

EXCHANGE RATE BEHAVIOR AND EXCHANGE RATE PUZZLES: WHY THE 18th CENTURY MIGHT HELP*

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RESUMEN

Este artículo analiza el comportamiento de los tipos de cambio entre España y Gran Bretaña durante el siglo XVIII; en concreto, de los tipos de cambio en el mercado de Londres sobre tres ciudades españolas, entre los años 1699 y 1826. Tras una breve exposición del funcionamiento del sistema monetario español y de la determinación de los tipos de cambio, estudiamos hasta qué punto el tipo de cambio respondía a variables fundamentales, utilizando dos modelos teóricos generalmente aceptados. Los resultados sugieren que la paridad de poder adquisitivo se cumplió durante el siglo XVIII, y que el tipo de cambio se movía de forma paralela a los diferenciales de inflación. Al final del siglo aparecen desviacio-

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nes de la paridad de poder adquisitivo, que atribuimos a alteraciones en el tipo de cambio real causadas por fluctuaciones en el comercio bilateral entre España y Gran Bretaña y, quizá, a diferenciales de productividad.

Palabras clave: tipos de cambio, siglo XVIII, historia financiera, España, Gran Bretaña, Paridades de Poder Adquisitivo

ABSTRACT

This article explores the behavior of exchange rates in Spain during the 18th century. We analyze the exchange rates quoted in London on three Spanish cities between 1699 and 1826. After a brief review of how the Spanish monetary system worked and how exchange rates were determined, we assess to which extent the exchange rate responded to market fundamentals by testing two theoretical models of exchange rate determination. The results suggest that purchasing power parity held during the 18th century, with the exchange rate tracking quite closely the behavior of inflation differentials. Deviations from PPP appeared at the end of the century, due mostly to changes in the real exchange rate caused by the bilateral trade between Spain and Great Britain and, maybe, due to productivity differentials.

Keywords: exchange rates, 18th century, financial history, Spain, Great Britain, Purchasing Power Parity

JEL classification: F31, N13, N23

1. INTRODUCTION

Mercantilist states in the 16th, 17th and 18th centuries could affect the market exchange rate of a currency in an effort to attract inflows or to avoid outflows of specific currencies or simply to obtain fiscal revenues. This could be achieved by altering the «official» value of the currency and the relative prices of gold and silver or of silver and copper. However, experience had shown that the multiple forces at play on the foreign exchange market ended up leading to significantly different exchange rates¹. One of the best descriptions of the working of this international market was offered by Antonio Bordázar de Artazu in 1736. According to Bordázar, international monetary relationships could be compared to a music recital, where each nation was obliged to follow others without losing the rhythm:

¹ See Van der Wee (1981, p. 375).

«[...] or let's say that the value of a currency is comparable to a melody, where the synchronicity of most players makes the rest know when they are out of tune and leads to movements up or down of the exchange»².

Following the metaphor, the role of the conductor could not be played by one single nation, but corresponded to the market forces or agents, namely the commercial traders, foreign exchange traders and bankers. Montesquieu commented that in this hypothetical battle:

«such violent operations [attempts on the part of national governments to influence the value of precious metals or currencies] could not occur nowadays, since the Prince who carried them out would be deceiving himself but would deceive nobody else. Currency exchange [*le change*] has taught the banker to compare all World currencies and to assign to them their fair value [...] currency exchange has done away with outrageous abuses of authority [*les grands coups d'autorité*] or, at least, with their possibilities of success»³.

Exchange rates in those early centuries seemed to be, therefore, the result of confronting the uncontrollable desires of governments to manipulate the relative prices of currencies or precious metals with the estimate of the «correct» relative prices made by the foreign exchange market.

Since purchasing power parity (PPP) was initially formulated in the 16th century, it has been consistently used as a baseline assumption in both theoretical and empirical research on exchange rates. The hypothesis that the exchange rate between two currencies should adjust to keep the prices in the two countries equal seems to be both intuitive and hard to refute. The empirical evidence in favor of PPP, however, is weak, and research reporting that PPP fails to hold is by now abundant⁴. Explanations for this apparent failure have been offered, some of which stem from economic considerations –the existence of transportation costs or barriers to trade, the use of non tradables in the construction of price indices, government intervention and speculation in the foreign exchange market– and some from difficulties in the empirical analysis –the use of short data series that cannot capture the statistical properties of deviations from PPP. Policy variables, such as the different exchange regimes available and the varying degree of

² «No hay funámbulos que así procuren sostenerse por medio del equilibrio sobre la cuerda como las naciones por la igualación de las monedas en el comercio, subiéndolas y bajando a la igualdad recíproca y conveniente; o digamos que el valor de la moneda es una música, en que el concierto de los más hace conocer a cualquiera su desentono y para hacer coro, sube y baja de punto.» Bordázar (1736, p. 104).

³ Cfr. Hirschman (1999, p. 98).

⁴ See Rogoff (1996) and Froot and Rogoff (1995).

exchange rate management implied by the regimes, have also been suggested as possible causes for PPP failure.

Furthermore, the dynamic determination of exchange rates is still an open question. Models that specify a set of fundamental economic variables that determine exchange rate behavior have been available for decades but when these models are fit to the data, the results are far from encouraging⁵. Ever since the demolishing analysis in Meese and Rogoff (1983), the apparent inability of fundamental variables to account for exchange rate movements has been puzzling international economists. Indeed, Obstfeldt and Rogoff (2000) comment how this apparent lack of «connection» between exchange rates and their fundamental variables –the *exchange rate disconnect puzzle*– is one of the main open questions in international macroeconomics.

