My ships come home a month before the day:
Venetian public debt servicing and precious metals from the Balkans

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Abstract

Was monetary base crucial for early sovereign debt sustainability? This paper analyses whether Venetian public debt servicing costs in the late medieval period were driven by the availability of gold and silver. We use an error correction model to describe changes in yields on perpetual bonds issued by the Venetian state. We document that the ability of the Venetian Republic to service its sovereign borrowing can be partially attributed to supply of precious metals. In particular, we show that the large increase in debt servicing costs during the 15th century can be associated with an abrupt halt in supply of gold and silver from mines in Serbia and Bosnia – mostly a consequence of the Ottoman western expansion. We control for other explanatory factors, such as mean reversion of nominal yield, real GDP growth and military conflicts.

JEL classifications: N23, E44, E51, F34

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1. INTRODUCTION

In the post-crisis era of quantitative easing, we naturally associate monetary policy with central banks. However, even in the days of commodity money, when modern instruments and institutions did not exist yet, sovereign debt monetisation was nevertheless a common practice. Is there a deeper link between monetary base and sovereign debt sustainability? Which lessons could be learned from the early days of public debt, when there were no central monethary authorities? The story of late medieval Venice may provide some of the answers.

As Venice gained its independence from the Byzantine Empire, Venetian merchants began to increase their economic power and diminish the influence of the nobility (Puga and Trefler, 2012). Long-distance trade, one of the principal sources of that power, led to many financial innovations and spurred the development of financial market in Venice (Pezzolo, 2003; 2007). The most notable of these innovations were the *prestiti*, perpetual bonds issued by Venetian state. *Prestiti* also became a popular international investment instrument, and eventually the most important source of revenue for the Republic.

Since the 13th century, Venetian debt was mainly monetised through import of precious metals, predominantly from the Balkan Peninsula (Blanchard, 2005). Until the 15th century, mines in Serbia and Bosnia were one of the main sources of silver and gold, not only for Venice, but also for many other European states. This research studies whether Venetian public debt servicing costs were driven by the availability of silver and gold from the Balkans. We use annual data on yields of *prestiti* between 1399 and 1470, as well as data from different available sources on silver and gold trading from major mines in Serbia and Bosnia during the same period. We combine the aggregated data from Italian and Serbian late medieval sources with micro-data on trading activities of prominent merchant houses of Ragusa, one of the major suppliers of monetary metals from the region.

We document that a significant increase in debt servicing costs of the Venetian Republic in the 15th century can be attributed to an abrupt halt in supply of precious metals from the Balkans, which was to some extent related to the Ottoman western expansion. The findings may have two important implications. Historically, they may broaden our perspective of the Ottoman-Venetian conflict. Economically, they represent the outcome of a natural experiment

from which we could deepen our understanding of the relationship between monetary base and public debt sustainability.

The paper contributes to a broader literature on sovereign borrowing and drivers of public debt servicing. Stasavage (2011), Tracy (2003) and Munro (2003) analyse the origins of financial revolution in medieval Europe, focusing on long-term state borrowing. Munro (2013) contrasts the differences between Italy and the Low Countries in terms of the role played by the usury doctrine. In a series of articles, Drelichman and Voth (2008, 2010, 2011a, 2011b), Álvarez-Nogal (2009), and Álvarez-Nogal and Chamley (2014, 2015) study the sovereign borrowing practices and debt sustainability in late medieval Castille and Habsburg Spain. Aguiar and Amador (2013) provide a review of sovereign borrowing from both historical and theoretical perspective, highlighting the reasons behind sovereign defaults and debt crises in general.

The remainder of the paper is organized as follows. Section 2 provides historical background for the research with an overview of main economic developments in Venice and the Balkan Peninsula during the period covered by our data. Section 3 develops the model, and presents the data and the main empirical results. Concluding remarks, as well as implications of the findings, are given in Section 4.

2. HISTORICAL BACKGROUND

The late medieval period in Europe is characterised by a notable scarcity of gold and silver, also known as the "great bullion famine". While the volume of international trade was continuously increasing (Braudel 1946; 1979), mining and production of precious metals in Central and Western Europe reached its minimum between 1250 and 1450 (Blanchard, 2005). The shortage of precious metals, amongst other things, contributed to creation of various monetary substitutes, such as bills of exchange, banknotes, letters of procuration, debentures and other paper forms of payment (Cessi, 1926). It also incited a growing interest for exploration of alternative mining facilities. Ore extraction from Balkan mines thus gained an increasing importance in late 14^{th} and early 15^{th} century. Albeit insufficient to fill the gap created by trade deficit with the East, gold and silver from the Balkans provided a significant contribution to partial alleviation of the monetary crisis in the Mediterranean and the rest of Europe. Production of precious metals from Serbia and Bosnia was predominantly exported

through the Republic of Ragusa to Italian city-states, but mostly to Venice. This exporting route had a major role in monetisation of gold and silver.

With the Ottoman invasion of the Balkans this supply chain was broken. Although the mines were essential for the monetary concerns of the Ottoman Empire, they were integrated into a completely different economic and social environment, remaining permanently beyond reach of the rest of Europe. The discovery of mines in the Americas at the end of the 15th century solved most of the problems with the money supply for a while, but also created a completely different balance of power in Europe.

