

NBER WORKING PAPER SERIES

TESTING ASSET PRICING THEORY ON SIX HUNDRED YEARS OF STOCK RETURNS:  
PRICES AND DIVIDENDS FOR THE BAZACLE COMPANY FROM 1372 TO 1946

David le Bris  
William N. Goetzmann  
Sébastien Pouget

Working Paper 20199  
<http://www.nber.org/papers/w20199>

NATIONAL BUREAU OF ECONOMIC RESEARCH  
1050 Massachusetts Avenue  
Cambridge, MA 02138  
June 2014

We would like to thank Bruno Biais, Chloé Bonnet, Claude Denjean, René Garcia, José Miguel Gaspar, Alex Guembel, Pierre-Cyrille Hautcœur, Christian Julliard, Ralph Koijen, Augustin Landier, Laurence Lescourret, Junye Li, Patrice Poncet, Jean-Laurent Rosenthal, Sandrine Victor, Maxime Wavasseur and especially Marianne Andries and Nour Meddahi, as well as seminar and conference participants at the Toulouse School of Economics, the CIFAR-IAST conference, UC Irvine, HEC, ESSEC, and Casa de Velazquez - Madrid for helpful comments and suggestions. We also wish to thank Geneviève Douillard and Daniel Rigaud, from the Archives Départementales de la Haute-Garonne, for her help in finding and reading original documents. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed a financial relationship of potential relevance for this research. Further information is available online at <http://www.nber.org/papers/w20199.ack>

NBER working papers are circulated for discussion and comment purposes. They have not been peer-reviewed or been subject to the review by the NBER Board of Directors that accompanies official NBER publications.

© 2014 by David le Bris, William N. Goetzmann, and Sébastien Pouget. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.

Testing Asset Pricing Theory on Six Hundred Years of Stock Returns: Prices and Dividends  
for the Bazacle Company from 1372 to 1946

David le Bris, William N. Goetzmann, and Sébastien Pouget

NBER Working Paper No. 20199

June 2014, Revised June 2014

JEL No. G12,N13,N23

### **ABSTRACT**

We use the Bazacle company of Toulouse's unique historical experience as a laboratory to test asset pricing theory. The Bazacle company is the earliest documented shareholding corporation. Founded in 1372 and nationalized in 1946, it was a grain milling firm for most of its 600 year history. We collect share prices and dividends over its entire lifespan. The average dividend yield in real terms was slightly in excess of 5% per annum, while the long-term price growth was near zero.

The company's unique full-payout dividend policy allows us to estimate an asset pricing model with fundamentally persistent dividends and a time-varying risk correction. The model is not rejected by the data. Variations in expected future dividends are found to explain between one-sixth and one-third of variations in prices. Moreover, the risk correction is correlated with macroeconomic shocks, in particular with the volatility of grain prices.

David le Bris  
KEDGE Business School  
680 cours de la Libération  
33405 Talence  
France  
david.lebris@gmail.com

Sébastien Pouget  
Toulouse School of Economics  
University of Toulouse  
21 Allée de Brienne  
31000 Toulouse  
France  
spouget@univ-tlse1.fr

William N. Goetzmann  
School of Management  
Yale University  
Box 208200  
New Haven, CT 06520-8200  
and NBER  
william.goetzmann@yale.edu

The present value relation is fundamental to economics and finance. It provides an analytical framework for asset valuation and the calculation of discount rates, and it serves as a benchmark for assessing market efficiency and the process by which economic agents form and use expectations about the future.

Testing the present value relation for traded financial securities like stocks and bonds has presented some challenges because of the role played by expectations and time-varying correction for risk. While it is simple to state that the present value of an asset should be equal to the expected discounted future value of the benefits it confers to its owner, the process by which expectations are formed and maintained must naturally be quite broad and complex because it must incorporate an entire future world of possibilities. Moreover, the appropriate level of price adjustment to account for risk is unobservable.

We use the unique experience of an extraordinarily long-lived company, called the Honor del Bazacle, as a laboratory to test the present value relation.<sup>1</sup> The Bazacle company was formally incorporated in 1372 via a merger of lesser firms that had operated in Toulouse since the 11th century. Shares of the company were owned and regularly traded by individuals and institutions over the course of its history. Following its conversion to a hydroelectricity generation company in 1888, the company listed on the Paris Stock Exchange and traded there until nationalization in 1946. Thanks to the available archives, we have share price and dividend data over most of a six century period during which the company operated on the bank of the Garonne river.

This company offers a particularly suitable testbed for asset pricing theory because it displays long periods of time with observable returns and without major technological or governance changes. Moreover, unlike most modern corporations, the firm maintained a dividend policy of paying out all profits each year. This peculiar feature allows us to estimate

---

<sup>1</sup>Using long time-series in financial economics has proved fruitful as illustrated by the studies of Homer and Sylla (2005), Goetzmann and Ibbotson (2006), Siegel (2007), Dimson, Marsh, and Staunton (2008), le Bris D. and Hautcœur (2010), and Dimson and Spaenjers (2011).

an asset pricing model without the confounding effects of precautionary smoothing. The firm's dividends thus reflect a fundamental, stationary economic process that was presumably well understood by investors, even at the date of the firm's incorporation.

Another factor that makes the Bazacle company a valuable case for study is that, over its extensive lifespan, shocks to consumption were frequent and significant in the form of wars, plague epidemics, and famines. Our data thus enable us to assess how the risk correction varies with macroeconomic events.

Although there are some institutional differences between the Honor del Bazacle and a modern industrial corporation which we explain below, Bazacle shareholders enjoyed limited liability, annual shareholder meetings, transparent accounting, a rotating board of directors, full transferability of shares and regular receipt of pro-rata dividends. We find dividends and prices to be stationary, consistent with the relatively stable business model of the Bazacle company. The dividend yield slightly exceeds 5% in real terms over the entire period. Dividends and prices were highly volatile. The average annual real total return exceeded 20% but the real capital gain over the entire period was essentially zero, taking into account the final disposition of the firm.

To study the rationality of the pricing of Bazacle company's shares, we set up an asset pricing model with persistent dividends and a time-varying risk correction. The dividend is assumed to follow an ARMA (1,1) process. The discount rate is stochastic and assumed equal to the risk-free rate plus a shock, modeled as a white noise. The covariance between the shock to the discount rate and the shock to dividends represents the risk discount that corrects the price of the Bazacle shares for systematic risk.<sup>2</sup> This risk correction is assumed to be autoregressive of order one. Given these assumptions, we explicitly derive the equilibrium

---

<sup>2</sup>Since, as shown below, Bazacle's dividends and prices are stationary, our model and empirical analyses focus directly on prices and dividends. The risk correction thus corresponds to a discount in the price of shares: riskier assets require lower prices for investors to be willing to hold them. If we instead had to deal with returns and dividend growth, the risk correction would materialize as a premium, i.e., an additional rate of return that compensates investors for holding risky assets.

pricing formula: we show that the price is a linear function of dividends, dividend shocks, and the risk correction.

We then estimate the model on the Bazacle company's dividends and prices expressed in real terms, i.e., in kilos of silver. We proceed in the following manner. We first fit an ARMA(1,1) model to the dividend process. We extract the ARMA parameters as well as the shocks to dividends. We then run a GLS regression of the share price on the dividends and the dividend shocks. This enables us to estimate the parameters of the pricing function. The autocorrelation of the regression residuals enables us to identify the evolution of the risk correction.

We test the model by studying overidentification restrictions. In particular, both the risk-free rate and the average dividend are determined by two equations. We test the model by using the delta method. Our period of interest ranges from 1441, the first year for which we have both dividend and price data, up to 1946. We check that our results hold if we use different subsample periods. The 1532-1815 period is particularly interesting because we have very few missing data after 1532, and because the business activity and the governance did not change over this entire period.

Our estimates show that the dividend process is persistent with an autoregressive coefficient around 0.80 and a moving-average coefficient around -0.35. Estimating the pricing equation, we find that prices are positively related to dividends and negatively related to shocks to dividends. This is in line with the asset pricing model's predictions given the respectively positive and negative autoregressive and moving-average coefficients estimated for the dividend process. This indicates that the basic pricing equation has good qualitative properties. Moreover, we find that between 15% and 43% of the variations in share prices are related to variations in dividends and dividend shocks. Finally, our overidentification tests indicate that we cannot reject the basic asset pricing model at the 95% confidence level.

These findings speak to the literature on the predictability of stock returns and dividend

growth.<sup>3</sup> Our findings about the existence of a link between share prices and expected future dividends are in line with recent results documented by Chen (2009) using US data on dividends starting from 1872 up to World War II, by van Binsbergen and Koijen (2010) on US data from 1946 to 2007 using a Kalman filter approach applied to dividends, and by Chen, Da, and Priestley (2012) from 1871 to 2006 using net payout and earnings (which are more difficult to smooth than dividends). For example, van Binsbergen and Koijen (2010) indicate that between 13% and 31% of variation in the price-dividend ratio is explained by variations in expected dividend growth. Our result that cash-flow news explain a significant portion of Bazacle share price variations is also consistent with Vuolteenaho (2002)'s finding that firm-level stock returns are mainly driven by cash-flow news.

To gain more insight into the macroeconomic forces driving the risk correction, we regressed the correction onto several macroeconomic variables. These macroeconomic variables proxy for bad times and include plague, famine, war, and riot episodes. We also introduce the yearly average of the Wheat/Rye price ratio in the regressors because historians have documented that rye prices increase more than wheat prices during bad times. Finally, we study how the volatility of the monthly Wheat/Rye price ratio, a proxy for consumption uncertainty, affects the risk correction.

We find that the risk correction increases with the volatility of the Wheat/Rye price ratio. This result is in line with long-run risk asset pricing models that emphasize the importance of volatility risk for risk correction (see, e.g., Bansal and Yaron (2004), Hansen, Heaton and Li (2008), Bonomo, Garcia, Meddahi and Tédongap (2011), and Bansal, Kiku, Shaliastovitch and Yaron (2014)) but also with the standard consumption-based asset pricing model with constant relative risk aversion (see Cochrane (2005) for a review). War episodes are also marginally correlated with the risk correction.<sup>4</sup>

---

<sup>3</sup>See for example Fama and French (1988), Campbell and Shiller (1988), Goetzmann and Jorion (1993, 1995), Bossaerts and Hillion (1999), Stambaugh (1999), Goyal and Welch (2003, 2006), Menzly, Santos, and Veronesi, (2004), Ang and Bekaert (2005), Cochrane (2008), and Pástor and Stambaugh (2009).