This paper tries to contribute to the debate of exchange rate determinants by looking at the behavior of exchange rates in Spain during the 18th century. Two major factors make this period of time especially relevant. First, an extraordinary development of the international capital markets –what Neal (2000, p. 117) has called the new «financial architecture»– took place during that century. Simultaneously, governments in European countries made a significant effort to bring stability to their monetary systems. Starting in the late 17th century, and most notably from 1720 to 1790, European governments restricted their intervention in monetary affairs, partly to avoid the inflationary episodes that previous interventions had inevitably led to and partly because they found safer and more stable sources of financing⁶. Pierre Vilar (1972, p. 378) aptly described the European monetary system of the 18th century: «there were no mutations, people were not betting on sudden movements of the exchange rate and the outflows and inflows of currency were clearly explained by the balances of payments».

Our choice of Spain proves especially relevant given the central role played by this country in the international monetary and financial system during the century. This privileged position came from its dominion over the main sources of silver and quicksilver, and from a persistent trade deficit –a result of the enormous volume of imports– that could be financed by a large increase of silver production in Mexico⁷. Consequently, availability of accurate and up to date information on the exchange rate of the Spanish currency became absolutely key for European traders and merchants. It is not surprising, therefore, that the publications that provided financial information devoted substantial attention to the exchange rates of the Spanish currency. These services quoted *market* exchange rates –the rates were calculated from the supply and demand of bills of exchange in the local

⁵ See Isard (1995), Obstfeld and Rogoff (2000) or Sarno and Taylor (2002).

⁶ See Bonney (ed.) (1995).

⁷ See Espina (2001).

market– which can therefore be used as the building blocks of subsequent analyses of exchange rate behavior.

The rest of the article proceeds as follows. In Section 2 we describe the characteristics of the monetary system extant in Spain during the 18th century. This description is necessary to understand the context in which the exchange rates were determined. In Section 3 we review the sources used to construct our exchange rate database. In Section 4 we carry out an empirical analysis of the exchange rate data that attempts to explain their evolution throughout the century, both in the historical context and in the context of formal models of exchange rate determination. In Section 5 we offer some concluding comments.

2. THE SPANISH MONETARY SYSTEM, SILVER AND EXCHANGE RATES

The monetary reforms undertaken all over Europe during the late 17th and early 18th centuries had a more intense stabilizing effect on domestic monetary conditions in Spain than in the rest of Europe. According to Hamilton (1988, p. 37) they also contributed greatly to the smooth functioning of the international system. By 1680 those that postulated the necessity of radical reforms that would solve the rampant inflation which resulted from the chaotic state of the monetary system seemed to be winning the battle⁸. The pressing financial needs of the Spanish Hapsburgs had forced them to continuously issue new *vellón* currency –an alloy of silver and copper. This monetary expansion led to an unstoppable inflationary process, to the disappearance of silver coins in circulation and to a significant premium on silver over *vellón*⁹. In 1680, when this premium had reached 275 per cent, a series of deflationary measures aimed at reintroducing silver currency into circulation were undertaken: the nominal value of *vellón* was reduced by 50 per cent and the issuing of copper currency with intrinsic value similar to its nominal value was permitted. Later on, additional measures, more inflationary in nature but still aimed at the reintroduction of silver currency, were implemented: in 1686 the weight of the newly issued *reales* was reduced by 25 per cent while keeping their nominal value, and the nominal value of silver coins was increased from 8 to 10 silver *reales*¹⁰. According to most researchers, the full package of measures was quite effective. Vilar called it a «surgical procedure», Domínguez Ortiz mentions how silver «abandoned its hideout and went to the market again»¹¹ and García de Paso (2000, pp. 72-73) considered it key to understand the «end of monetary disorder in 17th century Castile».

⁸ See García Guerra (2000, p. 34).

⁹ See Motomura (1994).

¹⁰ This 25 per cent revaluation of silver coins intended to attract individuals towards the mints.

¹¹ Cfr. García de Paso (2000, pp. 72-73).

Beyond the symbolic character of the reform, an important related consequence was the acknowledgement by the Government of the existing pressures on metal coins¹². Gold, rather than silver, was in demand in 1680, mostly from merchants involved in commerce with the colonies. According to García Cavallero, the revaluation of gold decreed by the Government was key among the 1686 reforms, given that merchants had already established a premium on gold over silver. Just as with *vellón*, the Government acknowledged market forces «considering it impossible to counter the People in the great importance given to gold and conforming with trade practices»¹³. There seems to be little doubt that the Government, when devaluing silver in favor of gold «was trying to keep the coinage ratio in accordance to that in the market»¹⁴. The problem came with the subsequent change in the bimetallic rate, that went from 15.45:1 prior to 1686 to 16.48:1 afterwards. According to Hamilton (1988, p. 54) this forced the rate farther from its value in the rest of Europe, thus making Spanish silver more attractive.

It is important to stress that the monetary reforms of the 1680s were exclusively applied in peninsular mints (*cecas* or *casas de moneda*), not in the American colonies¹⁵. Domestic monetary difficulties would therefore not be transferred to the currency of the colonies, which was widely accepted in international markets. Spain was thus following Holland or England in establishing a dual monetary system, with a prestigious international currency and a solid domestic currency¹⁶. This system had the disadvantage of duplicating the reference values, especially for international trade. Bordázar (1736, p. 104) explains that «having increased the value of gold and silver, it is to be expected that other nations will do the same, or that they will differentiate the exchange rates of the old and the new silver». Bordázar himself confirms that the most important international merchants were doing so as a current practice. The difference between both currencies was around 25 per cent in 1736 –the value established in 1686– and the preference for one or another depended on the access that the merchants would have to each local market¹⁷. The problem, therefore, could be quite efficiently solved by the market and by accounting practices¹⁸.

