Currency speculation around the opening of the telegraph between London and Paris in 1851

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Abstract

This paper employs the opening of the first international telegraph between London and Paris on 13 November 1851 as a unique event that enabled a virtually instantaneous information exchange between the largest financial centers. Before this opening, a London currency speculator comparing the short-term return between British pounds and French francs had to form an expectation about the current exchange rate in Paris. With the telegraph, this expectation became suddenly obsolete. Weekly data around 1851 suggest that returns in London and Paris were closely aligned. Apparently, currency speculators held on average quite accurate exchange-rate expectations before the introduction of the telegraph.

JEL classification: F31, N13, N23

Keywords: bills of exchange; currency speculation; exchange rates; interest-parity condition; telegraph

1 Introduction

For activities benefitting from up-to-date information, the electric telegraph, which became available to the broad public from around the mid-nineteenth century onwards, represented a momentous technological innovation. Before the telegraphic age, news could only travel at the speed of physical messengers. Almost inconceivable from today's perspective, they could take days and, sometimes, even weeks to reach faraway cities or countries. Via encoding short messages into electrical signals, which were transmitted across a network of cables

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in a reliable and virtually instantaneous manner, the telegraph paved the way for modern information society (see e.g. Standage 1998). In particular, by removing the effect of distance in communication, the "Victorian internet" transformed activities ranging from journalism to diplomacy (see e.g. Du Boff 1980; Wenzelhuemer 2013, ch.4). Last but not least, obtaining up-to-date financial data from around the world, as well as having the opportunity to swiftly place orders in foreign markets, also opened a new era in international finance (see e.g. Garbade and Silber 1978).

Against this background, this paper examines how the first landmark in international telegraphy, namely the submarine cable across the Strait of Dover to connect London with Paris, changed the way in which currency speculation occurred between these major financial centers. At the time, this kind of speculation was mainly undertaken by means of bills of exchange, whose domestic and foreign return were interconnected through an interest-parity condition. However, before the telegraph was opened on 13 November 1851, it took at least one day before information about the current interest and exchange rates of the Paris Bourse reached London. Hence, a London speculator wanting to exploit higher interest rates in Paris when compared with domestic rates after adjusting for the exchange rate between francs and pounds had to rely on corresponding expectations. After the opening of the submarine cable, literally overnight, these expectations became obsolete as the quotes in Paris were immediately "cabled" to London. In that sense, the telegraph offers a unique historical experiment to study the effect of expectations in international finance. More specifically, contemplating the shift between the interest-parity condition before and after the opening of the telegraph could provide clues as to whether currency speculators held biased expectations before foreign exchange-rate quotes became simultaneously known in London and Paris. Obviously, this issue is closely related with a voluminous literature on the interest-parity condition, which remains an important building block of modern exchange-rate theory and, therefore, has been the subject of a huge body of empirical research with recent data (see e.g. Sarno and Taylor 2002, ch.2; Engel 2014). However, today it is hard, if not impossible, to directly analyze the effect of information on financial expectations due to the absence of a counterfactual world, where global exchange and interest-rate data are not immediately available.

The economic effects of the telegraph have not gone unstudied in the literature. Du Boff (1980) has analyzed how the telegraph has fostered the integration of the US economy by restructuring the commercial, transportation, and financial industry during the decades after the mid-nineteenth century. In a similar vein, Field (1992) has argued that this breakthrough in information technology improved the efficiency of the US railways and, hence, boosted productivity and ultimately economic growth. At the global level, and for the decades after 1870, Lew and Cater (2006) suggest that the emerging worldwide telegraph network stimulated international trade in general, and helped to reorganize the shipping industry in particular in terms of reducing idle time ships had to spend in port and helping them to find more valuable cargo. As regards international commodity trading, Ejrnæs and Persson (2010) have found that grain prices quoted in Chicago and Liverpool converged after the opening of the transatlantic telegraph line in July 1866. For the very same historical event, Steinwender (2018) has found a similar integration for the cotton industry in terms of a reduced transatlantic price difference and lower volatility. The first transatlantic cable has also provided the stepping stone for studying asset prices with Garbade and Silber (1978, pp.826-828) and Hoag (2006) both finding a convergence of, respectively, the returns of dual-listed US government bonds and railway shares in New York and London after 1866. However, as noted by Hoag (2006, pp.343-344), this convergence could be spurious given the contemporaneous stabilization of the political and financial environment after the end of the American Civil War in 1865 and the abating crisis in the London financial market caused by the collapse of the discount house Overend Gurney in May 1866.

By means of weekly interest and exchange-rate data for the 1849-to-1854 period, this paper endeavors to uncover the effects of the opening of the telegraph between London and Paris on the interrelationship between their money and foreign-exchange markets. By doing so, the paper makes several contributions. In particular, it is the first to look closely at the financial effects of the telegraph for European countries in general, and for France and Britain in particular. Of note, during the nineteenth century, these countries hosted the leading financial centers (Cassis 2010, pp.60ff.). Furthermore, in contrast to earlier research on the transatlantic cable, instead of bond prices, shares, or commodities, this paper focuses on short-term currency speculation between the money and foreign-exchange market as embodied in the interest-parity condition. In this regard, a first thorough estimate of an interest-parity condition for the period around the mid-nineteenth century is provided. Last, but not least, the regime shift associated with the telegraph provides an excellent environment to directly test, under certain assumptions, whether or not London currency speculators held biased expectations about the current exchange rate in Paris.

The main findings of this paper are the following. First, around the mid-nineteenth century, the returns from bills of exchange in London and Paris concur relatively closely with the interest-parity condition. This result is remarkable given the large deviations from this condition that have commonly been found with modern data (see Hodrick 1987; Lewis 1995; and Engel 2014). Second, when comparing the just-mentioned returns between London and Paris around 13 November 1851, there is no evidence for a significant exchange-rate expectations bias before the telegraphic connection became available.

The paper is organized as follows. As historical background, Section 2 provides a synoptic overview of the role of bills of exchange for nineteenth-century currency speculation, the position of London and Paris as financial centers around 1850, and the emergence of electric telegraphy. Section 3 discusses the peculiarities of currency speculation and the interest-parity condition during the mid-nineteenth century. Section 4 reviews the weekly exchange and interest-rate data from London and Paris. Section 5 presents the econometric methodology and the corresponding results. Section 6 summarizes and concludes.

