization of the supply chain. It could therefore be that they also managed to find some liquidity to invest and were attracted by the lottery bonds. The social context was totally modified by the war as part of the wealth flew from cities to the rural parts of the country. Some social classes were crushed, whereas others managed to rise. Conway (2012, p.

¹⁸ J.M. Chevalier in a financial editorial, *Le Soir*, 31 July 1943.

8) notes that *"the middle class and the rural populations were the principal beneficiaries of the social changes"* but that *"For some, notably pensioners and white-collar employees on fixed income, the 1940s brought a marked decline in living standards"*. The war context probably gave birth to a new profile of investors. People that typically bought the lottery bonds before the war had to sell them given the circumstances and could have been replaced by a different kind of investors. Nonetheless, even if the type of investors did not change, the own attributes of the lottery bond holders might have been modified given the context, for example their wealth or their income. But this hypothesis is difficult to verify and there are no evidence that wealth, income, or other characteristics traditionally associated with risk aversion, changed in 1943. Moreover it is unlikely that these characteristics changed so brusquely as to dramatically modify risk aversion.

A last explanation could be of a psychological nature. Euphoria at the prospect of the war's end may explain this result. This would have induced a risk-seeking behavior as agents acquired the certainty that Germany was going to lose the war. According to Paul Struye (1945, p. 51) as early as January 1942, the belief that Germany was never going to win the war was widespread among the society. The strength of this conviction constantly grew during the following months and was amplified by the good military news: the British victory in Egypt, the Russian resistance in Stalingrad, and most of all the allied landing in North Africa on the 8th November 1942. Struye (1945, p. 1071) notes that this event was *"celebrated as a national day and considered as the first good day since the May 10th 1940"*. In 1943, for the majority of the population, the outcome of the war was certain, and liberation was expected for the end of the year or the end of 1944 at most. Could this increasing optimism have changed investors' risk behavior? In 1943, German occupation became harsher, the military command began to interfere in every aspect of the society and the compulsory work service was put in place, which had a great emotional impact on the population. Struye (1945) describes *"an atmosphere of terror"*

and civil war". Given this context, every good news for the Allied were celebrated; and during the period 1943-1944 good news were increasingly received. As a result, the risk-taking attitudes reported could simply be the manifestation of euphoria, or the expression of a feeling of relief. Also, in a gloomy daily life, lotteries could have been an outlet, bringing a little bit of thrill. Two things potentially tend to confirm this argument. First, stocks did not experience any growth during the same period. It seems thus that this risk-prone wave was only observable for the lottery bond. Secondly, risk aversion increased again in the post-war period, which shows that the particular risk behavior observed was due to the specific context of the years 1943-1944.

Although the current analysis is not precise enough to formally link this change in risk attitude to a change of psychological mindset, we find it to be coherent, especially with regards to the development in the field of behavioral finance. Research has shown how psychological factors might influence judgment and risk behaviors (Elster 1998; Lerner and Keltner 2001; Slovic and Peters 2006). Even if they did not change their risk preferences, investors could have changed their perception of the lottery risk.

6. Conclusion

On basis of an original database of Belgian lottery bonds, this paper analyzes changes in investors' risk preferences during the Second World War. Following the framework developed by Ukhov (2010), the pricing of two lottery bonds allows building two indices reflecting risk aversion.

The findings of the paper are twofold. First, investors' risk preferences changed dramatically over the period under consideration. Given the economic perspective and the news regarding the war, investors adapted their behavior. Secondly, risk

aversion changed dramatically in the middle of the war, at the beginning of 1943. Before this period, investors exhibited strong risk aversion, which was consistent in the context of uncertainty characterizing the beginning of the Occupation. Yet, from 1943 until the end of the Liberation, Belgian investors adopted a risk-seeking behavior. These findings are in line with the risk aversion literature. Several authors also report a sudden change in the investors' risk preferences when the social or the economic context is significantly altered (Jackwerth (2000); Guiso et al. (2011); Weber et al.(2012)). Others also give evidence of time-varying risk aversion (Campbell et al. (1999); Brandt et al. (2003); Ukhov(2010)).

To explain this puzzling result, several explanations: are suggested a modification of the investors' perception of the monetary perspective for the post-war period (expected inflation, fear of devaluation,...), a modification of the profile of the lottery bondholders, with the banks selling their lottery bond portfolio and middle-class and rural population buying it, a change in the investors' own characteristics (change in wealth, income,...) and finally, a psychological explanation, the euphoria brought by the hope of a quick liberation.

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