<sup>4</sup>Muir (2014) offers complementary insights on the formation of risk correction by studying asset pricing in

Our study complements the literature that empirically tests the consumption-based asset pricing model. Our findings, that proxies for bad times correlate with the risk correction, echo the recent results showing that various proxies for consumption or consumption risk can be related with asset prices (see, e.g., Lettau and Ludvigson (2001), Aït-Sahalia, Parker, and Yogo (2004), Parker and Julliard (2005), and Savov (2011)).<sup>5</sup>

Overall, our results suggest that modern asset pricing theory, derived from the modeling of consumption risk and yielding the present-value relation, is relevant for the pricing of the Bazacle company's shares from the Middle Ages onward. For the time period we consider, people were not instructed on how to apply asset pricing theory. Finding that this theory is consistent with the data is thus interesting because it cannot be due to investors being trained in the principles of modern finance. Instead, risk correction and rational expectations about future dividends and prices appear naturally as an economic response to uncertainty.

The paper is organized as follows. In the next section we provide historical background on the company. Section 3 presents our data sources. In section 4 we adapt the basic asset pricing theory to the peculiar circumstances of the Bazacle company, taking into account the fact that dividends are stationary and sometimes negative. Section 5 details our econometric methodology. Section 6 presents our results. Section 7 concludes.

---

the last 140 years in 14 countries. He shows that war episodes are associated with an increase in consumption risk and in risk premia, but that risk premia increase even more during financial crises despite no further increase in consumption risk. His results suggest that financial intermediaries play an important role in today's capital markets. In the time period we study in our paper, final investors directly held assets, so financial intermediaries might have played a less significant role (even if they were important for some financial markets, such as the credit market; see, for example, the studies by Hoffman, Postel-Vinay, and Rosenthal (1992, 2000) on French notaries in the seventeenth, eighteenth and nineteenth centuries). We are thus able to study asset pricing in sub-periods abstracting from many potential frictions induced by delegation of asset management to financial intermediaries.

<sup>5</sup>A test of the CCAPM, using consumption data and based, for example, on empirical likelihood methodologies in spirit of Ghosh, Julliard and Taylor (2013) and Almeida and Garcia (2014), is left for future research.

# 1. Historical background

Sicard (1953) provides a detailed study of the Honor del Bazacle up to 1472.<sup>6</sup> Our contribution is the collection of data for the company over the period following 1472. For this we rely on corporate records extant in the Haute-Garonne and Toulouse archives. These contain information on transaction prices, revenues, expenses and dividends. They are also the principal basis for our understanding of corporate operations up through modern times. In this section we provide a brief history of the company and an overview of relevant institutional details useful for understanding share prices and dividends.

## 1.1 Brief history

The Bazacle company was – and still is – located on the right bank of the Garonne river near a natural ford used since antiquity. Figure 1 shows the exact location of the mills in the Toulouse city area. A mill in this location was first mentioned in 1071 and, by 1248, 12 mills operated at the Bazacle. These smaller mill companies merged in 1372 to form the Honor del Bazacle. Shares in the company were called *uchaux* and shareholders were called *pariers*. Its principal source of revenue was a fee of 1/16 of the grain brought to the mill, which was distributed periodically through the year to shareholders (these distributions were called *partisons*).<sup>7</sup>

[Insert Figure 1 here]

The firm also leased secondary, unoccupied milling spaces and fishing rights to the Bazacle section of the river and these secondary revenues covered a portion of operating expenses.

---

<sup>6</sup>See also Saboly (2001), Goetzmann and Pouget (2011) and le Bris, Goetzmann and Pouget (2014) for more historical information on the Bazacle company.

<sup>7</sup>The fee charged by mills in the Toulouse region was fixed by the municipal authorities in the 12th century. Clients were free to direct their wheat to any mill but all mills were required to charge the same regulated fee. Competition to attract clients could thus only affect quality but not pricing of milling services. Mills could also try and increase their profitability by increasing their productivity.



The remaining operational deficits were charged during the year to shareholders who paid their contribution (called talha) in specie. An annual record of the talha and a time-series for the price of wheat allow us to calculate the dividend for a significant portion of the firm's history (i.e., for 417 years). Records of share transfers in notarial registers, in the books of the company, in fiscal registers, and in newspapers provide a time-series of share prices (data on prices are available for 364 years). For example, Figure 2 shows the register of pariers from 1530 for Jean de Bernuy, a rich pastel merchant from Toulouse. We use a time-series of silver prices to convert share prices and dividends into real terms.

[Insert Figure 2 here]

## **1.2 Was the Honor del Bazacle truly a corporation?**

Sicard (1953) makes a strong case that the Honor del Bazacle was essentially a corporation as we now define it. Its shares were fully transferable. Records of the sale of shares show that approval of the firm was not required for the ownership transfer. It had a juridical personality. Legal proceedings from as early as the 14th century treat the Honor del Bazacle as a legal entity apart from its shareholders. It had limited liability. When shareholders could not pay their talhas, their uchaux reverted to the company. Shares entitled owners to an equal distribution of dividends.

The firm was a private, profit-seeking enterprise. The investors in the Honor del Bazacle did not have a direct role in the firm's management, except through the duties related to participation in the board of directors. The governance of the firm resembled that of modern corporations. The company operations were controlled by a rotating board of directors appointed by a shareholder vote at an annual meeting, a time at which financial accounts were produced and the talha determined. By the mid 16th century, the governance and

management structure of the Honor del Bazacle included a chief operating officer, a treasurer and a clerk. This basic structure continued into the 19th century.

The Honor del Bazacle converted its operations to hydroelectricity generation in 1888 and became a Société Anonyme called Société Toulousaine du Bazacle in 1910. Its shares traded on both the Toulouse and Paris stock exchanges in the early 20th century. It was nationalized in 1946 along with all French electricity producers to form EDF, the national public electricity utility. Although a full discussion of the early development of the corporate form is not the topic of this paper, relevant factors contributing to its emergence in Toulouse included a feudal tradition of transferable, fractional property rights (called *pariage*) and a well-developed law of commerce that allowed and enforced commercial and financial contracts, including loans, mortgages and partnerships.

## 2. Data

### 2.1 Share prices

The founding charter, with agreed valuation of the contributed shares of the underlying 12 firms that constituted the company, is still extant in the archives of Toulouse. This charter gives us the first stock price of our series. From that point onward, transactions of shares in the Bazacle company were recorded by notaries, along with the price in livres tournois, which was the currency of account of the region. There are 38 prices recorded for Bazacle shares over the period 1375 to 1450.<sup>8</sup> During this time, the Bazacle company had between 80 and 96 *uchaux* and between 60 to 90 shareholders. Fractional transactions of *uchaux* were allowed, so the number of *uchaux* did not necessarily limit the number of shareholders.

A natural question is whether recorded prices reflect arms-length transactions or transfers

---

<sup>8</sup>The first price of the Bazacle company's shares in 1372 is obtained from the consolidating merger agreement. There are also 15 prices for shares in predecessor companies prior to the merger. We do not use these prices in the present analysis.

among family members at below market rates. An approximate test for this is to examine whether the lowest price per uchau in a given year varies with the median or average price. We find that they do. Another approach is to compare the variation in share prices across similar firms. According to Sicard (1953), the share prices for the Bazacle's major rival firm, the Castel Narbonens, moved roughly together with Bazacle shares during the 1375 to 1450 period, consistent with the hypothesis that prices reflected consistent if not rational economic valuation.

Our data collection effort takes up where earlier data collection left off (i.e., in 1450). However, rather than relying on notarial records of public sales, we use company shareholder registers. The Honor del Bazacle maintained meticulous documentation about distributions to shareholders, but only a few registers from the 15th century were preserved. From the early 16th century onward, the series of registers offers a nearly complete record of share ownership and transfer. Each page of the shareholder account book (i.e., register of partisons) corresponds to one parier (i.e., one shareholder) and indicates the grain received during a given year. When share transactions occurred, a notation in the margin recorded the date, the price and the name of the new parier. This enabled the company to distribute the grain dividend to the appropriate owner.

For the period after 1532, we are able to collect transaction data from a new register (the register of pariers, created by the company to follow the owners of uchaux) that reports not only transactions but also the number of uchaux in each shareholder's account. Each page of the register of pariers corresponds to one shareholder with the name and the number of uchaux he or she owned. Potential successive sales of uchaux are written below his or her name. Fractional ownership of uchaux was common, with, for example, one transaction record for 1/60th of a "demi-uchau" (i.e., 1/120th of a share).

This format was very similar to municipal real estate registers, providing some insight into the analogy recognized by Toulouse citizens of the time between real and financial

property and their corresponding rights to use and enjoyment. Four successive registers of this kind provide transaction data up until 1878. Thus, the system implemented during the Renaissance remained the same until the end of the 19th century. This continuity in financial procedure allows us to presume that the basic definition of share ownership and transactions itself remained stable for a long period of time. Unfortunately, one register is missing for the period 1817-1853.

Fortunately, a last source of prices comes from a tax (of 1%) on notary-recorded transactions (called “centième denier”) created in 1703. The bureau of Toulouse recorded in an annual register the tax collected indicating the date, contracting parties, nature, object and price of the transaction. This tax still exists and has been called “Droits d’enregistrement” since the Revolution. Most of these registers are available in the archives of the Haute-Garonne. For years without price from others sources, i.e., between 1703 and 1887, we went through the entire registers to find transactions.

After 1887, the local newspaper, “La Dépêche du Midi”, provides data from the “Bourse de Toulouse” where the uchaux traded, and we collect price data from this source, although it lacks volume information. In addition, national newspapers and the “Cote Officielle de la Bourse de Paris” reported share prices, since the firm was listed on the Paris stock exchange in 1910. For this last period, we collected the last price of the year that could be identified.