2 Historical background

2.1 Bills of exchange as cashless means of payment

During the nineteenth century, bills of exchange not only provided the principle cashless means of payment for domestic and international trade, but were also commonly used for purely financial purposes, such as issuing short-term credit or arranging arbitrage transactions (Denzel 2010, ch.3.3; Einzig 1962, ch.15). A bill of exchange was a written order by a person, called the drawer, requiring another person, called the drawee, to pay either on demand (sight-bill) or at a fixed or determinable future date (long-bill) a certain amount of money to a specified person, or to bearer.[1] As such, they were remarkably versatile in terms of combing elements of money and credit as well as allowing for payments in different currencies and at various terms to maturity. Furthermore, the possibility to transfer the right to receive the specified amount to the current bearer implied that bills could be sold in the open money market or to a central-note issuing bank, such as the Bank of England, before the maturity date. Owing to the importance of these kinds of transactions to raise liquidity,

[1] See British Act on Bills of Exchange of 1882. See also Herger (2018, p.3).

the corresponding charges, called "discount rates", became landmark short-term interest rates during the nineteenth century (see e.g. Clare 1902, pp.133ff.; Homer 1977, ch.13-16). However, official discounting at e.g. the Bank of England at the so-called "bank rate" was typically restricted to high-quality bills based on genuine mercantile transactions (Eichengreen 2008, pp.26-27; Herger 2019, p.21). A much wider range of bills could be traded in the open money market, which essentially comprised wholesale transactions through a network of large banks and specialized intermediaries called "discount houses" (Bagehot 1873, ch.11; Fletcher 1976). The resulting open-market discount rate was not uniform, but could vary across financial intermediaries and depended on the quality and term to maturity of the underlying bill. Typically, lower rates were charged for first class paper, e.g. bills with low default risk, and maturities at sight, where the payment became due after a couple of days rather than several months.

At the international level, bills of exchange could also be issued requiring payment in a different currency in a foreign city. Reflecting again their popularity, the standard payment of e.g. a certain amount of French francs in Paris through a bill issued in London determined the open-market exchange rate during the nineteenth century (Goschen 1861, ch.1; Denzel 2010, ch.3.3; Einzig 1962, p.174). In reaction to shifts in demand and supply, this rate could deviate to some degree from the official exchange rate as implied by the mint-pars of the involved currencies (see e.g. Goschen 1861, pp.44ff.; Clare 1902 pp.72ff.). For example, when the demand for French-franc bills was relatively high and/or their supply relatively low, the corresponding market exchange rate tended to appreciate above the official rate. Then again, foreign exchange transactions could either be arranged at sight, meaning that e.g. the payment of French francs in Paris had to be settled within a couple of days, or after a certain amount of time, typically after three months. Of note, long-bills differed from modern forward transactions in terms of not only prearranging a future exchange rate, but also involving a short-term credit during the term to maturity. Therefore, as was well understood at the time, these bills encapsulated an inconspicuous interest rate to compensate for the corresponding opportunity cost and financial risks (Goschen 1861, pp.52ff.; Clare 1902, pp.82ff.).

2.2 London and Paris as European financial hubs

By arranging payments, loans, and other financial transactions of the leading industrial and trading nation, London managed to strengthen its position as largest financial center in the world during the first part of the nineteenth century (Cassis 2010, pp.15ff., pp.41ff.). Since at least the eighteenth century, the advanced British financial system was characterized by a monometallic currency convertible—although suspended during the Napoleonic Wars—into gold, the issuing of paper money through the Bank of England as well as remarkably liquid financial markets for government debt, stocks, foreign currency, and bills of exchange. Major reforms during the decades before 1850 occurred with the resumption of banknote convertibility into gold in 1821, the removal of the interest-rate ceiling of 5 per cent with the lifting of usury laws in 1833, and the introduction of an official note-issuing monopoly for the Bank of England in 1844. These reforms had far-reaching consequences by creating a monetary architecture within which the central (note-issuing) bank controls the currency supply—at the time mainly in the form of banknotes—and manages the official currency reserves—at the time mainly in the form of gold. Meanwhile, the main tasks of commercial banks shifted to offering current accounts to the broad public and arranging the bulk of private loans and credit (Herger 2019, pp.12-17). Among other things, this two-tiered banking system began to manifest itself in the above-mentioned rates for discounting bills of exchange at the Bank of England or in the open money market. In particular, based on the interconnections between these rates, the lifting of usury laws paved the way for employing bank rate as monetary policy tool (Bagehot 1873, pp.113ff.; Clare 1902, pp.7-8; Homer 1977, pp.205-206). More specifically, until the 1830s, bank rate was typically stuck for extended periods at the 5 per cent ceiling. However, the 1840s witnessed a gradual transition towards a much more active discount policy characterized by the rules of the gold standard, which required central banks to increase their discount rate when an unsustainable capital outflow threatened to drain their official gold reserves (Eichengreen 2008, pp.26-27). Concretely, bank rate was for the first time increased beyond 5 per cent in 1839 and even reached 8 per cent when political unrest began to build up across Europe during the last quarter of 1847. The domestic level of interest rates became more and more influenced by this kind of monetary policy.

Sooner or later, countries on the European continent adopted similar reforms. In doing so, France with Paris as financial center came closest to rivaling London during the mid-nineteenth century (Cassis 2010, pp.24ff., pp.60ff.).[2] In particular, in 1800, the Banque de France was founded to remedy the monetary instability that had resulted from the political and financial turmoil after the French Revolution. However, unlike Britain, France retained a bimetallic currency system with the franc being convertible into gold and silver until the 1870s (Eichengreen 1870, pp.15ff.). By acting as financial hub for neighboring countries, such as Belgium and Switzerland, and benefitting form a relatively central location on the European continent, a highly active foreign-exchange market developed in Paris (Einzig 1962, p.177; Cassis 2010, pp.62-65). Nevertheless, mainly due to lagging behind in the level of global trade and industrial development, Paris' ambitions to challenge, and eventually surpass, London as financial center were never fulfilled (Cassis 2010, pp.60ff.). For example, because the Banque de France long held a dominant position in discounting bills of exchange, a vibrant money market with a closely watched open market discount rate did not emerge in Paris until the 1860s (Homer 1977, pp.228ff.). Hence, for a French speculator, the arbitrage opportunities between short-term investments in the domestic and foreign money market were still limited.