2.1. Mining in the Balkans

Massive exploitation of ore in the Balkans began in the middle of 12th century, when Serbian King Stefan Uroš I commissioned experienced Saxon miners to develop the extraction process (Jireček, 1912). Evidences of trading of silver from Serbian mines appear in Ragusan documents circa 1280 (Jireček, 1879). A significant expansion of the mining industry occurs in 1370s (Dinić, 1962; 1967; Ćirković, 1979), with a peak during the first half of the 15th century (Kovačević-Kojić, 1960). A combination of the abundance of natural resources,[1] advanced mining techniques brought by highly skilled Saxon miners, very liberal mining legislation (Marković, 1981) and high demand for precious metals were the main contributors of the expansion of export of silver and gold from Balkan mines. The increasing volume of trade brought representatives of various merchant houses from Ragusa (Kovačević-Kojić and Ćirković, 1982–1983), who seized the opportunity to gain from the intermediation.

According to Kovačević-Kojić (1970), 32 medieval mines were active in Serbia and Bosnia, while Ćirković (1979) lists about 50 different mines in the entire South-Eastern Europe. By far the largest regional mine of the period, both in terms of its area and production volumes, was Novo Brdo (Saxon: Neuberghe) in Kosovo. Novo Brdo was a complex of several mining facilities with large deposits of silver, gold, lead and iron ores, active since the first decade of the 14th century. It became famous for its production of silver, gold and auriferous silver,[2]

[1] Extraction of gold, silver, lead, copper and iron dates back to the Roman period, although on a much smaller scale than in the Middle Ages (Dušanić, 1977).

[2] Auriferous silver (*argentum de glama*) is a type of silver ore containing up to 33% of gold – typically between 20 and 25%. Merchants and craftsmen who mastered techniques to separate and refine the gold from this ore could gain substantial profits.

which peaked between 1420 and 1440 (Kovačević-Kojić, 1960). Second largest mining centre was Srebrenica in Bosnia, with seven mines active since 1352, six of which were abundant with silver.[3] Other important mines were located in Brskovo, Janjevo and Ostružnica. Silver could be extracted in 29 mines, while some facilities combined exploitation of precious metal ores with extraction of copper, lead and iron ore.

2.2. From Neuberghe to Rialto: tracing the supply chain of precious metals

Most of the metals from the Balkans were exported to Venice (Blanchard, 2005). Naturally, at least some fraction of it had to be transported over land. However, the actual volumes traded in this way are practically impossible to assess due to a negligible number of available sources on the matter. Bojović (2014) argues that most trading had to be by sea, especially after 1428, when King Stefan Tvrtko II of Bosnia imposed duties on silver in transit through the territories under his control. Even without the duties, trading by land was also riskier, as robberies were not uncommon (Spremić, 1994). The premia required by the merchants provide additional evidence: land trade carried returns of 10 percent, compared to the trading from Dalmatian ports to Venice, where typical returns were 2–7 percent (Tadić, 1968). Maritime trading through Ragusa was by far the most significant route in this supply network (Kovačević-Kojić, 1971). Apart from being a safer way and conducted indirectly through intermediation of merchant noble families, trading through the port of Ragusa was additionally made attractive after being partially exempt from levies and duties by some of the rulers of Serbia and Bosnia, especially during the period of Serbian Despotate in the 15th century (Bojović, 2014).

2.3. The intermediation role of Ragusan merchant houses

The extent of precious metal trading through Ragusa is evident from the trading activity of merchant houses of the Ragusan Republic (Kovačević-Kojić, 1999). The market price of silver was determined by its quality and purity. It ranged between 6 ½ Venetian golden ducats per one Ragusan pound at the beginning of the 14th century, to 8–8 ½ ducats in the 1370s, eventually becoming stable at 8 ducats in the first half of the 15th century.[4] The price of

[3] The name Srebrenica comes from "srebro", which means silver.

[4] A Ragusan pound (*libra*) was a measure of weight equal to 327.93 grams (Mosher-Stuard, 2006). This was in fact the same unit of measure as the ancient Roman pound. Some sources, however, conflate it with the so-called gross pound (*libra de peso grosso*), which was equal to 372.37 grams.

auriferous silver was 25–26 ducats per Ragusan pound, while the same quantity of pure gold was sold for a price ranging between 76 and 85 ducats (Vinaver, 1964; Voje, 1970).

Along with Venice, other major destinations for shipments of precious metals from Ragusa were Italian regions of Tuscany, Marche, Abruzzo, Puglia and Sicily (Tadić, 1960; Ćuk, 1990). In the second half of 14th century, Ragusan merchants took over almost the entire market for silver originally controlled by traders from Venice, Florence and Cattaro[5]. Precious metals were transported to Venice by city brigantines,[6] a fact that indicates the importance that the Republic gave to this trading activity. Ragusan merchants benefited from their various privileges granted by the Venetians, including the benevolence of the local authorities towards their (apparently frequent) smuggling habits. A fraction of precious metals from the Balkan mines was exported from Ragusa to Catalonia, Egypt and Syria, and even Central Europe (Hrabak, 1977; 1980), but to a much smaller extent and predominantly for the purpose of being exchanged for other commodities, such as wool or grain. Trading route from the Balkans to Venice via Ragusa in some sense contested the one from African mines to Genoa and Florence by way of Barcelona (Hrabak, 1980). Thus, the winners of the rivalry between Venice and other Italian city-states for the access to monetary metals were the Ragusan and Catalan suppliers, who clearly benefited from this type of monopolistic competition.