The time series of prices for Honor del Bazacle shares provides a record of equity investment value from the late Middle Ages to the middle of the 20th century. Figure 3 plots the latest available price of each year, in livres tournois and in silver. The gap from 1450 to 1532 is the period between the end of the notarial records studied by Sicard (1953) and Wolff (1954) and the beginning of complete corporate registers. After 1532, the series is nearly continuous. In real terms, share prices remained relatively stable through time.

[Insert Figure 3 here]

Prices and dividends tend to move together. This is an evidence in favor of the fact that share prices reflect information included in dividends. Below, we set up a model with predictable dividends that formally captures this idea.

Most of the low prices for Bazacle shares were associated with the destruction of the mills or of their dam system. Uchaux prices were low after a flood damaged the Bazacle dam in 1638, and 25 pariers failed to pay their talhas. In 1709, ice flows on the Garonne completely destroyed the Bazacle dam. Whereas the price of one uchaux typically exceeded the price of 20 tons of wheat, it fell to the price of 0.76 tons of wheat or 878 grams of silver in October, 1709. This crisis caused a high talha, a number of forfeited shares, and eventually led to the purchase of half of the uchaux by an engineer, M. Abeille who recapitalized the firm and restored the mills.

The dam was again destroyed in 1736 and uchaux prices dropped in that year to 7.24 tons of wheat or 3.2 kg of silver. A fire destroyed the mills in 1814 imposing a very high (and the last) talha of 4.5 kg of silver (1,000 francs) leading to another low price of 5.48 tons or 8.1 kg of silver in 1816. Another fire in 1887 resulted in a quasi-bankruptcy and financial restructuring that led to the conversion to electricity generation in the late 1880's. The financial conditions of the nationalization in 1946 explain the last two low figures. In sum, most of the periods of low uchaux prices were associated with natural disasters that destroyed the mills or the milldam.

Figure 4 shows the number of transactions per year. By any modern measure, the turnover is quite low. Prior to 1888, the average number of transactions per year was less than four, and for the period prior to 1532, the average was less than 1. The volume of transactions varies considerably through time, however. For example, the 16th century was a period of relatively high volume, as was the period around the French Revolution. In addition there were a few instances of massive sales. 16.25% of the capital turned over in 1597, 20.50% in 1639, 50% in 1714, and 28.50% in 1738 due to auctions of shares after

non-payment of a high talha. 21.30% turned over in 1791 due to expropriation and resale of clerical and “émigrés” holdings.

[Insert Figure 4 here]

The low turnover was certainly due, in part, to an unusual transaction tax on new shareholders. A new parier was required to host a dinner for the board of directors and to display at that time the notary act of his purchase. The dinner was likely expensive because the requirement was eventually changed to a fee of 60 livres in 1731 – about 1% of the value of a share at that time. As a comparison, the cost of the notary (for the act and the tax) was 4.4% in the 19th century.

### **2.1.1 Share outstanding**

Despite its very long life, the capital structure of the firm is straightforward to reconstruct. The Appendix reports the history of the firm’s outstanding capital. The company started in 1372 with 80 uchaux. As of 1384, 16 new uchaux had been created and exchanged for two mills that remained independent after the initial merger – an early example of a corporate acquisition. The number of uchaux rose from 96 to 100 in 1535 for reasons unclear – perhaps to simply make the accounting easier. When some shares occasionally reverted to the firm due to shareholder surrender, these were immediately auctioned, keeping the shares outstanding constant. Most of the time, when the firm needed new money, a high talha was imposed, instead of new uchaux issued.

The firm raised no significant outside capital from 1535 until 1714 when the number of uchaux increased to 128. A major capital infusion was necessary in order to repair the milldam. After incurring large expenses without resuming operations for years, many pariers defaulted on their talhas, and their uchaux were auctioned. However, these shares failed to

find acquirers. At this point, the enterprising engineer, M. Abeille, offered to invest capital to complete the repairs in exchange for half of the equity. As part of the restructuring, 28 new shares were issued. He raised investment capital from Genevan financiers, and the mills resumed operations in 1720 after 12 years of inactivity.

In 1803 (on 9 prairial XI), 8 new uchaux were created and sold to finance repairs. In 1888, following a devastating fire and a strategic reassessment, each uchau was divided into 4 shares. In 1910, the firm merged with the “Société Toulousaine d’Electricité” to create the “Société Toulousaine du Bazacle”: each shareholder from the Bazacle received, per share, 70 Francs and 6 shares of the new company. Between 1927 and 1928, the capital of the firm was reorganized (in the form of a merger between different kinds of stocks followed by a split). From that time until the nationalization in 1946, the capital was only affected by a stock issuance in 1943.

## **2.2 Dividends**

As discussed above, calculating dividends requires information about the distribution of grain to shareholders, the value of this grain and the annual assessment of the talha. We discuss each of these in turn.

### **2.2.1 Distribution of grain: Partison**

The distribution of grain (the “partison”) occurred around 13 times per year on average until 1817, at which point dividends were paid in specie. We collected data from the registers for about 4,000 partisons, beginning in 1439. These registers indicate the quantity of wheat paid to each shareholder during the year.

There are two series of yearly registers of partisons: one series records the partison per day of partison and a second series records the partison per shareholder for purposes of control. For a given year, if one parier did not receive the correct amount, the register mentioned the

quantity that should be reported to the next year to compensate for the missing quantity.

### **2.2.2 Grain value**

Shareholders received the wheat to their account as a result of partisons, and then could readily monetize it through sale, although they could also retain grain for their own use. Indeed, registers of partisons mention the price of wheat on the day of the partison after 1584 and otherwise only on the occasion of a sale of wheat by the firm on behalf of the shareholder to pay the talha.

Before 1584, we obtain data on the monthly price of wheat in Toulouse from Frêche and Frêche (1967) that allows us to convert the dividends into a single unit of account (livres tournois then converted into kg of silver) for purposes of analysis.

### **2.2.3 Talha**

Data on the talha, the annual shareholder contribution to expenses, come from three sources: partison registers, registers of the general meetings during which shareholders voted the amount of the talha, and the accounting registers which recorded the monetary transactions of the firm. Talha became less frequent through the 18th century. Instead, some partisons were sold for cash – “brulées” – for the benefit of the firm.

The talha was a contribution denominated in livres tournois except during the French Revolution. After February 1796, due to the extreme inflation of paper money during the revolution, the amount of the talha was set as a percentage of the partison. After this date, and despite the return of a strong currency with the ‘Franc Germinal’ in 1803, the principle of the talha was never reintroduced, except for one last, huge talha in 1814 to repair the mills.

The talha de facto disappeared after 1796 but left a trace in the accounting. Up until 1816, the main revenues of the firm came from the sale of wheat on partison dates. After



these dates, the amount paid to the shareholders appeared as an expense in the accounting of the firm. A standard dividend appeared after 1843, which corresponds to the year of the Bazacle's first modern accounting, ending a system that began in the 14th century.

#### 2.2.4 Net Dividend

For the period before 1816, we calculate the yearly dividend as the value of the partisons during the year minus the amount of the talha for that year. From 1816 to 1843, the dividend was a payment made by the firm to shareholders after operating costs were deducted from revenues. After 1843, the firm distributed a standard dividend. We collect these data from the accounting registers and, after 1887, from various newspapers.

The dividend record is somewhat more complete than the share price transaction record. Only 30 dividend records exist for the entire period 1372-1531, but there is only 1 missing year between 1532 and 1813. There are 33 years of missing dividend information between 1814 and 1887 due to a missing register, and none after this date.

Dividends could of course be negative because we calculate them as the difference between the partisons valued at prevailing wheat prices and the talha payment each year. As explained above, large negative dividends generally corresponded to years in which floods destroyed the mills or the milldam and thus can also be thought of as occasional capital investment in repair.

From an econometric perspective, an important advantage of the annual complete disbursements of profits is that the firm did not smooth dividends, nor did it self-finance from year-to-year using internal cash flows. Figure 3 shows the annual net dividends, expressed in grams of silver in order to adjust for inflation.<sup>9</sup> There are a dozen years in which dividends were negative; in four of these, pariers were required to make net payments equivalent to three to five kilograms of silver per uchau. This allows us to estimate an asset pricing

---

<sup>9</sup>The Appendix gives more information on the expression of dividends and prices in kilograms of silver.

model in the absence of managerial dividend smoothing which has long been recognized as an econometrically complicating factor in predictive regressions.

## 2.3 Macroeconomic data

In order to test the link between the pricing of shares and consumption risk, we collected various macroeconomic data. When analyzing the link between asset pricing and macroeconomic conditions, we focus on the period from 1532 to 1815 because this is a period with a fixed business technology and governance, as well as a dividend payment in grain.

A first measure of bad times is the ratio between the price of wheat and the price of rye. Rye is in general less appreciated than wheat and its price is lower than the price of wheat. Moreover, according to historians, rye is an inferior good: in bad times, consumption switches more to rye, and the Wheat/Rye price ratio decreases towards one.<sup>10</sup> We compute the yearly average of the monthly ratio between the prices of wheat and rye. Moreover, to capture uncertainty surrounding consumption, we compute the yearly volatility of the monthly Wheat/Rye price ratio. Wheat and rye constitute an important part of consumption for the time period between 1532 and 1815.

We also gather evidence on general political, social and economic events such as wars, famines, riots, and plague epidemics. We collected this evidence from various sources and restrict our attention to events in the Toulouse region.<sup>11</sup> Our long-term time-series with significant and severe macroeconomic variations is ideal to explore the hypotheses articulated by Rietz (1988) and Barro (2006).

As a control variable, we finally collected data on major damages that devastated the Bazacle mills or milldam. These are micro-events but could also be associated with the general consumption situation in Toulouse since the Bazacle company's mills were the largest

---

<sup>10</sup>See for example Labrousse (1933) and Baulant (1968).

<sup>11</sup>The sources include Schneider (1989), Rives (1969), Dom Devic and Dom Vaissète (1745), Dularier (1876), Raynal (1759), and Roucaud (1919).

in the Toulouse region and the suspension of their activity could have significantly affected consumption and the general economy in Toulouse.