2.3 International telegraphy and the financial industry

Despite increasingly fast postal connections thanks to the opening of railway lines and the introduction of regular steamship services, even in 1850, the dispatch time of a letter between London and Paris was at least one day (Kaukiainen 2001, p.28; Einzig 1962, p.179). The railway line between London and Dover had been completed in 1844. On the other side of the Straight of Dover, the connection between Paris and Lille had been opened in 1846 and extended to the coast at Calais in 1848. Nevertheless, in 1853, the journey between London and Paris by rail and ship took still at least 12 hours (Coghlan 1853, p.11).

Against this background, by creating the first means of virtually instantaneous communication, the electric telegraph represented a major technological breakthrough (Wenzelhuemer 2012, pp.30ff.).[3] Although early experiments to transmit messages by means of electrical signals had already been conducted around the year 1800, practical breakthroughs were

[2] Other important financial centers in Europe included Antwerp, Amsterdam, Frankfurt, Geneva, and Hamburg (Cassis 2010, pp.31ff). Across the Atlantic, the United States began to emerge as an important trading nation and financial market. However, New York clearly lagged behind the leading European financial centers until at least the late nineteenth century (Cassis 2010, pp.114ff.).

[3] During the preindustrial age, rudimentary telegraphic systems based on optical signals had already been put in place. For example, in 1794, the so-called "Chappe telegraph" was opened to transmit military and other official messages between the cities of Paris and Lille via a chain of towers, on which optical signaling systems had been installed (Shaffner, 1867, ch.3). However, optical (or visual) telegraphy regularly broke during adverse weather conditions, such as dense fog, and suffered from relatively high operating costs.

only made by William Cooke (1806 - 1879) and Charles Weatstone (1802-1875) in Britain during the late 1830s, and more famously by Samuel Morse (1791-1872) with his dot-and-dash system in the United States during the early 1840s (Kieve 1973, ch.1; Wenzelhuemer 2012, ch.3). Thereafter, telegraphy quickly entered everyday (business) life. In particular, a relatively low capital intensity to build the necessary cable network implied that it developed much more rapidly than e.g. the railway infrastructure (see e.g. Field 1992, p.401). Actually, it were the railway companies themselves that fostered the early construction of telegraph lines, because fast communication between stations helped to manage traffic and improve safety (Kieve 1973, ch.1-2; Du Boff 1980, p.465; Field 1992, pp.406-409). This railway telegraphy emerged in Britain as early as the late 1830s and subsequently grew into a national network for the transmission of all kinds of messages during the 1840s. In a more or less similar manner, "wires" connecting the major cities soon followed in other countries. By 1852, around 37,000 kilometers of telegraph lines had been laid within the United States, more than 3,500 kilometers within Britain, and more than 1,100 kilometers within France (Rider 2007, p.440).

Owing to the island status of Britain, its network could not be linked with the European continent before the development of cables that can withstand the corrosion, pressure, and tidal currents after being submerged in the sea. Only after years of experiments, many of which failed, a rubber called "Gutta-percha" was identified as an electrical insulator that proved sufficiently robust against the penetration of saltwater (see e.g. Shaffner 1867, pp.524ff.). Nonetheless, the development of submarine telegraphy suffered from further setbacks. Above all, a first major project failed in August 1850 when a Gutta-percha cable broke and disappeared into the depth of the sea only hours after having been laid across the Strait of Dover (Shaffner 1867, pp.607-608; Smith 1891, pp.1-12; Kieve 1973, p.104). A second attempt was only undertaken more than a year later, on 25 September 1851. However, the cable laid from the coast near Calais turned out to be more than 1 kilometer short to reach the planned destination point near Dover (Smith 1891, p.17). Fortunately, an extension could be manufactured within a couple of weeks. The direct telegraphic line between England and France finally opened for commercial use on 13 November 1851 (Smith 1891, p.41; Kieve 1973, p.104). This connection represented a landmark for international telegraphy by providing the blueprint for other lines linking England with Belgium and Ireland in 1853, and with the Netherlands and Germany in 1857 (see e.g. Shaffner 1867, pp.607ff.). However, when empirically analyzing the regime shift in information exchange that followed, it will be important to remember that the success of the pioneering submarine cable had been anything but certain. In particular, due to the novel technology involved as well as the early setbacks, the uncertainty about when and whether this project will be completed must have been pervasive. Against this background, the opening of the first major submarine cable can, arguably, be interpreted as a relatively clean historical experiment that abruptly changed the information environment in international finance between England and France.[4]

As early as the 1850s, international telegraphy turned into an indispensable tool for the mass media, led to a reorganization of the shipping industry, and offered new possibilities for diplomacy and colonial government (Wenzelhuemer 2012, pp.77ff.). Yet, perhaps more than any other industry, international finance quickly seized on the new opportunities. This is perhaps not surprising as speculative profits loomed large from receiving up-to-date information about financial prices in foreign markets. The following quote taken from the newspaper "The Economist" two days after the opening of the submarine cable across the Straight of Dover indicates how international financiers reacted:

> "The communication by electricity between Paris and England is now open to the public. [...] The announcement had hardly been made [...] when [...] up came a mounted express with the first message to be transmitted from London. It was the prices of the funds at the Stock Exchange up to noon. A jerk to the telegraph handle [...] and the Bourse [in Paris] knew as much about the English funds as we knew in England, and, no doubt in less than five minutes the *agioteurs* and *agents de change* were rushing to read the announcement [...]."