Tadić (1968) provides an excellent illustration of how lucrative the intermediation really was. When Catalan pirates robbed a ship from Ragusa on its way back from Venice in 1436, the loss was estimated to 15,000 golden ducats in coin and only about 3,000 ducats in other goods. This five-to-one ratio indicates that the main purpose of the voyage was to sell raw silver, gold and auriferous silver for money, while exchange for other commodities was secondary.

The archives of the Ragusan Republic in Dubrovnik (Croatia) allow for some crude estimates of the actual extent of exports of precious metals from the Balkans.[7] The registry of the Mint of Ragusa (*La Zecca di Ragusa*) contains exact quantities of coins minted in 1422. Based on

[5] Present-day town of Kotor, Montenegro.

[6] A brigantine is a two-masted type of vessel with her foremast fully square rigged and her mainmast rigged with two sails.

[7] The archives of the Ragusan Republic are unique not only in the level of detail, but also in their historical continuity from early medieval period to Napoleonic era.

these quantities, Bojović (2014) estimates that total exports of silver to Italian cities during that particular year was about 5.7 metric tons. Referring to Ćirković (1976), he further uses the data from the Mint on collected levies to estimate the production levels during the two following decades.[8] He points out that a significant drop in production occurred in 1440, immediately after the first Ottoman conquest of the territories ruled by Serbian Despots (1439–1444).

Additional evidence on quantity of exports of plain and auriferous silver and gold can be found in the trading books of the Caboga family company. The Caboga (Kabužić) family was one of the famous noble houses of Ragusa. The trading books of their company, covering the period between December 15, 1426 and May 25, 1433, are available in the Historical Archive of the city of Dubrovnik. They consist of general ledger (*quaderno*), diary (*giornale*) and reminder (*squarço*). They are among the oldest available trading books to apply a double-entry bookkeeping system (Kovačević-Kojić, 1999). The information available in these books is mostly related to purchase of precious metals from mines in Serbia and Bosnia, and their subsequent shipment to Venice. The level of details allows tracking of each particular transaction over the period of six and a half years.[9] Based on these data, the average trading volume of Caboga Company can be estimated to about 1770 Ragusan pounds (580 kg) per year, of which 1340 pounds (439 kg) were plain silver and 430 pounds (141 kg) were auriferous silver, the latter yielding about 107 pounds (35 kg) of gold after being processed. Some of the shipments included pure gold as well. The total revenue of their documented transactions was about 100,000 golden ducats, and approximately 90% of their income came from deals closed in Venice. The ships almost always carried money on their return voyage, and very rarely other commodities were purchased. Most of the revenues were reinvested (Kovačević-Kojić, 1996; 1999). Such detailed information is useful to estimate the orders of magnitude of production of precious metals during 15th century.

[8] The standard levy was 6%.

[9] Along with precious metals, trading books of the Caboga Company also contain transactions involving beeswax, while other goods appear only in negligible amounts. This is not merely a coincidence – Hrabak (1980) presents evidence that a common smuggling practice of the period involved hiding silver in beeswax rolls.

2.4. Production volumes

Earlier estimates of silver production in Serbia and Bosnia during 14th and 15th century ranged between 10 and 12 metric tons per year (Ćirković, 1979; Kellenbenz, 1979; Kovačević-Kojić, 1996). More recent research provides evidence that total production of precious metals in the Balkans during the first half of the 15th century should be set at least at 30 metric tons per year (Ćirković *et al.*, 2002; Kovačević-Kojić, 2004; 2010). An alternative lower bound of 11.5 metric tons per year could be established based on annual income of Serbian Despots, who controlled Novo Brdo and Srebrenica as the two most significant mining centres of the period (Bojović, 2014).

Annual income of Novo Brdo in 1433 was around 200,000 golden ducats (de la Brocquière, 1807).[10] In 1455, the income of Serbian Despot Đurađ Branković was 120,000 ducats (Fermendžin, 1892). Based on this evidence, Vinaver (1960) estimates that the total production of plain and auriferous silver in 1455 had to be between 7.5 and 9 metric tons. Ćirković (1976; 1979) and Kovačević-Kojić (2010) provide useful data on rents in Srebrenica, from which we can estimate that silver production had to be around 5–6 metric tons per year at its peak. Total income of Srebrenica in 1458, at the maximum of its activity, was 30,000 ducats, split equally between the Serbian Despot and the Bosnian King. In 1464, a year after Ottoman conquest of the territories under control of the Bosnian King, the income drops to 7,000 ducats. This suggests that mining activity was not only substantially influenced by the Venetian demand, but also that the Ottoman invasion had a critical impact on breaking the established supply channel through Ragusa. In fact, Radonić (1930) quotes the biographer of Mehmed II the Conqueror, who argues that the Sultan had political, strategic and financial reasons to conquer the territories under Serbian control or influence, rather than keeping them as vassal states. The biographer also mentions that "Serbian gold and silver are more abundant and have a better quality than that from India". Elezović (1932) quotes a different biographer, who indicates that Serbian lands have "inexhaustible sources of gold and silver".