## 2.4 Descriptive statistics

Table 1 reports summary statistics about the annual returns on Bazacle shares. Statistics are computed using the price closest to the end of each calendar year. We use data in kilograms of silver to neutralize the effect of monetary inflation. Prices and dividends are missing for various years. For capital appreciation returns, we only use years for which prior and current year prices exist. For income returns, we require the dividend from the current year and a price from the previous year. We present statistics for the full sample as well as for various sub-periods, the Middle-Ages from 1371 up to 1531 (for which we do not have a lot of data), the milling activity period from 1532 to 1887 (for which we have plenty of data), and the electricity period from 1888 up to 1946.

[Insert Table 1 here]

We are able to calculate the dividend yield for 327 years in the full sample. The average dividend yield over this entire period from 1372 to 1946 is around 5%. This holds for all the time periods we consider, suggesting stability in income return over centuries. The standard deviation is around 7% over the full sample period indicating that important fluctuations in the dividend yield were not unusual.

Figure 5 shows the time series of the dividend yield per share. The interruption around the dam destruction and repair in the early 18th century and the period before conversion to electricity production at the end of the 19th century are the only two major periods over which dividend yields were zero. Most of the other gaps are due to missing data. The series is also clearly stationary over the long run. Prices seem to adjust to different levels of

(expected) dividends. We give a closer look at this issue in the next sections. For example, real dividends exceeded 1,000 grams of silver in the 16th century and were considerably less than that in the 18th century, however yields in the two periods were not dramatically different.

[Insert Figure 5 here]

Over the periods from 1532-1888 and from 1889-1946, the average annual real capital gains were 18% and 6%, respectively. The geometric means of the capital gain (not reported here) were negative from 1372 to 1946 and this is also the case for all the sub-periods we consider. Such a near-zero long term capital gain is consistent with the dividend policy of the firm for much of its history – to pay out all earnings.<sup>12</sup> A real price appreciation close to zero is consistent with the fact that prices appear to be stationary. The difference between the low compound growth rate and the high arithmetic mean of the capital appreciation series is consistent with a a log-normal distribution with high volatility.

The volatility of annual capital appreciation series, ranged between 58% and 134% per annum after 1532. Such high levels of price uncertainty however would not be particularly unusual in the context of modern equity volatility. The highest volatility was experienced in the earlier period, 1532-1888, which also witnessed several major disasters.

### **3. Asset pricing model**

This section adapts the standard asset pricing model to the specificities of the Bazacle company. In particular, unreported Phillips-Perron tests do not reject stationarity of the dividend and price processes. Moreover, dividends can be negative. We will thus seek to derive equilibrium share prices rather than rates of return.

---

<sup>12</sup>This was also the norm for stocks in other markets during the 19th century; see Goetzmann, Ibbotson and Peng (2001).

We start with the basic pricing formula that derives from an investor's first-order condition when maximizing expected utility from inter-temporal consumption (see, for example, Cochrane (2005)):

$$P_t = \mathbb{E}_t [M_{t+1} (D_{t+1} + P_{t+1})]. \quad (3.1)$$

$M_{t+1}$  is the stochastic discount factor at date  $t + 1$ . It is a random variable that represents bad times coming at date  $t + 1$ .  $D_{t+1}$  is the dividend distributed at date  $t + 1$ .  $P_{t+1}$  is the post-dividend share price at date  $t + 1$ .

We now give more structure to this equation. To capture the stationarity of the dividend process, we assume that dividends follow an ARMA(1,1) process:<sup>13</sup>

$$D_{t+1} = \alpha + \beta D_t + \gamma \epsilon_t^D + \epsilon_{t+1}^D, \quad (3.2)$$

with  $\mathbb{E}(\epsilon_{t+1}^D) = \mathbb{E}_t(\epsilon_{t+1}^D) = 0$ .

We model the time varying stochastic discount factor as:

$$M_{t+1} = \frac{1}{1+r} (1 + \epsilon_{t+1}^M), \quad (3.3)$$

with  $\mathbb{E}(\epsilon_{t+1}^M) = \mathbb{E}_t(\epsilon_{t+1}^M) = 0$ . The variable  $r$  represents the risk-free rate of return.

Define the risk correction as  $\pi_t = -\text{Cov}_t(\epsilon_{t+1}^M, \epsilon_{t+1}^D)$ . We assume that:

$$\hat{\pi}_t = \pi_t - \mathbb{E}(\pi_t) = \delta \hat{\pi}_{t-1} + \epsilon_t^\pi, \quad (3.4)$$

with  $\mathbb{E}(\epsilon_t^\pi) = \mathbb{E}_{t-1}(\epsilon_t^\pi) = \text{Cov}_t(\epsilon_{t+1}^M, \epsilon_{t+1}^\pi) = 0$ .

We now have enough structure to solve explicitly for the share price. To do so, we start

---

<sup>13</sup>Unreported tests based on the Akaike Information Criterion suggest that an ARMA(1,1) model provides the best description of our dividend data, in the class of ARMA models. This echoes the findings of Yang, Koo and Wilson (1992), who find that an ARMA(1,1) model is a good fit for wheat yields (the grain milled by the Bazacle company), and of Bessler (1980), who tests subjective farmer beliefs about the inter-temporal crop yield variation with an ARIMA model and finds reasonable beliefs about time-series model parameters.

with the pricing conjecture:

$$P_t = a + bD_t + c\epsilon_t^D - d\hat{\pi}_t. \quad (3.5)$$

According to this conjecture, the share price depends on:

- the current dividend and dividend shock because these variables allow to predict future dividends;
- a risk correction that compensates investors for consumption risk.

We plug the above pricing conjecture taken at date  $t + 1$  into Equation 3.1 to obtain:

$$P_t = \mathbb{E}_t [M_{t+1} (a + (b + 1) D_{t+1} + c\epsilon_{t+1}^D - d\hat{\pi}_{t+1})].$$

We rewrite this expression as a function of date- $t$  variables by using Equations 3.2 and 3.3. Rearranging yields:

$$P_t = \frac{a + (b + 1) \alpha - (b + c + 1) \mathbb{E}(\pi_t)}{1 + r} + \frac{(b + 1) \beta}{1 + r} D_t + \frac{(b + 1) \gamma}{1 + r} \epsilon_t^D - \frac{(b + c + d\delta + 1) \gamma}{1 + r} \hat{\pi}_t. \quad (3.6)$$

This equation indicates that the pricing conjecture given by Equation 3.5 is satisfied. Moreover, after identification of Equations 3.6 and 3.5 term by term, we solve for the underlying parameters values:

$$a = \frac{1 + r}{1 + r - \beta} \frac{\alpha}{r} - \frac{1 + r + \gamma}{1 + r - \beta} \frac{\mathbb{E}(\pi_t)}{r}, \quad (3.7)$$

$$b = \frac{\beta}{1 + r - \beta}, \quad (3.8)$$

$$c = \frac{\gamma}{1 + r - \beta}, \quad (3.9)$$

$$d = \frac{1 + r + \gamma}{(1 + r - \beta)(1 + r - \delta)}. \quad (3.10)$$

These parameters indicate how share prices respond to the expected level of dividends

and of risk correction (parameter  $a$ ), to the current dividend and dividend shock (parameters  $b$  and  $c$ ), and to the current level of risk correction required by investors (parameter  $d$ ).

## 4. Econometric methodology

This section discusses how we identify and estimate the deep parameters of our asset pricing model. It also indicates how we can test the model by using various overidentifying restrictions.

### 4.1 Identification and estimation method

It is straightforward to see that parameters  $\alpha$ ,  $\beta$ , and  $\gamma$  are directly identified using the estimation of Equation 3.2 on dividend data. This estimation also yields an estimate of the process  $\{\epsilon_t^D\}$ . We estimate the ARMA(1,1) process given by Equation 3.2 by maximum likelihood.

Estimating Equation 3.5, using price and dividend data and the estimates of the dividend shocks, enables to identify parameters  $a$ ,  $b$ , and  $c$ . Since both  $d$  and the variance of  $\epsilon_t^\pi$  are associated multiplicatively, we cannot directly identify them separately. However, we can identify  $\delta$ , the autoregressive coefficient of the process  $\hat{\pi}_t$ , as the autocorrelation between the residuals of the regression of  $P_t$  on  $D_t$  and  $\epsilon_t^D$ . The GLS regression given by Equation 3.5 is estimated by maximum likelihood. The parameter  $d$  is identified thanks to Equation 3.10. We can then identify the variance of  $\epsilon_t^\pi$ .

The last parameter that we can identify is the average risk correction,  $\mathbb{E}(\pi_t)$ . We do so by plugging in Equation 3.7 the parameter  $r$  extracted from Equations 3.8 or 3.9 as well as the parameters estimated thanks to Equation 3.2. We obtain the following formula:

$$\mathbb{E}(\pi_t) = \frac{(1+r)\alpha - ar(1+r-\beta)}{1+r+\gamma}.$$

To evaluate the statistical significance of our parameters' estimations, p-values are based on standard errors computed with the delta method.

## 4.2 Overidentifying restrictions

The risk-free rate is determined by two formulae, Equations 3.8 and 3.9. Combining these two equations, we obtain a first overidentifying restriction:

$$\frac{\beta}{b} - \frac{\gamma}{c} = 0. \quad (4.11)$$

Provided that both the dividend and price processes are stationary, the unconditional expectation of dividends,  $\mathbb{E}(D_t)$ , is also determined by two different formula, Equations 3.2 and 3.5. Combining these two equations, we obtain a second overidentifying restriction:

$$\frac{\alpha}{1 - \beta} - \frac{\mathbb{E}(P_t) - a}{b} = 0. \quad (4.12)$$

We build confidence intervals for the left-hand side of these two overidentifying restrictions via the delta method. This enables us to test whether the asset pricing model is or not rejected by the data.

## 5. Empirical results

We first focus on the estimation of the dividend process and then proceed to study the pricing of the Bazacle shares. Finally, we relate the risk correction embedded in share prices to various macroeconomic variables representing bad times.

We use several sample periods to gauge the robustness of the results. Our analysis starts in 1441 which is the first year for which we could collect both a price and a dividend observation. The full sample period is interesting because it is the longest time series that



we could gather, from 1441 to 1946. Another interesting sample period ranges from 1532 to 1815 because it is a time in which there was no change in the business activity nor in the governance of the Bazacle company. For simplicity, missing values are linearly interpolated. This is not a major concern since, after 1532, we have very few missing data and the results are robust across time periods.