The emergence of modern news agencies illustrates much more broadly how international telegraphy transformed financial information into big business. In particular, after having some limited success by transmitting messages across a gap between the telegraphic networks of France and Germany with the help of carrier pigeons, Paul Julius Reuter (1816-1899) embarked on a new business project in London in 1851 (Read 1992, Ch.1). Thanks to the newly established telegraph between England and France, he was able to offer brokers

[4]A similar argument has been made by Steinwender (2018, p.685) as regards the telegraphic link between Europe and North America. After the completion of submarine cables through coastal waters, laying the first transcontinental cable represented a new challenge. A first attempt to do so failed in 1858. It was only in 1866, when a fully functional cable across the Atlantic opened to the public (see e.g. Hoag 2006).

and bankers, against the payment of a fee, two work-daily bulletins containing the current opening and closing prices of the London Royal Exchange and the Paris Bourse (Read 1992, p.16; Nalbach 2003, p.582). In essence, his business model rested on distributing the fixed cost of using the international telegraph across a large number of subscribers. Of note, in 1851, these cost amounted to a non-negligible 19 shillings—equivalent to around 80 pounds in current purchasing power—for sending a telegram from Paris to London (Kieve 1973, p.105). Obviously, that the original London telegraph office formed the nucleus of the "Reuters" news agency bears testimony to the commercial success that followed (Read 1992).

Taken together, international telegraphy represented a path-breaking technology for modern finance, where speculators almost immediately receive quotations from all relevant financial centers around the world. In particular, the cable across the Strait of Dover allowed for the first time to reliably exchange information about interest and exchange rates between London and Paris within business hours (Kieve 1973, p.51). Up-to-date financial information became widely available.

3 Currency speculation with bills of exchange

During the nineteenth century, bankers and other financial practitioners were already aware that excess returns between domestic and foreign money markets provide incentives for arbitrage transactions that, in turn, interconnect interest and exchange rates as described by the interest-parity condition (Einzig 1962, pp.171ff.).[5] For the era of the classical gold standard, Goodhart (1961), Coleman (2012), and Herger (2018) have indeed documented that the interest-parity condition held relatively well. Conversely, large deviations from this condition typically arise with modern data (see Hodrick 1987; Lewis 1995; Engel 2014).[6]

Around the mid-nineteenth century, the financial environment was already ripe for transactions exploiting return differences between similar assets denominated in different currencies. In particular, the Congress of Vienna had helped to restore political stability across Europe and, hence, had put an end to the economic and political chaos during the decades after the

[5] However, the seminal academic contributions on the interest-parity condition were only published by Fisher (1896, ch.9) and Keynes (1923, ch.2.4). For a textbook discussion of this condition see e.g. Sarno and Taylor (2002, ch.2).

[6] When estimating the interest-parity condition over the past two centuries, Lothian and Wu (2011) have indeed found that large deviations only arise when the sample is dominated by the period after the 1980s.

French Revolution. Furthermore, the first part of the nineteenth century was characterized by economic progress and a movement towards increasingly free trade and capital flows, including burgeoning investments in the booming railway industry (Einzig 1962, pp.183-184). Within this economic environment, especially the leading private banks, which were still the largest international financial players, regularly engaged in speculative transactions across financial centers (Cassis 2010, ch.2). Hints at this type of financial activity can be found in letters between the family offices of the leading private bank at the time, i.e. the House of Rothschild (Ferguson 1998, pp.272ff.). For example, the following letter written in 1832 by James Rothshild in Paris to his brother Nathan in London clearly refers to issues with interest-rate arbitrage and the sterling-to-franc exchange rate of bills of exchange:

> "I am starting once again to busy myself with the bills of exchange business, and beg you to evaluate [...] what you are sending us. We are buying London here at 25.65 francs and 3 per cent [which] is equal to 24.84½ and you send us £21,000 Parisian at 26.07½ [and] 4 per cent, which is equal to 25.89, that is a loss of a fifth [...]. Well, [...] we don't want to operate at a loss when dealing with the bills of exchange" (Quoted in Ferguson 1998, p.275).

Although the House of Rothschild is probably more famous for dealing in government bonds, transactions with bills of exchange were apparently also regularly undertaken.[7] Thanks to their short maturity—as compared with government bonds—and relatively low transaction cost—as compared with physical movements of monetary metals—these bills provided excellent vehicles for international speculation during the nineteenth century (Clare 1895, ch.8). Typically, this kind of speculation involved certain combinations between the above-mentioned sight and long rates (see also Clare 1895, ch.14-16; Herger 2018). Thereby, long-bills offered the preferred financial instrument to cover exchange-rate risk, because for most currencies, including sterling and franc, regular forward-exchange markets did not exist before World War I (see e.g. Einzig 1962, pp.180-181; Clare 1895, ch.14-16).

To see how these currency transactions worked, consider an example where at a given time period, denoted by subscript t, a London-based speculator has the choice between earning a short-term return in the local money market or in French francs over the next three months.[8] The short-term return in London coincided with the discount rate, denoted here

[7]Other private banks involved in large-scale bills-of-exchange speculation included Baring Brothers and Schröders (Ferguson, 1998, pp.275-285).

[8]For the era of the classical gold standard, Juhl *et al.* (2006) and Herger (2018) provide similar discussions.

by $1 + i_t$. Earning a comparable return via the Paris financial market typically involved the simultaneous buying of a sight bill in London on Paris, and a long-bill in Paris on London. The corresponding sight-rate is denoted by S_t, and the long-rate by L_t^*, where the superscript indicates that this rate pertains to a foreign financial market (e.g. Paris). Of note, before the introduction of the telegraph, the current long-rate in Paris was unknown to the London speculator and, therefore, could only be thought of in terms of an expectation, denoted by $E[L_t^*]$. All exchange-rates are defined as the price of French francs per British pound. Hence, for the London speculator, the expected gross return of $S_t/E[L_t^*]$ was positive—or larger than one—when the long-rate in Paris stood below the short rate in London, which was actually the case (see Sec. 4). Of course, the fact that L_t^* offered a better price for French currency than S_t encapsulated an inconspicuous interest rate from awaiting the promised payment in three months. Taken together, the expected excess return from investing in French francs was given by $S_t/E[L_t^*] - (1 + i_t)$. Applying the usual logarithmic approximation, whose variables are denoted by lowercase letters, and attributing the excess return to an average component $\bar{\rho}$ and a time-varying component ρ_t yields

$$s_t - E[l_t^*] - i_t = \bar{\rho} + \rho_t. \tag{1}$$

Excess returns reflected in $\bar{\rho} \neq 0$ and/or $\rho_t \neq 0$ are commonly attributed to, respectively, currency-specific and time-specific risk premia (see e.g. Sarno and Taylor 2002, pp.17ff.; Herger 2016, p.296). Alternative, and not necessarily mutually exclusive, explanations refer to non-negligible transaction costs (see e.g. Chinn and Meredith 2004, p.411).