¹² Muñoz de Amador (1755, p. 8) described it as «the most celebrated, which we still call *la Baxa de la Moneda* (the fall of the currency)».

¹³ García Cavallero (1731, p. 225). Moreover, «the trade with the *Reynos de las Indias* has introduced a Premium for the exchange of silver by gold, with merchants giving 8 and 10 percent, and sometimes even more, with the objective of avoiding increased expenses [...] thus turning their wealth to little volume and much value. Gold is bought with little thought, becoming so demanded that no practical considerations can avoid its revaluation». *Ibidem*, p. 207.

¹⁴ Hamilton (1988, p. 53).

¹⁵ See Santiago (2003, p. 209).

¹⁶ Following Vilar (1972, p. 337).

¹⁷ «In trade the old silver is worth 25 per cent more than the new one. Old silver is used in Cadiz and Seville whereas new silver is used in Madrid, Bilbao and San Sebastián. With Amsterdam we trade in *ducados* of 357 *maravedís* and the *ducado* is divided in *sueldos* and *dineros*. 1,138 *ducados*, 15 *sueldos* and 6 *dineros* from Cadiz or Seville are 3,131 florins, 12

The arrival of the Bourbons at the beginning of the 18th century did not drastically alter the monetary system, despite the fact that the pressing financial needs of the Succession War woke up old inflationary temptations. Governments managed to keep a stable and rational monetary system by favoring the unification of the currencies used in the different peninsular areas, tightly controlling the coinage and keeping the dual system. The defeat of the old kingdom of Aragon in the Succession War gave Philip V the legitimacy to put an end to the overlapping of several monetary systems within the country. Even though separate currencies were kept for internal use, the coinage of currencies different from that of Castile –which became the official national currency– was discontinued in 1724¹⁹. At the same time, the legal circulation of foreign currencies was prohibited. Coinage would exclusively be carried out by the mints on behalf of the royal finance (*Real Hacienda*), which would purchase the metal from individuals who, as a consequence, lost the capacity to issue currency²⁰. In order to exert a tighter control, the Treasury General became in charge of appointing the officials for the mints and of covering the coinage expenses while at the same time enjoying the seignorage²¹.

Philip V continued with the dual system based on a strong silver currency for the external market and a weaker domestic currency. Starting in 1717, new *reales* were coined for domestic use. These were called provincial silver (*plata provincial*), different from the old *reales* or national silver (*plata nacional*), that could be used in the Indias and Spain and which were the reference for international trade²². The *plata nacional* was given superior status and the exchange rate between the two was kept approximately at 75 per cent. This policy of a strong trading currency attempted to avoid «the loss of international prestige of the *real de a ocho*», in the words of Santiago (2003, p. 212). «The great volume and the relative stability of the national currency gave it an unprecedented position of privilege in international transactions all over the world»²³. The only drawback of this policy aimed at a strong currency was suffered by the American colonies, where the demand for currency generated a recurrent scarcity of the precious metal²⁴.

sueldos and 8 *dineros* in Amsterdam; the same 1,138 *ducados*, 15 *sueldos* and 6 *dineros* from Madrid or Bilbao correspond to 2,548 florins». Bordázar (1736, pp. 99-100).

¹⁸ Hamilton is more critical of the dual system than Vilar. According to him, in the case of Spain the dual silver system «accentuated the monetary confusion during a whole century». Hamilton (1988, p. 70).

¹⁹ See Mateu (1955).

²⁰ See Sardá (1948, p. 13).

²¹ See Santiago (2003, p. 215).

²² See Hamilton (1988, pp. 69, 87).

²³ Hamilton (1988, p. 86).

²⁴ Gelman (1987, pp. 485-486) explains this paradox of the scarcity of currency in the American colonies and analyzes the mechanisms that colonial merchants used to obtain gold and strong silver to be sent to Europe.

The monetary policy of the Bourbons also maintained the inflows of gold into Spain. In 1686 the relative value of gold was changed, with the intention of adapting its legal status to market practices. The increased production of gold coming from Brazil favored a reduction in both the international price and the domestic legal values of gold in European countries. Spain, which had a world monopoly on silver, was keen to attract gold, and kept the policy of overvaluation. Between 1686 and 1772 the value of gold in Spain increased by 11.1 per cent, from 16.75:1 to 14.87:1²⁵.

This policy had the problem of reducing the domestic value of silver, with the subsequent incentive to export it. The balance of payments deficit that Spain had with the rest of the European countries was accentuated. The peso went through several devaluations: according to Salvucci (1994, p. 132), in 1728 one peso contained 24.82 grams of silver whereas after 1777 it only contained 24.44 grams, thus having lost 1.5 per cent of its intrinsic value. This devaluation was explicitly demanded by Spanish politicians that attempted to slow down the silver «hemorrhage» that Spain was suffering²⁶. Additionally, there were reasons of economic opportunity. The increase in silver production in Mexico, added to the stability of the price of silver in international markets, compensated for this devaluation and led to an overvalued peso during the last thirty years of the 18th century²⁷.

The devaluation of the provincial silver currency, the one mainly used in Spain, was more severe. The equivalent in grams of silver of the copper *real de vellón* coined in the kingdom of Castile between 1688 and 1800 decreased by 29.5 per

²⁵ See Marién (1788, I, pp. 38-41). The values in Hamilton (1988, pp. 54, 99) differ slightly, but the trend is similar: 16.48:1 to 15.2:1, an 8.7 per cent revaluation, from 1686 to 1772.