Vinaver (1960) and Tadić (1968) also put the production from Serbian and Bosnian mines in a global perspective. With total European estimates ranging between 23 and 47 metric tons

[10] Bertrandon de la Brocquière, a pilgrim to the Holy Land and a spy for Philip the Good, the Duke of Burgundy, claimed that Serbian Despot Đurađ Branković was one of the richest rulers in Europe due to exorbitant income he was receiving from mining in Novo Brdo.

per year, at its apex it should have represented between 12.5 and 20% of the total quantity extracted in the entire continent.[11] Braudel (1979) provides rough orders of magnitude for the entire volume of gold and silver in Europe before the colonisation of the Americas. His estimate of the total quantity of gold in circulation was around 2,000 metric tons and the total quantity of silver around 20,000 tons. If we assume that the average annual output of mining industry in late medieval South-Eastern Europe was at least 10 tons, then a century of production of precious metals should have resulted in a minimum of 1,000 tons extracted. This quantity would contribute to around 5% of the monetary mass in Europe during 15th century. More recent findings of Kovačević-Kojić (2010; 2012), that estimate the annual output of mines in Serbia and Bosnia to be 30–40 tons, would set this fraction to as high as 15–20%.

Irrespective of the actual precise numbers, the orders of magnitude of gold and silver production from the Balkan mines are all but negligible. The Venetian economic downturn of the second half of the 15th century, although extensively analysed by historians,[12] often tends to neglect the role of the Ottoman invasion of the Balkans. In particular, it overlooks the sudden fall in quantity of monetary metals, as pointed out by Bojović (2014). Section 3 explores this link in a more formal way.

3. EMPIRICAL RESULTS

3.1. The model

Due to understandable scarcity of the relevant data, we adopt a reduced-form time-series model of Hall *et al.* (1992) to forecast yields. The model is based on the cointegration approach of Campbell and Shiller (1987). We will thus assume that the dynamics of bond yield y_t is given by:

[11] Even if a conservative approach is taken, where the minimum quantity extracted from the Balkan mines is compared to the maximum quantity extracted from mines across entire Europe, the number should be at least 10% (cf. Bojović, 2014).

[12] See, for instance, Braudel (1946; 1996) or Lane (1985).

$$\Delta y_t = \sum_{i=1}^{k} \alpha_i \Delta y_{t-i} + \beta s_t + \varepsilon_t , \tag{1}$$

where $t = 1, 2, ..., T$ labels the time periods (years), s_t represents the spread between yields on short-term and long-term debt instruments, while ε_t is the short-term disturbance. The intuition for this approach is relatively straightforward and does not rely on the weak form of the Efficient Market Hypothesis. Namely, investors reflect available information about future short-term rates through the prices they are willing to pay for long-term bonds. This automatically reflects on yields. Any information that investors have about future short-term end of the yield curve that is not contained in the past yields can be forecasted by the yield spread s_t. Campbell and Shiller (1987) used monthly observations of one-month and 20-year bond yields between 1959 and 1983. They could not reject the hypotheses that one-period yields were I(1) and the spread was I(0), which also justified their approach empirically.

Since the only historical data available for Venetian public debt during 14th and 15th century with a fairly regular frequency are prices and yields of *prestiti*, which are perpetual bonds, we cannot rely on spreads or any point along the term structure of interest rates to run the model. Instead, to make the model feasible, we modify the specification given by Eq. (1) to an error correction model (ECM) of the form:

$$\Delta y_t = \sum_{i=1}^{k} \alpha_i \Delta y_{t-i} + \sum_{j=1}^{m} \boldsymbol{\beta}_j' \Delta \mathbf{x}_{t-j} + \gamma u_{t-1} + \varepsilon_t , \tag{2}$$

where $\mathbf{x}_t$ represents a set of explanatory variables that capture the effect of the changes in future yields that are not contained in the historical yields, while u_t is the long-term disturbance. The long-run equilibrium relationship between the yields and the explanatory variables is given by:

$$y_t = \mathbf{b}' \mathbf{x}_t + u_t . \tag{3}$$

One of the main explanatory variables to consider in Eqs. (2) and (3) is the growth rate of gross domestic product (GDP), which is closely related to the yield curve spread, at least in modern developed markets.[13]

[13] See, for instance, Estrella and Mishkin (1998) or Ang *et al.* (2006).

3.2. The data

Our main dependent variable is the yield on *prestiti*, expressed in percent per annum, y_t. We use annual data between 1399 and 1470 available from the Global Financial Database. Table 1 presents the summary statistics. The plot of the time series is shown in Figure 1.

Table 1. Summary statistics for yield on Venetian *prestiti* during 1399–1470

Number of observations	72
Mean	14.85
Standard deviation	6.08
Minimum	7.46
Maximum	25.00
Skewness	0.19
Kurtosis	1.40
Autocorrelation (one lag)	0.96***
Ljung-Box statistic (five lags)	265.99***

Figure 1. Yield on Venetian *prestiti* during 1399–1470. Shaded areas indicate the periods of Ottoman control of the Balkan mines.