## 5.1 Dividend process

The results of Equation 3.2's estimation on dividend data are presented in Table 2. As mentioned above, unreported Phillips-Perron tests indicate that we cannot reject the hypothesis that the dividend process is stationary. This is in line with the stable business model of the Bazacle company based on the normally predictable force of the river and the regular seasonal crop yields brought to the mill. Some shocks are also present due to changes in the price of wheat and to occurrences of major damages, for example.

[Insert Table 2 here]

We then fit an ARMA(1,1) model to the dividend series that we collected. The estimation indicates that the dividend process is persistent. The parameter  $\beta$  is indeed positive and close to 1 in all the sample periods considered. Dividend shocks appear to revert: the parameter  $\gamma$  is indeed negative. But this reversal does not cancel the persistence: overall, the sum of the parameters is significantly positive. This indicates that there is predictability in the dividend process. The next subsection tests whether share prices accurately reflect this predictability.

## 5.2 Share prices

We use share prices, dividends and the dividend shocks extracted above to estimate the pricing Equation 3.5.<sup>14</sup> The GLS regression that it describes is estimated via maximum likelihood. The results are in Table 3.

[Insert Table 3 here]

The coefficients  $b$  and  $c$  are significant, indicating that share prices incorporate some information from dividends and dividend shocks. Moreover, the signs of the coefficients, positive for  $b$  and negative for  $c$ , are in line with the asset pricing model's predictions: Equations 3.8 and 3.9 predict that, provided that the denominator is positive, the signs of  $b$  and  $c$  should be the same as the signs of  $\beta$  and  $\gamma$ , respectively. This is exactly what we find in the data. This provides us with a first indication that asset pricing theory is useful to qualitatively understand our data.

Based on the estimates presented in Table 3, we can estimate what proportion of share price variations are due to changes in expectations of future dividends. This is in spirit of the seminal analyses of Shiller (1981) and Leroy and Porter (1981). Taking the variance of the price as given in Equation 3.5 indicates that the proportion of price volatility associated with variation in dividends and dividend shocks is:  $\frac{b^2 \text{Var}(D_t) + c^2 \text{Var}(\epsilon_t^D)}{\text{Var}(P_t)}$ . This proportion is indicated in Table 3 under the title pseudo- $R^2$ .

The proportion of price variations explained by changes in expectations of future dividends ranges from 15% to 43%. This result is in line with recent conclusions from the empirical asset pricing literature. Chen (2009) uses data on the aggregate US stock market and shows that dividend-price ratio changes predict future dividends over the period ranging

---

<sup>14</sup>As mentioned above, unreported Phillips-Perron tests indicate that we cannot reject the hypothesis that the price process is stationary.

from 1872 to World War II. Such predictability disappears in the second part of the twentieth century, possibly because of the tendency to smooth dividends.

Moreover, Chen, Da, and Priestley (2012) use data from 1871 to 2006 and show that, using net payout and earnings (that are more difficult to smooth) instead of dividends, predictability does not disappear after WWII. It is remarkable that, during the period before 1815 during which dividends of the Bazacle company corresponded exactly to earnings, we find the closest relationship between share prices and expectations of future dividends.

Also, using a Kalman filter approach on data from 1946 to 2007, van Binsbergen and Kojen (2010) are able to identify some predictability of future dividends thanks to the dividend-price ratio: they find that between 13% and 31% of the variation in the price-dividend ratio is explained by variations in expected dividend growth. These figures are very similar to what we find for the Bazacle company over several centuries. Finally, our result that dividend forecasts explain a significant portion of Bazacle share price variations is consistent with Vuolteenaho (2002)'s finding that, in the US market from 1954 to 1996, firm-level stock returns are mainly driven by cash-flow news.

We also estimate the autoregressive coefficient of the risk correction,  $\delta$ . Table 3 shows this to be high – between 0.67 and 0.81 depending on the sample period. This suggests that the risk correction is persistent. The persistence in the risk correction appears higher than that of the dividend. This result is also consistent with the findings of van Binsbergen and Kojen (2010) who show that expected returns are more persistent than expected dividend growth rates.

We test the asset pricing model by studying the two overidentification restrictions displayed in Equations 4.11 and 4.12. We use the delta method to generate standard errors and 95% confidence intervals for the left-hand side of these equations. The results are in Table 4.

[Insert Table 4 here]

The 95% confidence intervals for all the sample periods include 0. We thus cannot reject the hypothesis that the equalities in Equations 4.11 and 4.12 are true at a conventional level of significance. Moreover, the model is only rejected with very high p-values (and thus low levels of confidence), higher than 46%.

Our asset pricing model, in addition to making predictions that are qualitatively verified, cannot be quantitatively rejected at usual levels of significance. This result suggests that, during a time period in which investors were not trained to apply asset pricing theory, its principles and quantitative predictions are not rejected by the data.

Our estimates, not reported here, suggest that the risk-free rate is not different from 0 at the 95% confidence level. A low risk-free rate makes sense given that we are focusing on real rates and given the low average growth for most of the time period under consideration. Also, the average risk correction in proportion of the share price, a variable that corresponds to the risk premium, is estimated between 0.75% and 1.56%.

### **5.3 Risk correction**

To shed some light on the nature of the risk correction, we study whether it is related to macroeconomic variables that proxy for bad times. The macroeconomic variables we use represent plague, famine, war, and violence episodes that affected the Toulouse region. These variables are coded as dummy variables taking the value 1 the year the event took place and 0 otherwise. We also include the Wheat/Rye price ratio because, as indicated above, historians have argued that it tends to decrease during bad times. Finally, we include the volatility of the ratio over a given year as a proxy for the uncertainty surrounding consumption.

We control for the occurrence of damages to the river dam or the mills. These damages called for capital infusion that shareholders were not always able to deliver, potentially due to liquidity constraints. Such liquidity issues, when they occurred, could have negatively affected share prices over and above future dividend expectations and risk correction.

We focus here on the period from 1532 to 1815 because it corresponds to a time of stationary business activity and corporate governance. It is also a period in which important macroeconomic events for the Toulouse region can be clearly identified.

Equation 3.5 enables us to extract the risk correction as  $\hat{\pi}_t = -\frac{P_t - a - bD_t - c\epsilon_t^D}{d}$ . We then regress this risk correction on the various macroeconomic variables indicated above, using a GLS approach to account for autocorrelation. The results are in Table 5.

[Insert Table 5 here]

Table 5 indicates that the risk correction is positively related to the volatility of the wheat-price ratio.<sup>15</sup> The increase in the risk correction during bad times could be due to an increase in risk aversion or to an increase in risk (see Cochrane (2005) for a discussion of these various aspects) in the context of the standard consumption-based asset pricing model. It could also reflect the pricing of volatility risk as predicted by long-run risk models (see for example, Bansal and Yaron (2004)). Further tests are required in order to differentiate these various consumption-based models using our data.

The risk correction appears marginally related to war episodes. This result indicates that disasters are important for understanding risk correction in asset markets. In this sense, they are in line with the emphasis of Rietz (1988), Barro (2006), and Gabaix (2012) on disaster risk being an important driver of asset pricing. In our context, the Bazacle shares seem to constitute a hedge against war episodes since the discount in share prices (that compensates for risk) is lower in times of war. This is a reminiscence of the result documented by le Bris (2012) according to which stock prices of French companies increased during World war II.

The risk correction is not associated with famine episodes. This result might indicate that shareholders, who were in general rich individuals or religious institutions, did not

---

<sup>15</sup>We obtain the same results if we introduce our macroeconomic variables directly in the estimation of the pricing equation 3.5.

really suffer during these catastrophes. If this is indeed the case, it is reasonable for the risk correction, that is set by the marginal shareholder, to not depend on famines. This line of reasoning is related with the analysis of Ait-Sahalia, Parker, and Yogo (2004) who rationalize the equity premium by the fact that stocks are held by rich people whose consumption of luxury good is a better candidate to price stocks than the consumption of more common goods.

Overall, our results indicate that consumption risk is an important driver for asset pricing in the time period we consider. This echoes recent results obtained on more recent data by using novel ways of measuring consumption (see, e.g., Parker and Julliard (2005), and Savov (2011)).

## 6. Conclusion

The Bazacle company existed over several centuries, and for much of that time, it generated a variable flow of dividends punctuated by occasional disasters. Shares in this early example of corporate enterprise were traded at market prices. Our analysis examines whether future expected dividends are being accurately reflected in share prices, and studies the nature of the risk correction included in these prices. Risk for Bazacle shareholders included not only volatility but also the possibility of ruinous events, one of which caused the re-capitalization of the company in the early 18th century.

Perhaps the simplest but most remarkable result of our study is that real income returns, measured by the dividend yield, were slightly in excess of 5% over most of the firm's life. Including annual capital appreciation, the arithmetic total return was roughly 20% – a slightly deceptive number because invested capital over the entire period of study would have yielded only the 5% dividend return. This is because the geometric average of price appreciation was nearly null.

Another remarkable result is that basic asset pricing theory cannot be rejected on the Bazacle data. Changes in expectations of future dividends explain between 15% and 43% of the variation in prices, depending on the time period we consider. Moreover, the risk correction that is embedded in share prices is positively correlated with the volatility of grain prices. Overall, using the Bazacle company as a laboratory to test asset pricing theory, we find strong evidence in favor of basic principles of asset valuation.

## 7. Appendix

### 7.1 History of Outstanding Capital

Period	Number and nature of shares	Reason
1372-1374	80 divisible	Merger of independent mills
1374-1384	88 divisible	Purchase of a mill
1384-1535	96 divisible	Purchase of another mill
1535-1714	100 divisible	Unknown
1714-1804	128 divisible	M. Abeille receives half of the shares
1804-1888	136 divisible	8 shares are issued to pay for repairs
1888-1910	544 divisible	Split 1:4
1910-1928	6,450 non-divisible	Merger with “Toulousaine d’Electricité”
1928-1943	205,875 non-divisible	Unification of different stocks and split 5:1
1943-1946	319,375 non-divisible	Issue of new shares



## 7.2 Adjustment for Inflation

There is considerable research into the question of how best to measure inflation over the very long term, however we take silver prices as the primary index since it was the basis for the French monetary system and the only metal used in the Toulouse mint after 1540.