	Marién Spain	Hamilton Spain	England	France
1685		15.45		
1686	16.75	16.48	15.39	14.91
1726	15.13	16		
1728	16	15.06	15.2	14.6
1730	15.06			
1737		15.06		
1772	14.88	15.03	15.2	14.63
1779	15.8			
1786	16	16.61	15.2	15.5

²⁶ It was a recurring metaphor in economic literature to compare silver to «blood» that the body, Spain, was constantly losing. Solutions proposed went from purely monetarist to increased confidence in commercial activities and a reduction of the balance of payments deficit. However, the accepted view was that something explicit had to be done to stop the outflow of silver. Stein (1989), Sardá (1988).

²⁷ See Salvucci (1994, p. 137).

cent. This reduction was not uniformly carried out throughout the century. The *real* lost 20.1 per cent of its value between 1688 and 1708; 5.6 per cent between 1708 and 1738; 3.4 per cent between 1738 and 1778 and, finally, 0.4 per cent between 1778 and 1800²⁸. Thus, the largest devaluations of provincial silver took place during the early decades of the century.

The limited scope of these devaluations was underscored by Sardá (1948, pp. 17-20), who maintained that the Bourbons did not really carry out a policy aimed at stopping the outflows of metal but had fiscal considerations in mind. According to him, the control that the royal finance exerted on the mints encouraged the Government to use the devaluations as a means to increasing fiscal revenues. The Crown did not want to increase the fees paid in the *cecas* or give up seignorage. Thus, the 1728 devaluation, which implied one more *real* per mark, was devoted to favoring the mint officials and to financing technical improvements in the coinage process. The secret devaluations carried out in 1771 and 1786 were intended mainly to finance the technical upgrading of the Spanish mint²⁹.

The Spanish monetary system went through a major breakthrough in 1780 with the introduction of fiduciary money guaranteed by the Government, a process studied by Herr (1977). In order to finance the expenditures of the war against Great Britain, the Government authorized the issuing of paper money (*vales reales*) for a given nominal amount. The first issue of *vales* amounted to a nominal value of 600 pesos, and would pay an interest rate of 4 per 100. More *vales* were issued in the following years, reaching a total nominal value of 450 million *reales*. This led to a depreciation of the *vales* up to 22 per cent. Once the war was over, confidence in the *vales* was restored, and from 1786 on they were exchanged at 1 per cent or 2 per cent above nominal value. We do not know the impact that this increase in fiduciary money had over the total monetary supply, but in any case the market reacted in a positive manner to the creation of paper money, at least until 1794. In this year a new war started and between 1794 and 1799 new *vales reales* were issued for a nominal value of 1,762 million *reales*, which quickly led to sharp depreciation³⁰.

In general, therefore, the Spanish monetary system evolved during the 18th century towards increased stability and uniformity. The new monetary order favored the existence of a strong international currency, although a scarcity was generated in the colonies. The outflows of silver, originally caused by the recurring

²⁸ According to Feliu (1991, p. 20).

²⁹ See Santiago (2003, p. 217).

³⁰ In July 1799, when the discount on *vales reales* was already 40 per cent, they were recognized as a «true currency» with a discount of 6 per cent. Attempts by the Government to withdraw the paper money from the market were ineffective, and in the subsequent years until 1807 the discount stayed at around 50 per cent. Data from Herr (1978, p. 123).

trade balance deficit, were accentuated by the interest to attract gold towards Spain and the Indies. After intense interventions by the Government in monetary issues in the first half of the century, an improvement in the trade deficit and an increased inflow of silver towards the metropolis significantly reduced the need for intervention. The monarch had to adapt to market forces more frequently than he would have desired. In the confrontation between him and the merchants –who usually would have opposite needs– there was still much margin for market forces.

The conclusion stemming from this brief analysis of the monetary reforms in 18th century Spain seems to be that most of the reforms were consequences of pressures on the exchange rate –i.e., the relative prices of currencies given their metallic content– and not vice versa. This supports the thesis that the value of quoted exchange rates was more a result of economic forces than of government intervention in the exchanges, which was somehow more reactive than proactive. A closer look at the way Spanish exchange rates were quoted during that period would therefore clarify and strengthen our analysis, and this we do in the following section.

3. THE COURSE OF EXCHANGE, THE LLOYD'S LIST AND THE SPANISH EXCHANGE RATE

The exchange rate data that we use in this paper come from two British publications from the 18th century: *The Lloyd's List* and the *Course of the Exchange*³¹. These periodicals offered abundant financial and commercial information, and so they have become a well-known source used by numerous researchers to analyze issues related to 18th century finance and economics³².

The research done so far has focused on the main financial and commercial marketplaces –Amsterdam, London and Paris– but the Spanish markets have been severely neglected. This lack of attention to markets that were in fact very active is to be stressed, since one of the main elements of financial markets is the importance of arbitrage and their inherent multilateral character³³. At the same time, the relevance that Spain had in European trade –especially with Great Britain– gives to this country a prominent role in the economic context of the period.

The mentioned lack of interest in Spain contrasts sharply with the importance that the data sources themselves attached to the Spanish exchange rates: Spain was

³¹ We have consulted the collection of *The Lloyd's List* of the University of Leicester, and that of the *Course of the Exchange* at the British Library.

³² Among others, McCusker (1992), Neal (1990), and Schneider *et al.* (1991).