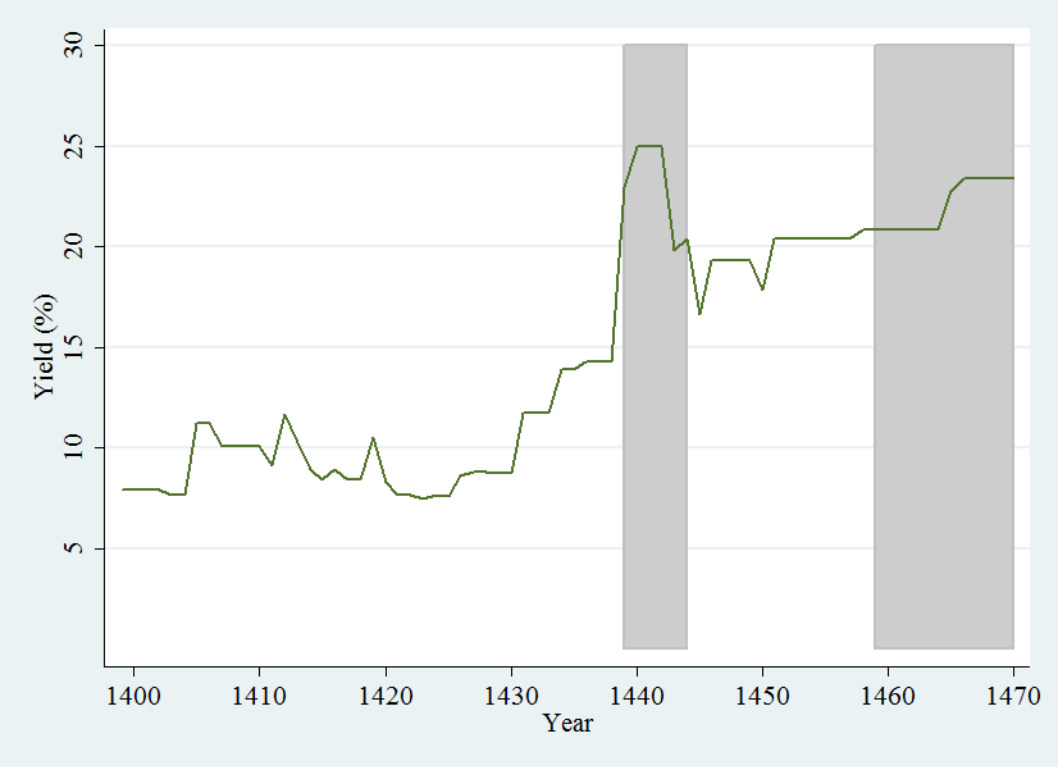


Table 1 suggests that there is a very high degree of autocorrelation in yield y_t. In fact, the Augmented Dickey-Fuller (ADF) test statistic of –0.98 indicates that the null hypothesis of a unit root cannot be rejected. On the other hand, the first difference of the yield, Δy_t, does not exhibit unit-root non-stationarity, since the corresponding ADF statistic (–8.73) is highly significant.

As a collection of explanatory variables $\mathbf{x}_t$ we use the time trend (*t*), real GDP growth rate, a proxy for the money supply, and a dummy that indicates the Ottoman control of mines in Serbia and Bosnia. The intuition for economic significance of the explanatory variables is the following. First, interest rate on public debt and output should have the usual negative relationship, since lower debt servicing costs would have allowed the state to invest more, resulting in higher GDP. The real GDP growth rate for Venice will be approximated by GDP estimates for city-states in Northern Italy, available in Malanima (2011).

Second, a sovereign borrower can improve debt sustainability by reducing primary fiscal deficit (through an increase in tax income or a reduction in public expenditures), by increasing output growth, or by reducing the real interest rate. Theoretically, higher money supply should put a downward pressure on real interest rates. The *prestiti* were paying a fixed nominal interest rate of 5% per year on the remaining face value (see Pezzolo, 2003 or Homer and Sylla, 2005).[14] Therefore, in the absence of a monetary authority that sets the reference rate of interest,[15] any increase in the nominal yield (or, equivalently, any decrease in price of *prestiti*) can be explained through a combined effect of increase in premia for default risk, illiquidity and inflation risk. Since *prestiti* were amongst the most sought-after securities in 14th and 15th century, both by Venetian nobility and European investors (Homer and Sylla, 2005), it is reasonable to assume that their liquidity was relatively high, at least when compared to other available investment vehicles. Thus, we can suppose that increases in the nominal yield were predominantly driven by a combination of default and inflation risk premia. Since public debt was financed through a combination of tax income *and* base money, at least some part of changes in yield should be attributed to increase in monetary base, i.e.

[14] The nominal interest of 5 percent was paid in two annual installments of 2½ percent. Occasional repayments of principal were subordinated to repayments of interest.

[15] The Venetian state did participate in the secondary market at the Rialto bridge, buying back a portion of issued securities and thus effectively paying out a fraction of the principal (see Munro, 2013).

the quantity of golden ducats and silver *grossi* in circulation. Inflationary risks could not be mitigated if the economy was growing slower than money supply. The price indices available in Malanima (2011) allow us to set a crude estimate for the rate of inflation in the 15th century's Northern Italy at 1.4% per year on average, with a standard deviation of 18.7%. With a modest nominal GDP growth rate of around 2% on average, we may expect that debt monetisation has contributed to inflation in Venice, and subsequently to additional risk premium required by investors. Hence, there is a combined effect of supply of precious metals.