4 Interest and exchange rates in London and Paris

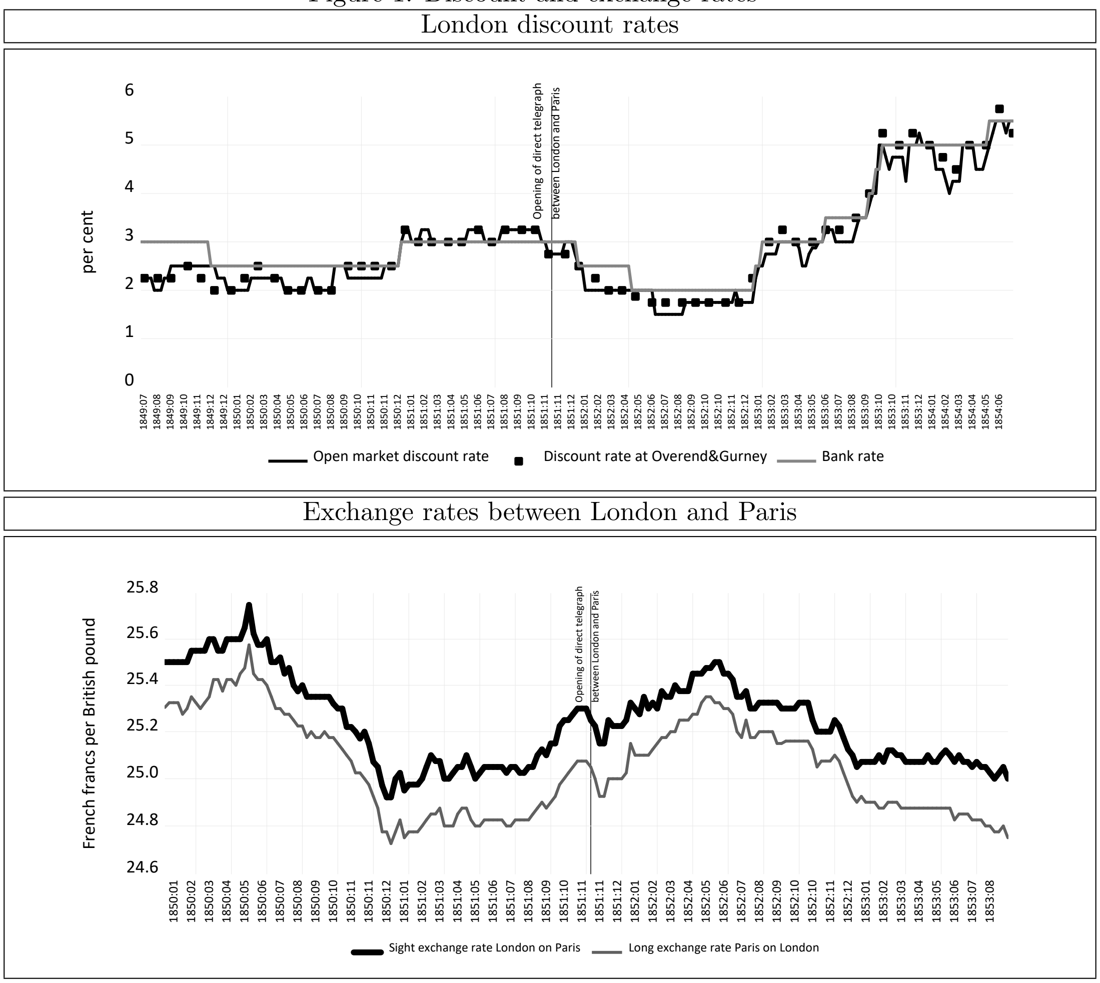
This section provides an overview of the exchange and interest rates that underpin (1) with data. Their exact definitions and sources can be found in Table 3 of the appendix. Observation occurs at the weekly frequency and refers to end-of-the-week quotations, e.g. on Friday, as originally reported in the Saturday edition of commercial newspapers, such as "The Economist" in London and the "Cours de la Banque et de la Bourse" in Paris.

For the years around the opening of the London-to-Paris telegraph, the solid black line of the top panel of Figure 1 depicts the interest rate for discounting bills of exchange in London's open money market. This discount rate stood at around 2 per cent at the beginning of

1850, increased with some fluctuations to 3.25 per cent during the next year, subsequently fell to as low as 1.5 per cent during the middle of 1852 before climbing to more than 5 cent towards the end of 1853. As an alternative measure, which is only available at the monthly frequency, the dots refer to the rate charged for discounting first-class bills of exchange by Overend Gurney, which was a leading London discount house until its notorious failure in 1866. Obviously, the Overend Gurney discount rate follows the market rate quite closely. The official discount rate of the Bank of England is depicted by the solid grey line. In conformity with the normal discount policy at the time, "bank rate" was increased when gold outflows put the Bank of England's bullion reserves, and hence the promise to maintain the convertibility of sterling, at risk (Eichengreen 2008, pp.24-29). Around the year 1851, this risk, and hence the fluctuations of the official discount rate, was relatively low and stable. Typically, a monetary tightening occurred in periods of aggravated political and economic uncertainty. For example, reflecting the outbreak of the Crimean War, bank rate was rapidly raised from 3.5 to more 5 per cent around September 1953. In a similar vein, the official discount rate had been raised substantially during the Revolutions of 1848.

The bottom panel of Figure 1 depicts the exchange rates from bills of exchange between French francs and British pounds. Further to the discussion above, different time series refer to the sight-rate in London on Paris, i.e. S_t, and the long-rate—with a three months term to maturity—in Paris on London, i.e. L_t^*. Recall also from the discussion above that the long-rate in Paris, as depicted by the grey line, stood typically below the short-rate in London, as depicted by the black line. Moreover, the French franc was at the time convertible according to a bimetallic standard into gold and silver, while sterling was on a monometallic gold standard. Hence, the corresponding exchange rates were far from being fixed, but mainly depended on the market prices of the underlying monetary metals. During the period under consideration, it was especially the discovery of rich gold deposits in Australia in 1851 that reduced the relative price between gold and silver (Eichengreen 2008, pp.9-12). In the foreign exchange market, this reduction manifested itself in a depreciation of currencies entirely based on gold, such as sterling, around the year 1851.