³³ This has been argued by Schubert (1989), Quinn (1996), and Michie (1998), among others.

the country with the largest number of cities listed in both publications. This predominance increased significantly during the last years of the century. At the beginning of the century three out of seventeen European cities listed were Spanish –Bilbao, Cádiz and Madrid. By the end of the hundred-year period, the Spanish cities listed were five or six out of a total of twenty five and, at some points, as many as eight –San Sebastián, Corunha, Barcelona, Seville, Málaga and Gibraltar had been added.

Similarly, this neglect of Spanish cities does not parallel the strategic role played by Spain in the international capital markets. All financial intermediaries needed to be well aware of the behavior of the main Spanish markets in order to provide customers with that information. By including an ever increasing number of Spanish cities, the British press was just reflecting the pressing demand by British financial intermediaries of up to date and accurate information on the Spanish position.

The main Spanish markets on which exchange rates were quoted in the British press were Madrid, Cádiz and Bilbao. Madrid and Cádiz were quoted from the very first issue in 1699; Bilbao was added in May 1714. The quotes were maintained until 1826, and were only discontinued momentarily during years of war involving Spain and Great Britain –namely, in 1702-1713, 1797-1801 and 1810-1813. This interest for the three Spanish cities was related to their importance in the Spanish commercial and financial structure, but also to their position in international trade with Europe and America. All three cities shared a markedly international character in their financial and commercial operations, acting as intermediaries for the settlement of balances between Spanish and foreign markets³⁴. Given that a significant proportion of Spanish imports were balanced in those three cities, it was key that information on those cities be provided accurately and speedily. Studies on the internal Spanish market show that other cities used one of these three in their clearing operations, as it was the case of Barcelona with Madrid³⁵.

Spanish exchange rates reflected the behavior of the main Spanish markets in their particular relation to the City, so they did not strictly reflect the evolution of the domestic market. Exchange rate quotations and movements were determined by the market of bills of exchange. In 1780, Luis de Luque (1780, p. 105) explained the exchange rate in Cádiz by noting that «the price of exchange increases or decreases depending on the context and on the abundance, or scarcity, of bills drawn on that city». We find this idea again in 1793, when the editors of a Spanish publication, the *Correo Mercantil*, explained volatility of exchange rates:

«sometimes there is an abundance of people who want to send money to a city and sometimes of those who want to receive it. In the first case it is natural that the exchange rate will decrease and in the second case it will

³⁴ «Spanish merchants that import goods issue bills against *Madrid, Cádiz and Bilbao, which is where the Spaniards pay*». Marién (1788, I, p. 32). Italics added.

³⁵ See Maixé (2001).

increase, because in this, as in everything, abundance depreciates and scarcity appreciates»³⁶.

Spanish exchange rates would, therefore, reflect the market of bills of exchange between London and each city and not the evolution of the domestic market. It has to be stressed that there was a generalized consensus that the relative price of the currencies was given by the supply and demand of both –or, equivalently, of bills of exchange– and therefore that the exchange rate quotes were mainly market driven.

Discrepancies among the different Spanish cities were, in fact, quite small: Considerations of risk and time lags in the clearing of operations would lead to small differences in the rates. Also, the different cities had slightly different procedures for the payment of debts. For example, bills drawn from London on Madrid and Bilbao had a fourteen day courtesy period after maturity, whereas those on Cádiz only had six³⁷. However, the correlation of across-city exchange rate variations –significantly above 0.5 for both Madrid-Cádiz and Madrid-Bilbao– points at a high synchronicity throughout the complete century. Furthermore, the average degree of discrepancy was below 1.17 per cent in the case of Madrid-Cádiz and below 1.77 per cent for Madrid-Bilbao, having been on average even smaller during the second half of the century³⁸. That is, Spanish financial markets behaved much similarly with respect to London throughout the 18th century, and the existing discrepancies tended to disappear. This tendency came to a sudden stop in the 19th century, as data from the first three decades of the century show. Einzing (1962, p. 175), based on information from British periodicals, pointed at intense variations in exchange rates among the different Spanish cities in 1893 and measured that discrepancy –which he attributed to increased insecurity and risks of robbery– in more than eight per cent.

The City, therefore, showed throughout the 18th century an extraordinary interest in accurate information on the Spanish financial centers. The British periodicals, however, did not specify the type of currency that was being quoted, probably because that was common knowledge among merchants and bankers, who were the main audience of the publication³⁹. The evidence suggests that the

³⁶ *Correo Mercantil de España y sus Indias* (31-1-1793), p. 68.

³⁷ See Marién (1788, II, p. 59).

³⁸ See Torres *et al.* (2003).

³⁹ Spain used three types of currencies for international trade: the silver *doblon*, that was worth 32 *reales* of old silver; the silver *peso*, worth 8 *reales* of old silver, and the silver *ducado*, equivalent to 11 *reales* plus 1 *maravedí* of old silver. These currencies were not used indistinctly in European cities, but tradition had led to preferences depending on the trading area. Thus, the silver *peso* was used when moving capital to London, Lisbon, Genoa or Liorna. The silver *doblon* was used with Paris and the silver *ducado* was used for relationships with Amsterdam and Hamburg. This regional specialization remained until the end of the 18th century. When trade was established with new areas –Russia, Prussia or Sweden– the currency chosen was that of the market that functioned as intermediary –i.e., Amsterdam, and the silver *ducado*. See Marién (1788, II, p.121).

exchange rate was quoted in pence per silver *peso*⁴⁰. This conclusion is confirmed by the examination of manuals for merchants. In one of them, that of Savall (1778, p. 161), we find the quote «Londres gives 39 *dineros* and a half on Cadiz and Madrid for one *peso* of 8 *reales* of old silver»; similarly, Marién (1788, I, p. 7) mentions that «in London, a silver *peso* is exchanged for 37 sterling pence». These figures are quite close to the average value of the exchange rate on all Spanish cities that we obtain for the whole 18th century: 38.392⁴¹.