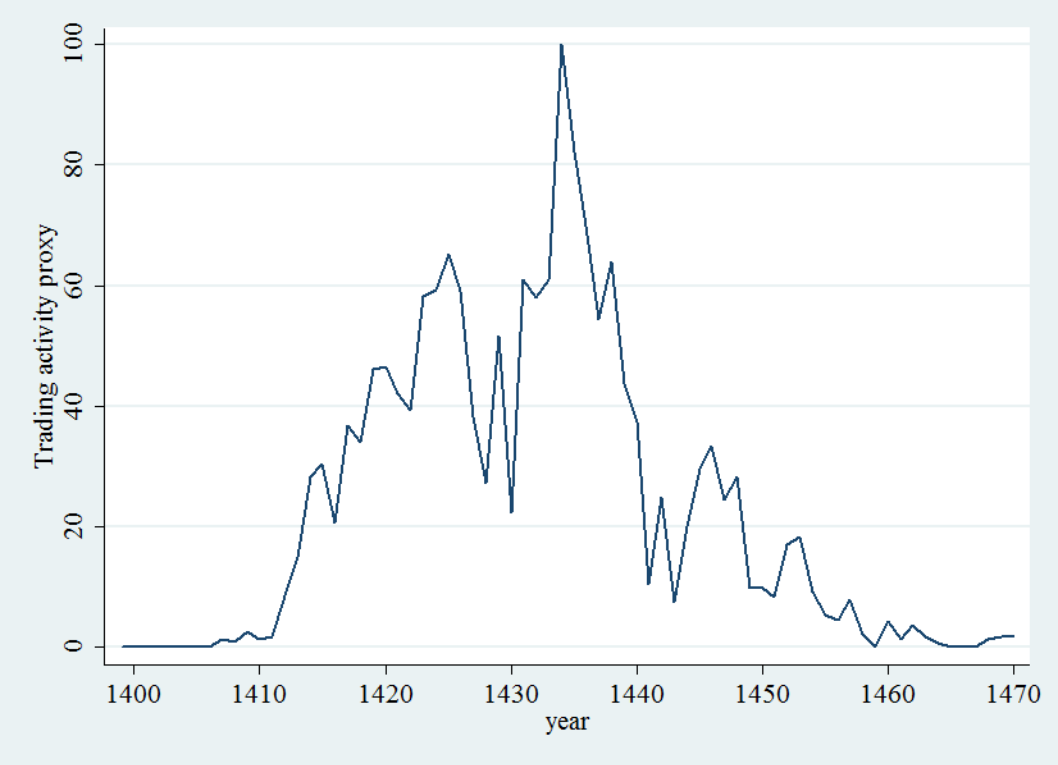
To capture the net effect of money supply, we use a measure of trading activity with mines in Serbia and Bosnia during 1399–1470 as a proxy. Since most of the precious metals exported from the Balkans to Venice went through Ragusan merchants, it is reasonable to use the number of citizens of Ragusa registered near the major mining centres in a particular year as a measure of trading activity in that year. Therefore, we use the annual data on the number of Ragusan nobility and other citizens who appeared in the legal affairs in towns of Priština (the settlement closest to the mine of Novo Brdo) and Srebrenica, available from Kovačević-Kojić (2012) and Kovačević-Kojić (2010), respectively. We construct an index of trading activity in each period, $TradingActivity_t$, by setting it initially to zero, and change it with each increase in the total number of Ragusan citizens in Priština and Srebrenica combined, relative to the historical maximum of this number, which is normalized to 100. The series is displayed in Figure 2.

To determine the impact of Ottoman occupation of the Balkans on Venetian debt servicing cost, we introduce a dummy variable which is equal to one if the Ottomans control the Balkan mines in a particular year, and zero otherwise. The years in question were 1439–1444 and 1459–1470, also represented by the shaded areas in Figure 1.[16] Evidently, these periods do in fact coincide with some of the highest levels of yield on Venetian prepetual bonds.

[16] In 1439 the Ottoman army, led by the sultan Murad II, temporarily sacked Serbia. Serbian Despot Đurađ Branković fled to Hungary. His castle Smederevo fell on August 18, 1439 after three months of siege. The last of cities in the region were conquered in March 1442. A broad Christian coalition of Hungarians (under command of János Hunyadi, the White Knight of Wallachia), Romanians (under Vlad II Dracul) and Serbs (under Despot Đurađ) advanced into Serbia and Bulgaria in September 1443. Serbian territories were fully restored by the Peace of Szeged on August 15, 1444. This interregnum lasted until 1459, when the Ottomans reconquered Smederevo and the rest of the Despotate. The territories under control of Bosnian king were fully conquered by the Ottomans in 1463 (Babinger, 1992; Fine, 1994; Ćorović, 2001; Miller *et al.*, 2010).

In regards to possible explanations why debt servicing became quite expensive for the Venetian state during the 15th century, conventional wisdom is that interest payments began falling into arrears due to frequent conflicts with neighbouring states (Homer and Sylla, 2005; Munro, 2013). Indeed, the reigns of Doge Tommaso Mocenigo (1413–23) and Doge Francesco Foscari (1423–57) were particularly marked with ongoing periods of war. To control for the potential impact of military conflicts, we introduce another dummy variable labelled $Wars_t$, equal to one if Venice was at war in a particular year, and zero otherwise. The conflicts we considered include war with Sigismund of Hungary (1411–1413), maritime conflict with the Turks (1416), conflict with the Duchy of Milan (1420), four Lombardian campaigns (1423–1426; 1427–1428; 1431–1433; 1438–1441), short war with Florence and Milan (1450) and first Ottoman-Venetian war (1463–1479). We also run a set of regressions using a separate dummy for each war.