A few details are necessary to interpret the silver price series. Before 1803, all uchaux and wheat prices (except for the very first prices which were sometimes quoted in gold) are quoted in livres tournois, the main unit of account in France during the pre-1803 period. Livres tournois had an official and a market rate of exchange to silver and we require the market rate. Unfortunately, data on the market rate of exchange between livre tournois and silver are only available at a low frequency. For example, we just have seven exchange rates for the period 1372-1533. Thus we are forced to linearly interpolate these values. After 1533, exchange rates are frequent.

After 1803, prices are in Franc germinal, which had a fixed conversion rate of 1 livre tournois to 0.9877 franc. Between 1803 and 1876, the value of the Franc germinal remains stable in silver thanks to the Gold/Silver standard (1 franc = 5 grams of silver at 900/1000 thus 4.5 grams of pure silver). After 1876, France adopted the pure gold standard. Between 1877 and 1946, we convert gold into silver using the rate of 15.5 grams of silver for a gram of gold which is the fixed rate established during the Silver/Gold standard until 1876.

The most problematic periods for adjusting to real values are France's experiments with fiat money. For a brief period in 1719 and 1720, France replaced metallic currency with paper money – a decision that was quickly reversed following a monetary crisis. This event seems not to have affected the prices of uchaux in Toulouse, however. In the revolutionary period from 1789 to 1796, France again issued paper money – Livres-assignats. We use weekly values of the assignats in silver coins in the Haute-Garonne from Caron (1909).

## References

- [1] Aït-Sahalia Y., Parker J., and Yogo M. (2004). Luxury Goods and the Equity Premium. *Journal of Finance* 59, 2959-3004.
- [2] Almeida C. and Garcia R. (2014). Assessing Misspecified Asset Pricing Models with Empirical Likelihood Estimators, forthcoming in *Journal of Econometrics*.
- [3] Ang, A., and Bekaert G. (2007). Stock return predictability: Is it there? *Review of Financial Studies* 20, 651-707.
- [4] Bansal, R., and Yaron A. (2004). Risks for the long run: A potential resolution of asset pricing puzzles. *Journal of Finance* 59, 1481-1509.
- [5] Bansal, R., Kiku D., Shaliastovich I., and Yaron, A. (2014). Volatility, the Macroeconomy and Asset Prices. Forthcoming *Journal of Finance*.
- [6] Baron M. (1917). *La monnaie de Toulouse : historique, organisation, juridiction*, thèse en droit, Toulouse, Bonnet.
- [7] Barro R. (2006). Rare disasters and asset markets in the twentieth century. *Quarterly Journal of Economics*, 121, 823-866.
- [8] Baulant, M. (1968). Le prix des grains à Paris de 1431 à 1788. *Annales Economies, Sociétés, Civilisations*, 23.3, pp. 520-540.
- [9] Bessler, A. (1980). Aggregated personalistic beliefs on yields of selected crops estimated using ARIMA processes. *American Journal of Agricultural Economics* 62, 666-674.
- [10] van Binsbergen, J., Brandt, M., and Koijen, R. (2012). On the Timing and Pricing of Dividends. *The American Economic Review*, 102(4), 1596-1618.

- [11] Bonnet C. (2013). Jean de Bernuy, les moulins du Bazacle et l'espace urbain : stratégies et réseaux à Toulouse, 1500-1555. Master thesis. Université Le Mirail, Toulouse.
- [12] Bonomo M., Garcia R., Meddahi N. and Tédongap R. (2011). Generalized Disappointment Aversion, Long-run Volatility Risk, and Asset Prices. *Review of Financial Studies* 24, 82-122.
- [13] Bordes, F. (2006). Formes et enjeux d'une mémoire urbaine au Bas Moyen Age: Le premier Livre des Histoires de Toulouse (1295-1532), Tome 3 : Entre Histoire et Mémoire Urbaine, Thèse Doctorat Histoire, Toulouse.
- [14] Bossaerts, P., and Hillion P. (1999). Implementing statistical criteria to select return forecasting models: what do we learn? *Review of Financial Studies* 12, 405-28.
- [15] le Bris D. (2012). Wars, inflation and stock market returns in France, 1870-1945. *Financial History Review* 19, 337-361.
- [16] le Bris, D., Goetzmann, W. N., and Pouget S. (2014). Modern Introduction to Germain Sicard's *The Mills of Toulouse*. Yale University Press, forthcoming.
- [17] le Bris D., Hautcœur P.-C. (2010), A Challenge to the Triumphant Optimists, A Blue Chips Index for the Paris Stock Exchange (1854-2007). *Financial History Review* 27, 141-183.
- [18] Campbell, JY and RJ Shiller (1988). The dividend-price ratio and expectations of future dividends and discount factor. *Review of financial studies*.
- [19] Caron, P. (1909). *Tableaux de dépréciation du papier-monnaie*. Imprimerie Nationale, Paris.
- [20] Cochrane, J. (2005). *Asset pricing*. Princeton University Press.

- [21] Cochrane, J. (2008). The dog that did not bark: A defense of return predictability, *Review of Financial Studies* 21, 1533-1575.
- [22] Cogley, T., and Sargent, T. J. (2008). The market price of risk and the equity premium: A legacy of the Great Depression? *Journal of Monetary Economics*, 55(3), 454-476.
- [23] Dom Devic, and Dom Vaissète (1745). *Histoire Générale du Languedoc*, volume 5, Jacques Vincent, Paris.
- [24] Dimson, E., Marsh, P., and Staunton, M. (2008). *Triumph of the optimists: 101 years of global investment returns*. Princeton University Press.
- [25] Dimson, E., and Spaenjers C. (2011). Ex post: the investment performance of collectible stamps. *Journal of Financial Economics* 100, 443-458.
- [26] Dularier (ed.), (1876). *Histoire Générale du Languedoc*. Tome 13. Privat, Toulouse.
- [27] Fama, E. F., and French, K. R. (1988). Dividend yields and expected stock returns, *Journal of Financial Economics* 22, 3-25.
- [28] Fourasti (1969). *L'Evolution des prix à long terme*. PUF, Paris.
- [29] Frêche G. and Frêche G. (1967). *Les prix des grains, des vins et des légumes à Toulouse (1486-1868)*. PUF, Paris.
- [30] Gabaix, X. (2012), Variable Rare Disasters: An Exactly Solved Framework for Ten Puzzles in Macro-Finance. *Quarterly Journal of Economics*, 127(2), 645-700.
- [31] Ghosh A., Julliard C. and Taylor (2013). What is the Consumption-CAPM missing? An Information-Theoretic Framework for the Analysis of Asset Pricing Model, Working Paper, Carnegie Mellon University, London School of Economics, and Manchester Business School.

- [32] Goetzmann, W. N., Ibbotson, R. G., and Peng, L. (2001). A new historical database for the NYSE 1815 to 1925: Performance and predictability. *Journal of Financial Markets* 4, 1-32.
- [33] Goetzmann W. N. and Ibbotson R. G. (2006). *The Equity Risk Premium: Essays and Explorations*. Oxford University Press.
- [34] Goetzmann, W. N., and Jorion, P. (1993). Testing the Predictive Power of Dividend Yields. *Journal of Finance* 48, 663-679.
- [35] Goetzmann, W. N., and Jorion, P. (1995). A longer look at dividend yields. *Journal of Business*, 483-508.
- [36] Goetzmann, W. N., and Pouget, S. (2011). A shareholder lawsuit in fourteenth century Toulouse, in *Origins of Shareholder Advocacy*, Edited by Jonathan G.S. Koppell, Palgrave-MacMillan.
- [37] Goyal, A., and Welch I. (2003). Predicting the equity premium with dividend ratios. *Management Science* 49, 639-54.
- [38] Goyal, A., and Welch I. (2006). A comprehensive look at the empirical performance of the equity premium prediction. *Review of Financial Studies* 21, 1455-1508.
- [39] Hansen, L. P., Heaton J. C., and Li N. (2008). Consumption strikes back? Measuring long-run risk. *Journal of Political Economy* 116, 260-302.
- [40] Hoffman P.T., Postel-Vinay G. and Rosenthal J.-L. (1992). Private Credit Markets in Paris 1690-1840. *Journal of Economic History* 52, 293-306.
- [41] Hoffman P.T., Postel-Vinay G. and Rosenthal J.-L. (2000), *Priceless markets, the political economy of credit in Paris, 1660-1870*, University of Chicago Press, Chicago and London.

- [42] Homer S. and Sylla R. (2005). *A History of Interest Rates*. Fourth Edition, Wiley.
- [43] Jacks, D. S., O'Rourke, K. H., and Williamson, J. G. (2011). Commodity price volatility and world market integration since 1700. *Review of Economics and Statistics*, 93(3), 800-813.
- [44] Labrousse, E. (1933). *Esquisse du mouvement des prix et des revenus en France au XVIIIème siècle*. Dalloz, Paris.
- [45] Leroy-Ladurie E., (2004). *Histoire humaine et comparée du climat, canicules et glaciers, XIIIème-XVIIIème siècle*. Paris.
- [46] Leroy S. and Porter R. (1981). The present-value relation: tests based on implied variance bounds. *Econometrica* 49, 555-574.
- [47] Lettau, M., and Ludvigson S. (2001). Resurrecting the (C)CAPM: A Cross-Sectional Test When Risk Premia Are Time-Varying. *Journal of Political Economy* 109, 1238-1287.
- [48] Menzly, L., Santos T., and Veronesi P. (2004). Understanding predictability. *Journal of Political Economy* 112, 1-47.
- [49] Munro, J. H., (2003). The Medieval Origins of the Financial Revolution: Usury, Rentes and Negotiability. *The International History Review* 25(3), 505-562.
- [50] Neal, L. (1993). *The rise of financial capitalism: International capital markets in the age of reason*. Cambridge University Press.
- [51] Pástor, L., and Stambaugh R.F. (2009). Predictive systems: Living with imperfect predictors. *Journal of Finance* 64, 1583-1628.
- [52] Parker J. and Julliard C. (2005). Consumption Risk and the Cross Section of Expected Returns. *Journal of Political Economy* 113, 185-222.