In any case, the exchange rates quoted in the City were determined by the market of bills of exchange drawn on each of the different Spanish cities. Of course, there was a limit for this market-driven floating of the rate. This limit would correspond to the *gold point* of the different currencies and to the different attempts by the governments to change the nominal of the currency. However, within that range, it seems that indeed quotes on Spanish rates depended directly on the economic variables behind the market for bills of exchange. This context, therefore, provides a much appropriate setting for the analysis of the relationship of the exchange rates to relevant economic fundamentals. We go on to this analysis in the following section.

4. EMPIRICAL EVIDENCE: THE XVIII CENTURY AS A TESTING GROUND FOR EXCHANGE RATE MODELS

In this section we analyze the exchange rate between the Spanish and the British currencies –*pesos* and pence respectively– in the 18th century⁴². We first describe the behavior of these rates by means of a simple graphical analysis, trying to identify the periods determined by different economic contexts. We then describe the formal models that we build upon, and the econometric methodology used in order to analyze the relationship between 18th century exchange rates and economic fundamentals. We present some of the additional data collected on relevant variables –or closest proxies available–, and mention the sources of the data. Finally we present the results of the estimation. We also comment on the limitations of the analysis, which point at directions for future research.

⁴⁰ The other equivalences of the old silver *peso* were as such: it was worth a quarter of a silver *doblón* or 272 old silver *maravedís*; in terms of copper (*vellón*), to 512 *maravedís de vellón*, or 15 *reales* and 2 *maravedís de vellón*, or 128 *cuartos*.

⁴¹ We would like to thank the referees for asking us to specify the currency unit to which the quoted exchange rates referred.

⁴² «A sterling pound was composed of 20 shillings, each of which corresponded to 12 pence. One pound was equivalent to 95 Spanish *reales* plus 22 *maravedís de vellón*. A Spanish *peso* was equivalent to 15 *reales* plus 2 *maravedís de vellón*» Marién (1788, I, p. 139). London exchange rates on Spanish cities were quoted in pence, so at the time that Marién wrote 36 pence were needed to buy a Spanish *peso*.

4.1. Evolution of Spanish Exchange Rates in London

We show in Figure 1 the evolution of the monthly exchange rate during the complete 18th century. The rates are quoted in pence per *peso* and we use the three longest series available, those for Madrid, Cádiz and Bilbao. Discontinuities in the series correspond to periods of war between the two countries, when the rates would not be quoted.

The graph shows at first sight a constant appreciation of the pence against the *peso* during the 18th century, a trend that only reverses in the last years of the century. At the end of the 17th century, the exchange rate on Madrid and Cádiz was around 53 pence per *peso*. From this maximum value, that was never achieved again, the Spanish *peso* began a downslide that continued throughout the century: the exchange rate on all three Spanish cities had decreased to less than 39 pence per *peso* halfway through the century⁴³. This appreciation of the British currency was especially intense during 1720-1739, peaceful years that witnessed a continuous increase in economic linkages between Spain and Great Britain and the Spanish devaluation of silver at the end of the 1720s. During the first forty years of the century, exchange rates on Spanish cities decreased by 30 per cent, reaching a level of 40 pence per *peso*. The following years brought some stability. This was a consequence of the notable decrease in trade between Great Britain and Spain –the constant appreciation of the sterling pound seemed to slow down– and of the War of Succession and the War of Jenkins' Ear (1739-1748). As a matter of fact, during these war periods the *peso* only lost an average of 0.9 per cent in the three main cities. The stability period extended until 1777, at which time the cumulative depreciation of the *peso* was only a 1.2 per cent with respect to 1739. Notice that we have stressed especially the relationship between the bilateral trade and the exchange rates, even though later we will attribute much of the *peso* depreciation in these years to inflation differentials. The relationship between the bilateral trade balance and the exchange rate, even though present during the whole century, is much more noticeable at the end of the century. It is in those last years when the bilateral trade becomes much more volatile and so does its effect on the exchange rate.

The tendency of the *peso* to depreciate accelerated again after 1777. Whereas previous war periods seemed to have had a positive effect on the *peso* –mainly because of the reduction induced in trade with Great Britain, which eliminated the deficit and the pressure for exchange rate depreciation– the new conflict strengthened the pound. Between 1777 and 1785 the *peso* lost an average of 14.2 per cent in the three Spanish cities, bringing the cumulative depreciation to 55.8

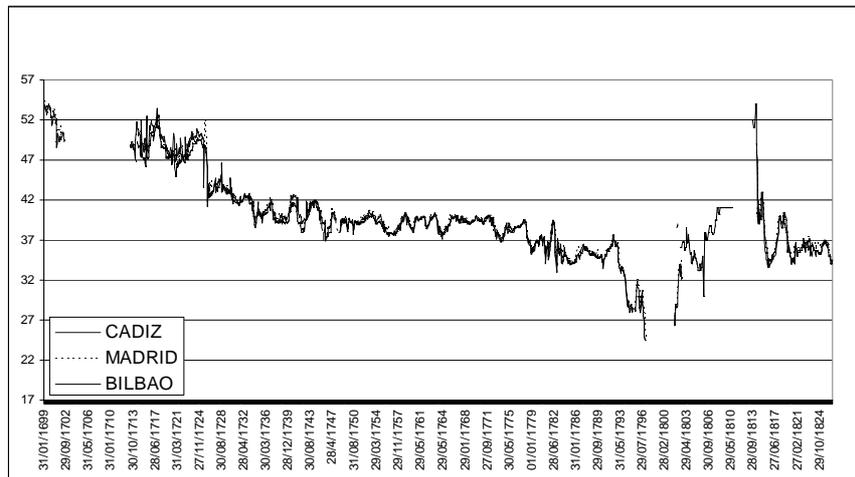
⁴³ Annual data on these three cities can be accessed in the working paper version of this article (<http://www.unav.es/econom/investigacion/working/wp1204.pdf>).