Figure 2. The proxy for the trading activity in precious metals between Venice and the Balkans during 1399–1470



3.3. The results

To assess the long-term and short-term impact of explanatory variables, we apply Engle-Granger two-step procedure. First, we run a cointegrating regression given by Eq. (3) using an ordinary least squares (OLS) estimator. The results are summarised in Table 2.

The first column corresponds to the model without the war dummies. Time trend is highly significant and positive, which is not surprising for a regression with nominal yield levels on its left-hand side. The logarithm of real GDP has an expected highly significant and negative impact. Similarly, the trading activity proxy is negative and significant at 5 percent level. This corresponds to the intuition established in Section 3.2 that, *ceteris paribus*, an increase in money supply should lead to a decrease in interest expenses paid on sovereign debt. The dummy for the Ottoman control of the mines in Serbia and Bosnia is significant and positive, indicating that the break in supply chain of precious metals from the Balkans to Venice had a significant long-term impact on increase in debt servicing cost. The regressors explain 86.2 percent of the variation in long-term yield. The null hypothesis of Dickey-Fuller test that the estimated residuals $\hat{u}_t$ have a unit root can be rejected only at 10 percent significance level.

The second column of Table 2 shows the results when we also introduce a control for military conflicts. The dummy is significant and negative, which implies that wars were overall beneficial for reduction in effective interest expenses of the Venetian debt. The R^2 slightly increases, to 0.879, and Dickey-Fuller statistic is now significant at 5 percent level. However, significance of some of the explanatory variables changes, possibly due to multicollinearity.

The third column of Table 2 contains estimates for the model with dummies for each conflict, which allows us to isolate the individual impact of wars. With the exception of the war with Hungary (1411–1413), all conflicts have a significant long-term effect on yield. Moreover, only the fourth Lombardian campaign (1438–1441), which counterbalanced the Venetian victories in the previous three (Machiavelli, 2016), had an increasing effect on interest expenses. All remaining wars led to a significant decrease in debt servicing costs. Venice was mostly victorious in all of them, with the exception of the war with Florence and Milan and the First war with the Ottoman Empire. However, despite the military defeats, the Republic managed to gain major strategic wins. The aftermath of the 1450 war was the alliance with Kingdom of Naples, which re-established the balance of power in the region and lead to the Treaty of Lodi; at the end of the Ottoman-Venetian war Venice recouped its lost territories by

de facto acquisition of the Crusader Kingdom of Cyprus (see, for instance, Norwich, 1982; Goffman, 2002; Finlay, 2005). Aside from the war dummies, other variables have the same significance as in the first regression. Moreover, the regression has an R^2 of 0.938, while Dickey-Fuller test statistic is –5.435, indicating that the null hypothesis of a unit root can now be overwhelmingly rejected.

As the second step, we use the estimates of lagged residuals from the first regression, $\hat{u}_{t-1}$, to run the first-difference regression, Eq. (2). We use the maximum likelihood estimator (MLE) and sort the models by lags in Δy_t based on their Schwarz Bayesian information criterion (SBIC). The models considered for the sorting procedure were the ones having *p*-value of the χ^2 statistic for joint significance not higher than 0.10. This procedure results in ECM model with one lag in Δy_t as the optimal choice.

Table 3 summarises the results of coefficient estimates for ECM(1). The three columns correspond to the three cointegrating regressions from Table 2. The coefficient of lagged residuals $\hat{u}_{t-1}$ is significant and negative, justifying the cointegrating relationship between the yields and the explanatory variables. Since the numerical values of the coefficients are between 0 and –1, while the first lag in Δy_t is insignificant (except in the third regression, but only at 10 percent), the integrated model would establish a relationship between the yield and its first lag such that the coefficient next to y_{t-1} is between 0 and 1 and highly significant. This indicates a strong mean-reverting behaviour, which is a common property of yields and interest rates throughout history (van der End, 2011).

The first difference in the logarithm of the real GDP (i.e., the GDP growth rate) and the Ottoman dummy are again highly significant. The coefficient corresponding to real GDP growth rate, which is scaled by 100 in these regressions, has a negative sign, suggesting that in periods of higher economic growth the cost of public debt was lower. More precisely, one percentage point increase in real GDP growth rate would resulted in a decline in yield of 6.96 percentage points on average.[17] When we introduce controls for wars, this value goes as high as 8.82 percentage points. The trading activity is insignificant in all three regressions. Hence,

[17] Despite the lack of formal evidence, it is reasonable to assume that GDP growth exhibited a high positive correlation with consumption growth, as in modern economies. This would result in negative beta coefficients in a regression of (excess) bond returns on consumption growth, as in Cochrane and Piazzesi (2005).

there is only a long-term impact of money supply on debt servicing costs (Table 2), while the short-term impact is negligible. The dummy for the Ottoman control of the mines in Serbia and Bosnia is again significant and positive. Thus, the break in supply chain of precious metals from the Balkans to Venice had a significant impact on increase in short-term interest expenses. On average, the yield on *prestiti* increased by 3.25–4.10 percentage points in years in which the Ottomans took control over the mines. The wars had a significant short-term impact overall. The coefficient in the second model is again negative, and shows that the yield on sovereign debt decreased by 78 basis points on average in years during which Venice was at war. Individually, the two military campaigns that were most beneficial for the short-term debt servicing were war with the Duchy of Milan in 1420 and the Fourth Lombardian war (1438–1441), which can be seen from the third column in Table 3.