- [53] Raynal J. (1759). Histoire de la ville de Toulouse. JF Forest, Toulouse.
- [54] Rietz, T. A. (1988). The equity risk premium a solution. *Journal of monetary Economics*, 22(1), 117-131.
- [55] Rives (1969).
- [56] Roucaud J. (1919). La peste à Toulouse des origines au XVIIIème siècle. Thèse en médecine, Toulouse.
- [57] Rutterford, J. (2004). From dividend yield to discounted cash flow: a history of UK and US equity valuation techniques. *Accounting, Business & Financial History*, 14(2), 115-149.
- [58] Saboly, M. (2001). L'analyse d'une crise: les Moulins du Bazacle, une étude de cas moderne?. *Entreprises et histoire*, (1), 70-88.
- [59] Savov A. (2011). Asset Pricing with Garbage, *Journal of Finance* 66, 177-201.
- [60] Schneider, R. A. (1989). *Public Life in Toulouse, 1463-1789: From Municipal Republic to Cosmopolitan City*. Cornell University Press.
- [61] Shiller, R. J. (1981), The Use of Volatility Measures in Assessing Market Efficiency. *The Journal of Finance*, 36: 291304.
- [62] Sicard, G. (1953). *Aux origines des sociétés anonymes. Les moulins de Toulouse au Moyen Age*. Armand Colin, Paris.
- [63] Siegel J. (2007). *Stocks for the Long Run*. Fourth Edition, McGraw-Hill.
- [64] Stambaugh, R.F. (1999). Predictive regressions. *Journal of Financial Economics* 54, 375-421.

- [65] Vuolteenaho, T. (2002). What drives firm-level stock returns? *Journal of Finance* 57, 233-264.
- [66] Wolff, P. (1954). *Commerce et marchands de Toulouse, v.1350-v.1450*. Plon, Paris.
- [67] Yang, S-R., Koo, W. and Wilson, W. (1992). Heteroskedasticity in Crop Yield Models. *Journal of Agricultural and Resource Economics*, 17(1).



Table 1: Summary statistics

Table 1 reports summary statistics about the annual returns on Bazacle shares. Statistics are computed using the price closest to the end of each calendar year. We use data in kilograms of silver. Prices and dividends are missing for some years. For the dividend yield, we require the dividend from the current year and a price from the previous year. For capital gains returns, we only use years for which prior and current year prices exist. We do the same to compute price changes which represent the difference between current and prior share prices. We present statistics for the full sample as well as for various sub-periods, the Middle-Ages from 1371 up to 1531 (for which we do not have a lot of data), the milling activity period from 1532 to 1888 (for which we have plenty of data), and the electricity period from 1889 up to 1946.

Data in Silver	Dividend Yield		Capital Gain		Price Change	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
<b>1372-1946</b>	5.16%	7.55%	15.48%	122.36%	30.72	6697
Obs. (p-value)	327	(0.00)	295	(0.03)	295	(0.94)
<b>1372-1531</b>	4.94%	6.11%	-2.70%	36.68%	-271.48	1168
	3	(0.16)	11	(0.81)	11	(0.44)
<b>1532-1888</b>	5.14%	8.16%	18.44%	134.86%	75.25	6366
	270	(0.00)	232	(0.04)	232	(0.86)
<b>1889-1946</b>	5.29%	3.34%	6.13%	58.86%	-104.05	8640
	54	(0.00)	52	(0.45)	52	(0.93)

Table 2: Dividend process estimation

Table 2 reports the estimation of an ARMA(1,1) model applied to the dividend process. The estimated equation is:  $D_{t+1} = \alpha + \beta D_t + \gamma \epsilon_t^D + \epsilon_{t+1}^D$ , with  $D_t$  being the dividend distributed during year  $t$ . We assume that  $\mathbb{E}(\epsilon_{t+1}^D) = \mathbb{E}_t(\epsilon_{t+1}^D) = 0$ . Non-reported Phillips-Perron tests indicate that we cannot reject the hypothesis that the dividend process is stationary. We fit the model via Maximum Likelihood.

Period	$\alpha$	p-val	$\beta$	p-val	$\gamma$	p-val
<b>1441-1946</b>	181	0.00	0.80	0.00	-0.35	0.00
<b>1532-1946</b>	229	0.00	0.77	0.00	-0.32	0.00
<b>1532-1888</b>	214	0.00	0.77	0.00	-0.35	0.00
<b>1532-1815</b>	144	0.00	0.84	0.00	-0.38	0.00

Table 3: Estimation of the asset pricing equation

Table 3 reports maximum likelihood estimations of GLS regressions representing the pricing equation:  $P_t = a + bD_t + c\epsilon_t^D + \epsilon_t^P$ .  $D_t$  and  $\epsilon_t^D$  are the dividend and the dividend shock during year  $t$ , respectively. The residual  $\epsilon_t^P$  captures the risk correction and is assumed to follow an AR(1) process with an autoregressive parameter  $\delta$ . Non-reported Phillips-Perron tests indicate that we cannot reject the hypothesis that the share price process is stationary. The pseudo- $R^2$  represents the proportion of price volatility associated with variation in dividends and dividend shocks and is equal to:  $\frac{b^2 \text{Var}(D_t) + c^2 \text{Var}(\epsilon_t^D)}{\text{Var}(P_t)}$ .

Period	$a$	p-val	$b$	p-val	$c$	p-val	pseudo- $R^2$	$\delta$	p-val
<b>1441-1946</b>	14,682	0.00	3.90	0.00	-1.84	0.01	15%	0.81	0.00
<b>1532-1946</b>	15,295	0.00	4.09	0.00	-1.96	0.01	17%	0.77	0.00
<b>1532-1888</b>	14,356	0.00	4.71	0.00	-2.45	0.01	24%	0.77	0.00
<b>1532-1815</b>	12,217	0.00	6.59	0.00	-3.51	0.00	43%	0.76	0.00

Table 4: Testing the model

Table 4 reports, for the two overidentifying conditions of our model, the bounds of the 95% confidence intervals as well as the p-values at which the model is rejected. The model is rejected with a p-value of 5% if zero is not part of the 95% confidence interval. These two overidentifying conditions are related to the risk-free rate and to the unconditionally expected dividend that are, each of them, characterized by two equations. The confidence intervals and p-values are based on standard errors computed with the delta method.

Period	risk-free rate restriction			expected dividend restriction		
	lower bound	higher bound	p-val reject	lower bound	higher bound	p-val reject
<b>1441-1946</b>	-0.073	0.108	0.71	-683	598	0.90
<b>1532-1946</b>	-0.064	0.109	0.61	-664	568	0.88
<b>1532-1888</b>	-0.049	0.086	0.60	-616	562	0.93
<b>1532-1815</b>	-0.030	0.068	0.46	-535	476	0.91

Table 5: GLS regression of the risk correction on macroeconomic variables

Table 5 reports the results of a GLS regression of the risk correction onto various macroeconomic variables that capture bad times. These macroeconomic variables are dummies that indicate years in which plague epidemics, famines, wars, and riots occurred in the Toulouse region. They also include the yearly average of the monthly Wheat/Rye price ratio that, according to historians, tends to be low in bad times, and the yearly volatility of the monthly Wheat/Rye price ratio, as a measure of economic uncertainty. As a control variable, we include a dummy that indicates years with major damages that devastated the Bazacle mills or milldam. The focus is on the 1532-1815 time period. Estimation is done by maximum likelihood.

Variables	Coef	p-val
AR1	0.8	0.00
Intercept	69.9	0.66
Plague	27.1	0.65
Famine	40.3	0.30
War	-95.2	0.13
Violence	16.6	0.64
Damage	53.2	0.33
Wheat/Rye	10.4	0.91
Volatility Wheat/Rye	340.0	0.01



Figure 1: Bazacle company's location in Toulouse on the river Garonne.

This Figure shows the location of the Bazacle company (red dot) at the northwest of Toulouse on a map from 1631 from Melchior Tavernier. The Bazacle mills' dam is also visible on the map.

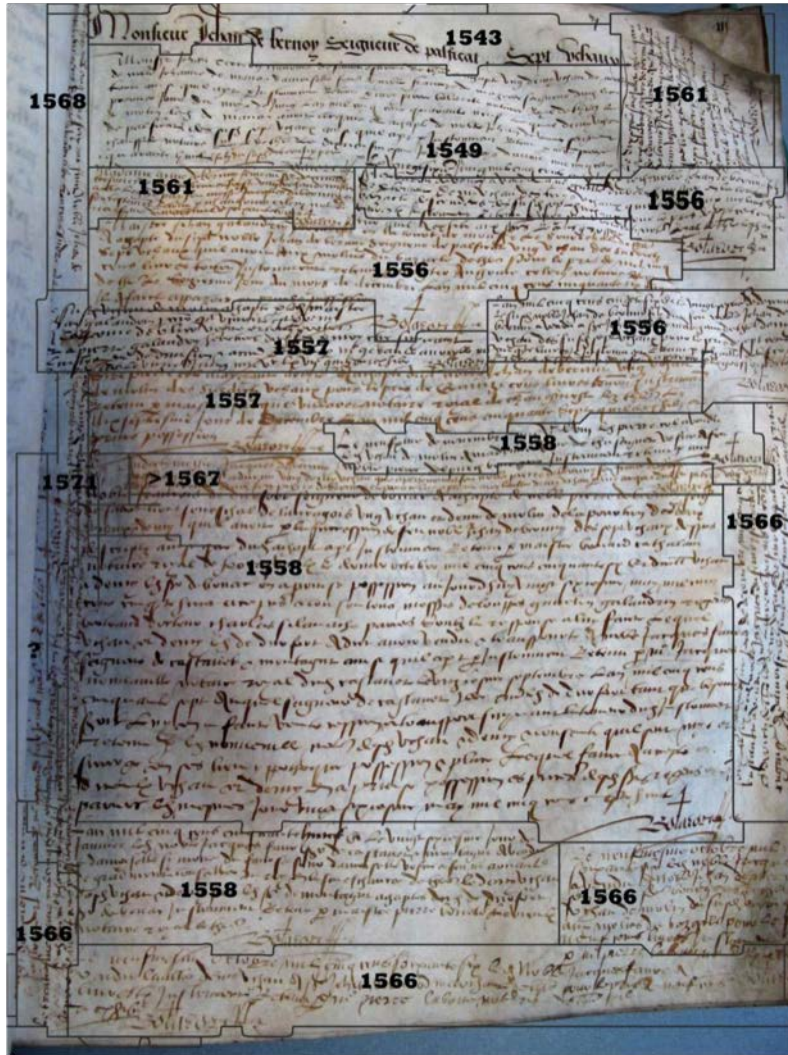


Figure 2: A register of pariers (i.e., shareholders) from 1530.