Figure 1: Discount and exchange rates



5 Empirical methodology and results

5.1 Interest-parity regressions

This section transforms (1) into an econometric equation that can be estimated with the data of Section 4. As regards notation, the corresponding time series will be indexed with subscript $t = 1, 2, \ldots, u-1, u, u+1, \ldots, T$. Thereby, the intermediate date $t = u$ indicates the third week of 1851 when the direct telegraphic connection between London and Paris had opened to the public. Coefficients pertaining to the period before this opening, i.e. $t = 1, 2, \ldots, u-1$, are indicated by superscript 0, and coefficients pertaining to the period thereafter, i.e. $t = u, u+1, \ldots, T$, with superscript 1.

Equations, such as (1), do not lend themselves for estimation without additional assumptions about market expectations. To illustrate these assumptions within the current context, contemplate transactions before London and Paris were connected via the telegraph. During this period, London currency speculators could not know the current long-rate of exchange in Paris l_t^* and, hence, had to form a corresponding expectation $E[l_t^*]$. In this regard, an important benchmark are rational expectations, where the realized value l_t^* is only supposed to deviate from $E[l_t^*]$ by a stochastic error η_t with expected value zero, i.e. $E[\eta_t] = 0$, and no correlation with interest rates as explanatory variable (Chinn and Meredith 2004, p.412; Chinn 2006, p.9). However, especially the recent exchange-rate theory has considered systematic deviations between market and rational expectations (see Sarno and Taylor 2002, pp.24.ff; Engel 2014, pp.510-513). Accounting for this possibility by introducing an expectations bias $\bar{\eta}^0$ implies that $E[l_t^*] = l_t^* + \bar{\eta}^0 + \eta_t$. Inserting this expression into (1) and rearranging yields $s_t - l_t^* = \bar{\rho}^0 + \bar{\eta}^0 + i_t + \rho_t + \eta_t$. Transforming this theoretical into an empirical equation yields an interest-parity regression with respect to bills of exchange given by

$$s_t - l_t^* = \alpha^0 + \beta^0 i_t + \epsilon_t \qquad t = 1, 2, \ldots, u-1. \tag{2}$$

In (2), $\alpha^0 = \bar{\rho}^0 + \bar{\eta}^0$ is an intercept collecting currency-specific factors—especially a risk premium—and a potential expectation bias. Furthermore, β^0 is a slope-coefficient indicating in how far returns from discounting bills in the London money market are correlated with returns from bills-of-exchange transactions via Paris. In particular, $\beta^0 = 1$ means a perfect correlation implying a one-to-one movement between the just-mentioned returns. Broadly speaking, $\beta^0 = 1$ reflects that the interest-parity condition holds.[9] Finally, $\epsilon_t = \rho_t + \eta_t$ is a statistical error term including time-varying risk premia and random expectation errors.

Although estimation of (2) by least-squares is straightforward, the statistical properties and economic interpretation of the resulting coefficients are susceptible to econometric pitfalls associated with unobserved risk and expectation formation.[10] In particular, from statistical theory, it is well known that the slope-coefficient estimate $\hat{\beta}^0$ is biased when the stochastic error term ϵ_t is correlated with i_t. Equation (2) might suffer from this econometric problem, because the error term includes time-varying risk ρ_t for which a correlation with the open-market discount rate is plausible. In that case, ignoring ρ_t would give rise to an omitted variables bias in the least-squares estimation of (2). Because ρ_t is not directly observable, this econometric problem cannot be addressed without entering the controversy from imposing assumptions about the behavior of time-varying risk.[11] In a similar vein, it is difficult to disentangle the components summarized in the constant α^0. With particular regard to the current context, this constant includes an expectations bias $\bar{\eta}^0$ as well as a currency-specific risk premium $\bar{\rho}^0$ that are both not directly observable.

To shed more light on the role of exchange-rate expectations, consider the period after the opening of the telegraph between London and Paris. During this period, information about the current exchange rate in Paris reached London almost immediately. Hence, there is no reason why substantial errors or biases in forming market expectations should remain. Formally, the immediate exchange of financial information implied that $E[l_t^*] = l_t^*$. Hence, the interest-parity regression equation approximating (1) simplifies to

$$s_t - l_t^* = \alpha^1 + \beta^1 i_t + \epsilon_t \qquad t = u, u+1, \ldots, T, \tag{3}$$

with $\alpha^1 = \bar{\rho}^1$ and $\epsilon_t = \rho_t$.

As regards the sample, the baseline estimation of (2) and (3) focuses on the weeks between the beginning of January 1850 and the beginning of July 1853. This period not only covers

[9] Broadly speaking, because it is assumed that (2) correctly captures risk premia and expectation formation. For similar derivations of interest-parity regressions in a modern context, see e.g. Isard (1995, pp.83f.), Chinn and Meredith (2004), Chinn (2006), or Lothian and Wu (2011).

[10] A more manageable econometric issues arises as regards the estimation of the coefficient standard deviations. In particular, a dataset combining long-bills with observations at the weekly frequency gives inevitably rise to overlaps within the sample that introduce moving-average terms to the residuals. Chinn (2006, pp.9f.) suggests to control for this kind of serial correlation by means of heteroscedasticity and autocorrelation (HAC) robust variance-covariance matrix towards a fixed length reflecting the overlap.

[11] In modern versions of the interest-parity regression, the same issue arises (see e.g. Chinn and Meredith 2004, p.412; Chinn 2006, p.9).

roughly one and a half years before and after the opening of the telegraph between London and Paris, but also avoids some events with extraordinary levels of political instability in Northwestern Europe. In particular, the sample starts around two years after the outbreak of the Revolutions of 1848.[12] While Britain did not suffer from widespread civil unrest, in France barricade fights erupted in the streets of Paris in February 1848 triggering the collapse of the Bourbon monarchy under Louis Philippe I. Until autumn 1849, similar uprisings had swept across other European countries; especially Austria-Hungary, Italy, and the German Confederation. Meanwhile, in France, political stability had, by and large, been restored under the new reign of Louis Napoleon Bonaparte, who was elected President in December 1848 and crowned, as Napoleon III, Emperor of the French in December 1852. The sample ends in July 1853 when Russia invaded the Ottoman Empire and, hence, started the Crimean War, which was officially declared on 16 October 1853. Although Britain and France did not formally enter this conflict before declaring war on Russia in March 1854, they had already pledged support to the Ottoman Empire around the outbreak of the conflict.[13] Hence, anticipating the financial burden associated with this major war, British and French interest-rate levels increased substantially as soon as the second half of the year 1853 (see Figure 1).