per cent with respect to the levels prevailing at the beginning of the century: in 1785 the *peso* was exchanged for 34.2 pence. The war against Portugal and the subsequent war with Great Britain (1777-1783), added to the American War of Independence, paralyzed the Atlantic-based economic relationships. Spanish ties with the colonies were severed, and the Government was forced to issue fiduciary money (*vales reales*) starting in 1780. This was severely penalized by the City, and the *peso* depreciated intensely, especially in the years 1784 and 1785. Ironically, by this time the wars were already over and capital was flowing back to Spain from America.

Between 1785 and 1792 economic conditions and trade relationships were especially favorable, and the tendency for the *peso* to depreciate was reversed. In that eight year period the exchange rate of the Spanish currency appreciated by 6 per cent. Again, the effect of the bilateral trade balance can be seen here, since it is in these years when the Spanish trade deficit starts to improve significantly (see also Figure 3).

In 1792 a new war cycle began and the subsequent massive increase in public debt to finance the war expenses –new *vales reales* were issued– changed the trend again and threw the exchange rate into a free fall that lasted from 1792 to 1806. During those years the exchange rate depreciated by 79.9 per cent and it was not until a new alliance was established between Spain and Great Britain that the *peso* recovered and its exchange rate stabilized at around 36.2 pence in 1817.

FIGURE 1
EXCHANGE RATE BRITISH CURRENCY / SPANISH CURRENCY



Sources: See text.

The immediate question arises as to the economic causes of this evolution of the exchange rate, especially in regards to the relationship with economic fundamentals. Was this evolution that we have just superficially described linked to the values of economic variables? In order to give some visual evidence, we present in Figures 2 to 4 the evolution of prices –more exactly, inflation rates–, the Spain-Great Britain trade balance and relative money supplies⁴⁴.

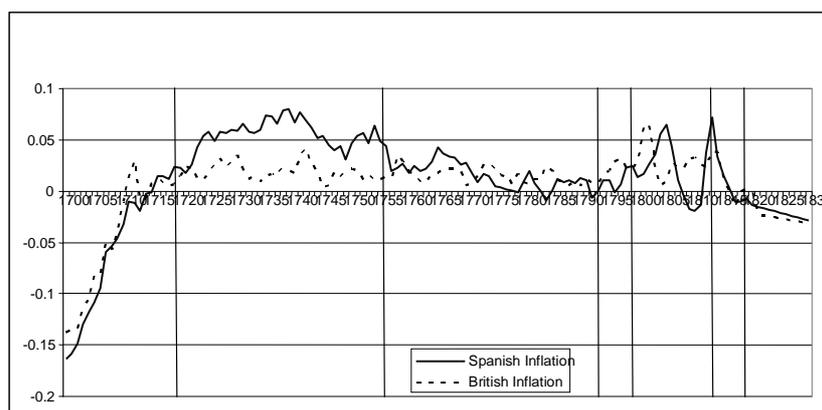
The first significant finding, in line with the subsequent statistical analysis, relates inflation rates and the theory of relative purchasing power parity (Subsection 4.2). There is only one period during which the inflation rates of both countries are significantly different, namely 1720-1755. It is noticeable in Figure 2 how during those years the Spanish inflation rate was consistently above that in Great Britain. Purchasing power parity considerations would imply that the *peso* should steadily depreciate in order to compensate for those inflation differentials, if no real shocks were present. As we have seen above, this is indeed the case. In fact, when the inflation rates equalize around 1755 –this trend continues during the rest of the sample period– the depreciation of the *peso* stops and the exchange rate stabilizes. The bilateral trade was basically balanced during those years (see Figure 3), therefore the exchange rate seemed to be entirely PPP-driven: the relative price of the two currencies would move in order to compensate inflation differentials and keep the relative prices –the real exchange rate– constant. The reason for these inflation differentials can be found in the evolution of our measure of relative money supplies, which is seen to increase significantly –money supply in Spain increased relative to that in Great Britain– during the first half of the century. Why the subsequent decrease in the relative money supplies did not lead to a significant appreciation of the *peso* should be explained in terms of the higher growth of real activity in Great Britain during the second half of the century⁴⁵.

We now turn to the bilateral trade balance between Spain and Great Britain. Here the evidence is again quite revealing. During the earlier years, almost until 1787, trade between the two countries was basically balanced, and no significant deficits or surpluses persisted over long periods. We noted before, though, that a (small) chronic deficit between 1750 and 1770 may have accentuated the exchange rate depreciation during years when the inflation rates were already equalized. However, it is noticeable that, starting in 1787, trade between the two countries becomes increasingly unstable, with large Spanish surpluses being followed by

⁴⁴ Inflation rates have been smoothed with a moving average since they present quite a volatile behavior during the sample period. Subsection 4.3 describes the sources and construction of the variables used in the analysis.

⁴⁵ It was mentioned in Section 2 that the amount of silver in the *peso* changed significantly throughout the century. This nominal depreciation of the Spanish currency was, however, insufficient to explain the secular depreciation of the exchange rate, so we believe that the inflation differential story is still consistent with the data.