This Figure shows an example of register of pariers from 1530. The parier is Jean de Bernuy, a rich pastel merchant from Toulouse. Various transactions are written at different points in time reflecting the various times at which Jean de Bernuy or his heirs have sold their uiaux (i.e., shares). The original document is available at the “Archives Départementales de la Haute-Garonne” in Toulouse. This picture is taken from Bonnet (2013).

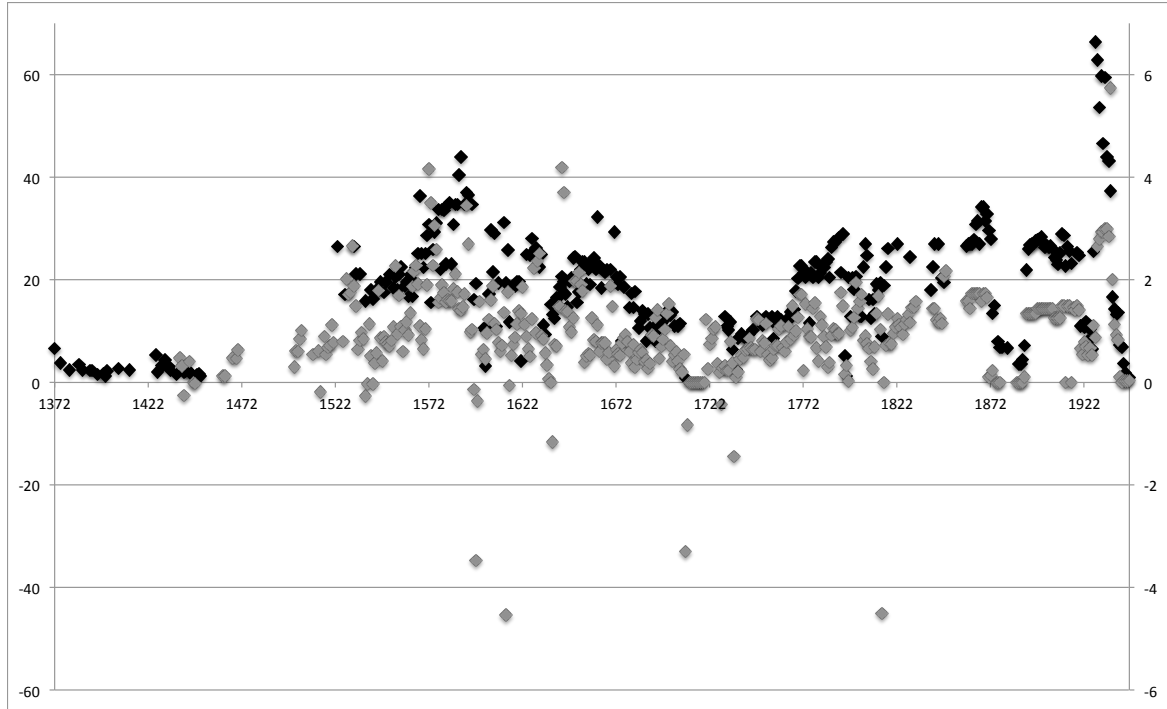


Figure 3: Bazacle share prices and dividends from 1372 to 1946 (in kilograms of silver).

This Figure shows Bazacle company's end-of-year share price and dividend from 1372 to 1946. Missing data before 1532 are due to lack of information. The data is in kilograms of silver to control for monetary inflation. The left axis is for share prices (in black), the right one for dividends (in grey).

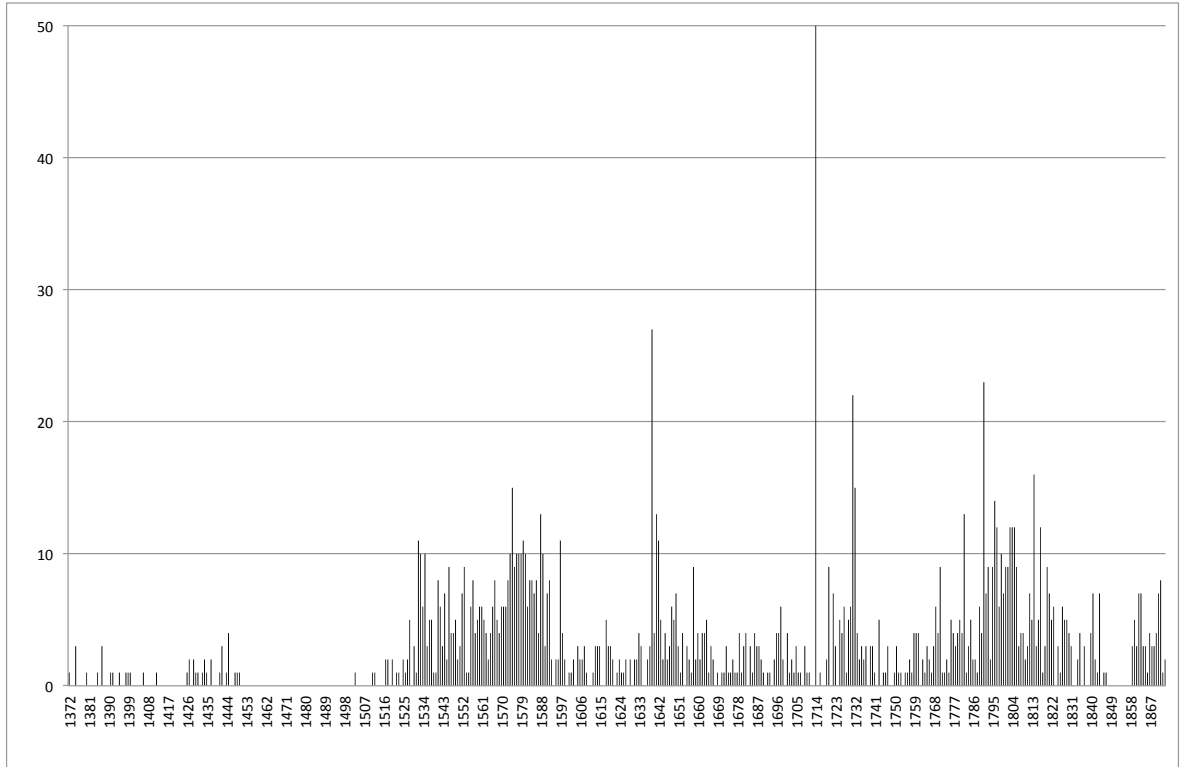


Figure 4: Number of transactions per year from 1372 to 1888 (in shares).

This Figure shows the number of share transaction for the Bazacle company from 1372 to 1888, the grain milling period of the Bazacle company. Missing data before 1532 are due to lack of information.



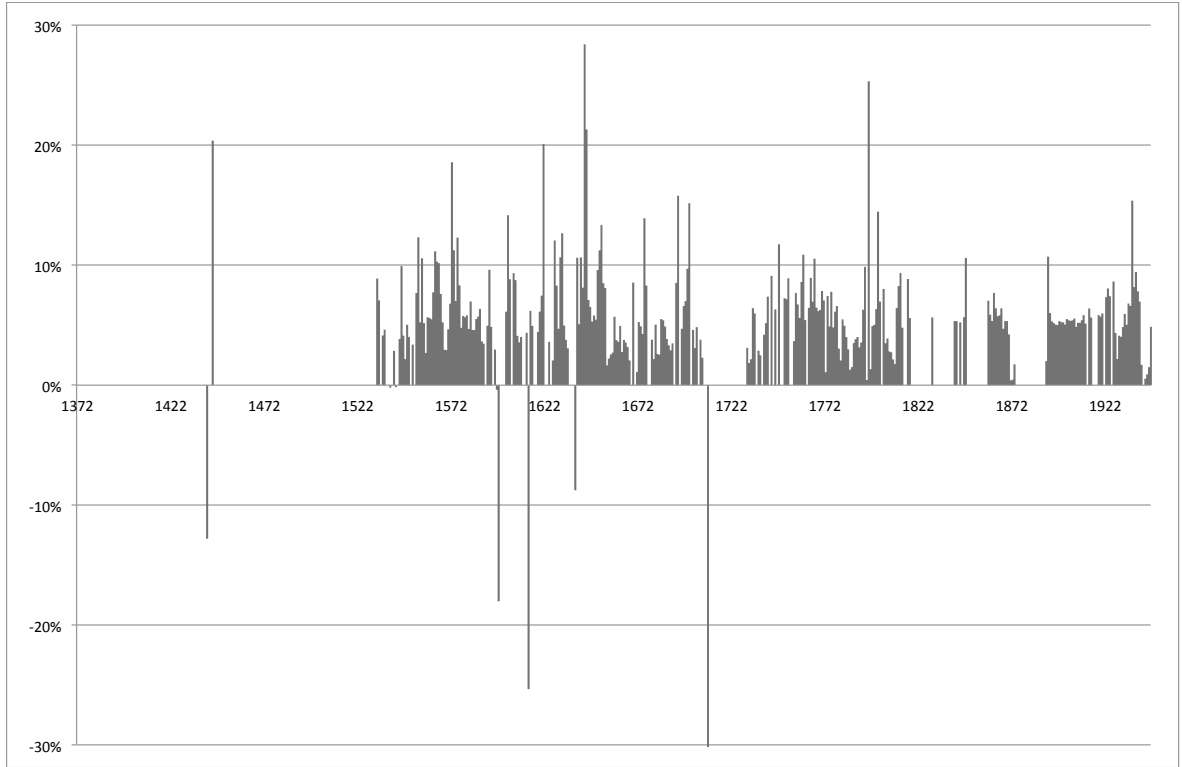


Figure 5: Dividend yield from 1372 to 1946.

This Figure shows the dividend yield. For an observation to be recorded, we require the dividend from the current year and a price from the previous year to be available. Price and dividend data used to compute the dividend yield are in kilograms of silver.