Column 1 of Table 1 reports the least-squares estimates of (2) for the 98 weeks between the beginning of January 1850 and the second week of November 1851. Of note, the resulting slope coefficient of 0.69 is positive, but differs significantly from a value of 1. However, further to the discussion above, it remains unclear whether this deviation provides genuine evidence for different returns from discounting in the London money market and bills-of-exchange transactions via Paris, or reflects an estimation bias from ignoring time-varying risk. Furthermore, the intercept suggests that currency-specific risk premia, transaction cost, and expectation biases added up to more than 1 per cent. Column 2 of Table 1 reports the estimates of the intercept and slope coefficient of (3) for a sample covering 84 weeks after the opening of the London-to-Paris telegraph. Insofar as this new means of electric communication led to a close alignment of information on transacting bills-of-exchange via Paris or discounting in London's open money market, it is perhaps not surprising that the estimated slope coefficient of 0.93 concurs almost perfectly with interest-parity benchmark. Indeed, even at generous levels of rejection, this value does not differ statistically from a

[12]For a historical overview of the Revolutions of 1848, see e.g. Langer (1971).
[13]For a historical overview of the Crimean War, see e.g. Figes (2010).

value of 1.

Table 1: Interest parity regressions with bills of exchange

Specification:	Baseline		2SLS		Overend Gurney	
Sample:	Before 13.11.1851	After 13.11.1851	Before 13.11.1851	After 13.11.1851	Before 13.11.1851	After 13.11.1851
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept ($\widehat{\alpha}$)	1.32***	0.74***	1.07**	0.58***	1.05**	0.70**
	(0.38)	(0.15)	(0.45)	(0.14)	(0.48)	(0.31)
i_t ($\widehat{\beta}$)	0.69***	0.93***	0.78***	1.00***	0.83***	0.92***
	(0.12)	(0.07)	(0.15)	(0.07)	(0.15)	(0.15)
Reject $\beta = 1$	***					
Chow-test(α^0=α^1 β^0=β^1)	2.35		2.91*		0.48	
R^2	0.42	0.65	0.41	0.64	0.47	0.64
Obs.	98	84	98	84	23	19

Notes: This table reports estimates of equations (2) and (3) with dependent variable $s_t - l_t^*$ (expressed as annualized per cent). Coefficient estimation is by OLS in columns 1, 2, 5 and 6 and by two-stage least squares (2SLS) in columns 3 and 4. Coefficient standard errors reported in parentheses are robust to heteroscedasticity and autocorrelation (Newey-West with a fixed bandwidth of leads and lags covering three months). Significant coefficients are indicated by * at the 10% level; ** at the 5% level, and *** at the 1% level. The null hypothesis that the returns from discounting bills in the London money market or via Paris are perfectly correlated implies that $\beta = 1$. Significant deviations from this are indicated by * at the 10% level; ** at the 5% level, and *** at the 1% level. The Chow-test on the equivalence of the coefficients is F-distributed with degrees of freedom according to the number of restrictions (i.e. 2) and the number of observations minus twice the number of restrictions. Obs. denotes the number of observations (weeks or months).

A comparison between the results of columns 1 and 2 of Table 1 provides the basis for a Chow breakpoint tests on the hypothesis of identical coefficients before and after the telegraph between London and Paris became available. In this regard, the Chow-test statistic of 2.35, which is F-distributed with 2 and 178 degrees of freedom, does not allow to reject the hypothesis that $\alpha^0 = \alpha^1$ and $\beta^0 = \beta^1$ at any conventionally used level. Taken together, the financial information transmitted via the telegraph has apparently not given rise to a profound structural change as regards the interest-parity regression with bills of exchange.

Columns 3 and 4 of Table 1 check the previous results for robustness by employing bank rate as instrumental variable for the open market discount rate. With two-stage least squares (2SLS) estimation, this approach could mitigate against reverse causality from time-varying currency risk premia when they are not correlated with bank rate. This is plausible because, as discussed above, bank rate mainly reacted to protect the gold reserves of the Bank of England rather than to the currency risks within the bills-of-exchange market. Furthermore, columns 5 and 6 employ the discount rate charged by Overend Gurney as explanatory variable. Although this rate has only been published monthly, it has the advantage of reflecting the actual money-market return of a major discount house rather than average market conditions. Taken together, the main results are robust to these changes. Before, and especially after, the introduction of the direct telegraph between London and Paris, the interest-parity condition held quite well. Furthermore, the corresponding transition was not associated with massive structural change.

5.2 Exchange-rate expectations bias before November 1851

This section exploits the information regime shift associated with the telegraph to uncover the bias between rational and market expectations about the long-bills exchange rate. This kind of analysis is much harder with modern data, where unobserved risk components and the expectations bias typically appear jointly and, therefore, cannot be disentangled without resorting to theoretical assumptions. In contrast, the opening of the London-to-Paris telegraph in November 1851 resembles a natural experiment, where biases and errors as regards exchange-rate expectations unexpectedly disappear more or less overnight. Meanwhile, there is no reason why e.g. the financial risk environment would have suddenly changed during the weeks and months around this event.

In particular, the expectations bias $\overline{\eta}^0$ will be estimated via the shift between the intercept $\alpha^0 = \overline{\rho}^0 + \overline{\eta}^0$ of (2), and $\alpha^1 = \overline{\rho}^1$ of (3). To capture this shift, define an expectation dummy variable e_t indicating the weeks when London currency speculators had no up-to-date information about the current exchange rate in Paris, i.e. before a direct telegraphic connection became available, that is

$$e_t = \begin{cases} 1 & \text{if} \quad t = 1, 2, \dots u - 1 \\ 0 & \text{else.} \end{cases} \tag{4}$$

Adding (4) as regressor to an econometric equation across the entire sample, that is

$$s_t - l_t^* = \alpha + \beta i_t + \delta e_t + \epsilon_t \quad t = 1, 2, \dots, T, \tag{5}$$

yields a coefficient, labelled with δ, reporting the just-mentioned intercept shift, that is $\hat{\delta} = \hat{\alpha}^0 - \hat{\alpha}^1 = \overline{\rho}^0 + \overline{\eta}^0 - \overline{\rho}^1$. Hence, under the assumption of equal currency-specific risk, i.e. $\overline{\rho}^0 = \overline{\rho}^1$, the coefficient pertaining to (4) reflects the expectations bias before the introduction of the telegraphic link, i.e. $\hat{\delta} = \overline{\eta}^0$.