Table 2. Cointegrating regressions (OLS)

y_t	(1)	(2)	(3)
constant	66.384***	77.348***	71.141***
	(16.842)	(18.138)	(19.158)
Time trend	0.227***	0.229***	0.251***
	(0.015)	(0.015)	(0.012)
Log real GDP	–12.993***	–15.354***	–14.061***
	(3.720)	(4.022)	(4.231)
Trading activity	–0.027**	–0.015	–0.029**
	(0.013)	(0.012)	(0.012)
Ottoman control	2.705**	3.413***	2.554**
	(1.149)	(1.112)	(1.066)
Wars		–1.804***	
		(0.566)	
War with Hungary			0.134
			(1.308)
Maritime conflict 1416			–2.840***
			(0.480)
War with Milan 1420			–3.371***
			(0.611)
First Lombardian campaign			–2.467***
			(0.661)
Second Lombardian campaign			–2.799***
			(0.560)
Third Lombardian campaign			–2.020**
			(0.777)
Fourth Lombardian campaign			3.672**
			(1.648)
War with Florence and Milan			–1.081**
			(0.455)
First Ottoman-Venetian war			–3.749***
			(1.067)
Observations	72	72	72
R^2	0.862	0.879	0.938
Dickey-Fuller statistic	–2.820*	–3.196**	–5.445***

(Standard errors in parentheses. The asterisks ***, **, and * indicate 1%, 5%, and 10% significance levels respectively.)

Table 3. Short-term impact (MLE)

Δy_t	(1)	(2)	(3)
constant	0.160	0.161	0.174
	(0.152)	(0.149)	(0.123)
Δy_{t-1}	0.076	0.120	0.154*
	(0.097)	(0.099)	(0.080)
Log real GDP	–6.960***	–8.206***	–8.734***
	(2.007)	(2.076)	(1.727)
Trading activity	0.008	0.007	0.007
	(0.014)	(0.013)	(0.012)
Ottoman control	4.019***	4.103***	3.286***
	(0.743)	(0.733)	(0.621)
Wars		–0.775**	
		(0.354)	
War with Hungary			–0.428
			(0.731)
Maritime conflict 1416			–0.267
			(0.752)
War with Milan 1420			–1.814**
			(0.757)
First Lombardian campaign			–1.117
			(0.842)
Second Lombardian campaign			–0.499
			(0.863)
Third Lombardian campaign			–1.357*
			(0.761)
Fourth Lombardian campaign			0.136
			(0.719)
War with Florence and Milan			–2.045***
			(0.725)
First Ottoman-Venetian war			–1.882*
			(1.055)
$\hat{u}_{t-1}$	–0.169**	–0.195**	–0.498***
	(0.071)	(0.079)	(0.092)
Observations	70	70	70
R^2	0.416	0.434	0.619
SBIC	3.653	3.681	3.771

(Standard errors in parentheses. The asterisks ***, **, and * indicate 1%, 5%, and 10% significance levels respectively.)

4. CONCLUSION

This research attempts to establish a nexus between interest expenses paid on sovereign debt and money supply in the absence of a central monetary authority. We use an error correction model to describe changes in yields on *prestiti*, perpetual bonds of the Venetian Republic issued between 1399 and 1470. Our main finding is that the ability of the Republic to service its sovereign borrowing can be partially attributed to supply of precious metals from the Balkans. The quantity of silver and gold supplied to Venice had a persistent impact on debt servicing, as an increase in quantity of commodity money tend to reduce interest costs on average. A significant increase in yield on perpetual bonds issued by the Republic during the 15th century can be explained by the Ottoman control of the Balkan mines. This had both a long-term and a short-term effect. These results hold even when we control for other explanatory factors, such as real GDP growth or military conflicts between Venice and other European states.

The Ottoman control of the mines is therefore among the main exogenous determinants of a sharp increase in yield on *prestiti* during the second half of the 15th century. With a limited ability to monetise its debt, Venice could not keep it sustainable. Deprived of one of its principal sources of financing, the Republic spiralled into an economic crisis from which it never fully recovered. With the discovery of the New World, it transformed from a Mediterranean superpower into a minor player in the global scene, engaged in frequent European conflicts and local squabbles.

The findings may contribute to broadening of our understanding of an often disregarded economic perspective of the Ottoman-Venetian conflict, an ongoing struggle that extended over two and a half centuries. The first Ottoman-Venetian war started in 1463, which is the year when the territories of the King of Bosnia fell under Ottomans.[18] Given the strategic brilliance of Mehmed II, it is not unimaginable that he may have destabilised one of his main rivals in the Mediterranean economically, by seizing their main supply of precious metals. The rule over Venetian tributary cities in Greece, which is commonly regarded as the *casus belli*, could be just a step in a wider stratagem.

[18] Four years before that, the Ottomans definitely took control of the territories of Serbian Despots, which were only under suzerainty up to that point.

Our research can be also regarded as a natural experiment that confirms the link between monetary base and public debt sustainability. From a modern perspective, the topic is definitely worth investigating further, as it may bring additional insights into the fundamentals of interplay between monetary and fiscal policy.

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