Column 1 of Table 2 reports the results of regressing the London open-market discount rate i_t on the return from a bills-of-exchange transaction via Paris for the weeks between the beginning of January 1850 and the beginning of July 1853. The estimated slope coefficient $\hat{\beta}$ concurs, more or less, with the previous results that did not contemplate the full sample. Column 2 adds e_t of (4) as additional explanatory variable to reflect the regime shift due to the introduction of the telegraph. With a value indicating an average reduction in the

Table 2: Estimating the expectations bias

Robustness check:			2SLS	Overend Gurney	Jul.1849-Jul.1854	Jul.1851-Jul.1852
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept ($\widehat{\alpha}$)	1.00***	0.99***	0.75***	0.80***	0.86***	0.86***
	(0.17)	(0.18)	(0.16)	(0.22)	(0.17)	(0.33)
i_t ($\widehat{\beta}$)	0.81***	0.82***	0.92***	0.88***	0.91***	0.93***
	(0.06)	(0.08)	(0.07)	(0.10)	(0.06)	(0.12)
e_t ($\widehat{\delta}$)		-0.02	-0.06	0.13	0.07	-0.18
(No telegraph)		(0.12)	(0.12)	(0.17)	(0.15)	(0.13)
Reject ($\beta = 1$)	***	**				
R^2	0.57	0.57	0.56	0.61	0.73	0.59
N	182	182	182	42	261	53

Notes: This table reports estimates of equations (2) or (5) with dependent variable $s_t - l_t^*$ (expressed as annualized per cent). Coefficient estimation is by least-squares with heteroscedasticity and autocorrelation robust standard errors (Newey-West with a fixed bandwidth of leads and lags covering three months). In column 3, estimation is with 2SLS. Significant coefficients are indicated by * at the 10% level, ** at the 5% level, and *** at the 1% level. The null hypothesis that the returns from discounting bills in the London money market or via a foreign financial center (e.g. Paris or London) are perfectly correlated implies that $\beta = 1$. Significant deviations from this are indicated by * at the 10% level, ** at the 5% level, and *** at the 1% level. Obs. denotes the number of observations (weeks or months).

return on bills-of-exchange via Paris by 0.02 percentage points, the corresponding coefficient estimate is both economically small and far from being statistically different from a value of 0. Hence, under the above-mentioned assumption $\bar{\rho}^0 = \bar{\rho}^1$, this result suggests that the bias in forming exchange rate expectations before the direct telegraphic connection between London and Paris became available was negligible.

To check the robustness of this result, column 3 and 4 reemploy, respectively, the 2SLS estimation with bank rate as instrument and the monthly Overend Gurney rate to measure i_t. Furthermore, the time window might be crucial to uncover a potential expectations bias. Therefore, column 5 considers a much shorter sample covering the weeks between the beginning July 1851 and the beginning of July 1852. Column 3 moves in the opposite direction by considering a larger sample between the beginning of July 1849 and the beginning of July 1854. Across all these permutations, the main result that the coefficient estimate pertaining to the expectations bias is small and insignificant remains intact.

6 Summary and conclusions

This paper has analyzed changes in currency speculation around the opening of the electric telegraph between London and Paris in November 1851, which allowed for a virtually instantaneous exchange of information on current interest and exchange rates between the leading financial centers of the mid-nineteenth century. A remarkable consequence for international finance was that from one day to the other, currency speculators in London no longer had to form expectations about exchange rates in Paris. Therefore, the regime shift associated with this novel information technology offers an environment for directly estimating whether an exchange-rate expectations bias existed before the telegraphic age.

There are two main findings. First, the interest parity from bills-of-exchange transactions between London and Paris held remarkably well during the mid-nineteenth century. Although returns between discounting bills in London or via Paris were not perfectly aligned, the corresponding correlation is quite close to being perfectly positive. This result contrasts the clear rejection of the interest-parity condition often found with modern data, but coincides with similar findings during the classical gold standard period. Second, the sudden availability of up-to-date financial information after the opening of the direct telegraph between London and Paris did not give rise to a significant structural break in the interest-parity condition. In particular, there is no evidence for an expectations bias before the introduction of the telegraph. Apparently, the expectation of London currency speculators, on average, reflected the actual exchange rate quoted in Paris quite closely.

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A Data appendix

Table 3: Description of the data set

Variables refer to transactions between London and Paris between July 1849 and July 1854. Unless stated otherwise, the data have a weekly frequency (end-of-the week observation on Friday).

Variable	Unit	Description	Source
S_t	French francs per £ (in logarithms).	Exchange rate inherent in a sight-bill of exchange issued in London on Paris.	Bankers Gazette taken from The Economist Historical Archive.
L_t^*	French francs per £ (in logarithms).	Exchange rate inherent in a long-bill of exchange issued in Paris on London. The term to maturity is three months.	Banque de France/Maison Historique/Base de donnés historiques/Le systeme bimetallique European 1800-1873. Also available from Bankers Gazette taken from The Economist Historical Archive.
i_t	Per cent (annualized).	Interest on a short-term investment in London. The interest arises from discounting a bill of exchange in the open money market. If an interval is given, the lowest rate is taken, which refers to first-class bills.	Bankers Gazette taken from The Economist Historical Archive.
i_t (bank rate)	Per cent (annualized).	Interest on a short-term investment in London. The interest arises from discounting a bill of exchange at the official rate of the Bank of England.	Hawtrey (1938, pp.287ff.).
i_t (Overend Gurney)	Per cent (annualized).	Interest on a short-term investment in the London money market. The interest arises from discounting a first-class bill of exchange at the discount house Overend Gurney. The corresponding data are available at the monthly frequency.	British Parliament: Appendix to 1857 Report from the Select Committee on the Bank Acts (1857, pp.4881-4882).