FIGURE 2
(SMOOTHED) INFLATION RATES

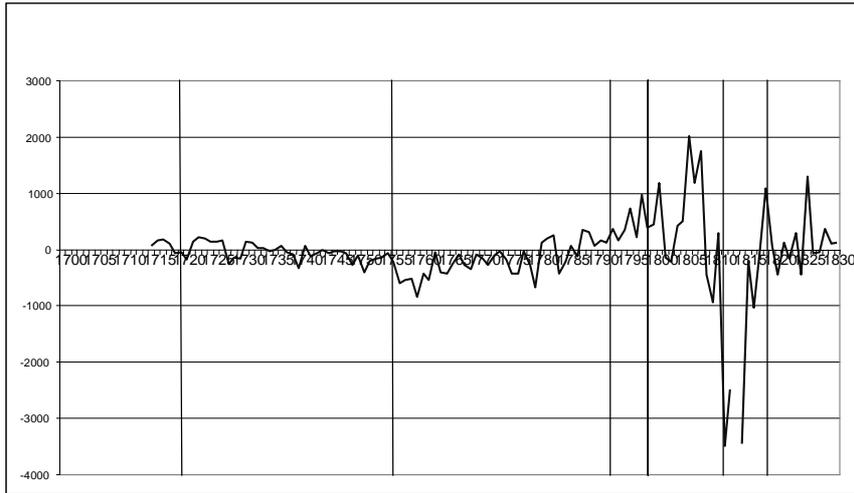


Sources: See text.

large deficits. We mentioned earlier some possible causes for this instability. If the evolution of the trade balance in the years 1790-1830 is compared with that of the exchange rates, the parallelism is noteworthy. There is a textbook-like inverse relationship between the two series: Trade surpluses came hand in hand with currency appreciations and vice versa. Thus, in a period with stable relative money supplies and comparable inflation rates, the value of the exchange rate seemed to be driven by another fundamental variable, the trade balance. Given that inflation rates were similar, the implication is that the nominal exchange rate was affecting the real exchange rate –the relative prices in the two countries– which therefore experienced large swings until 1819. The causes for these fluctuations in the real exchange rate rest most likely on real shocks on the production side, differentials in output growth or productivity, or cost related shocks. These would most likely be a consequence of the profound changes in the production side that Great Britain was experiencing at the turning of the century.

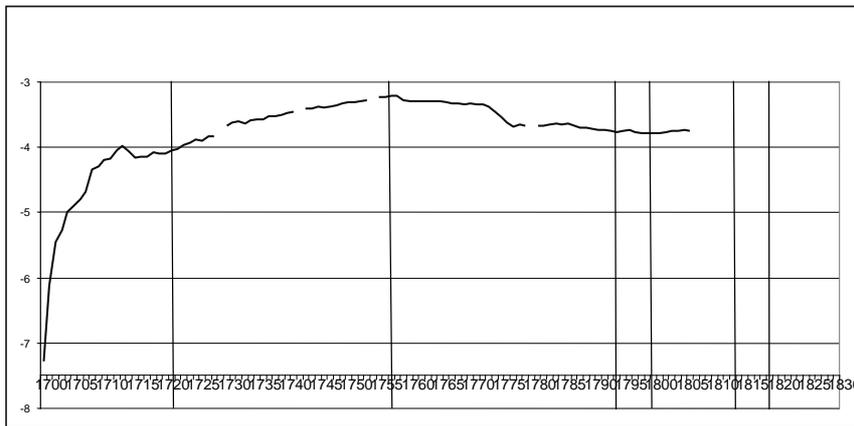
Finally, Figure 4 shows our proxy for the relative money supply defined as the logarithm of the ratio of money supplies in Spain and Great Britain. As we can see, this proxy presents negative values during the sample period which indicate that at the beginning of our period of analysis the money supply in Great Britain was greater than that in Spain. The subsequent increase in the relative money supply in Spain is parallel to the inflation differentials shown in Figure 2 and thus the information in the figure is perfectly consistent with our previous comments. In the second half of the century relative money supplies seem to stabilize, and again the story is consistent with the equalization of inflation rates.

FIGURE 3
BILATERAL TRADE BALANCE SPAIN-GREAT BRITAIN



Sources: See text.

FIGURE 4
PROXY FOR (LOG) RATIOS OF MONEY SUPPLY



Sources: See text.

Our previous analysis has provided us with preliminary evidence that the exchange rate was significantly linked to the evolution of some economic fundamentals during the complete century. We review now some theoretical models of exchange rate determination that link the exchange rate to economic variables. These models will be the basis of the econometric analysis in Subsection 4.4.

4.2. Alternative Theories of Exchange Rate Determination

The two macroeconomic theories of exchange rate determination that are the focus of our empirical analysis are the purchasing power parity and the monetary model of the exchange rate⁴⁶.

PPP and the Monetary Model of the Exchange Rate

The purchasing power parity (PPP) hypothesis, though hinted at in the 1500s, was first formally stated in the 17th and 18th centuries. PPP states that the exchange rate between two currencies should be that which would equate the relative national prices if expressed in a common currency⁴⁷. Thus, if E_t is the exchange rate between two currencies –expressed in units of currency of country A per unit of currency of country B– and P_t^A and P_t^B are the price levels in the two countries, PPP states that $E_t = P_t^A / P_t^B$. Given the arbitrariness of the base year for price levels, PPP is usually stated in relative form, which implies that the changes in the exchange rate should exactly offset the changes in relative prices. In other words, the rate of depreciation of the exchange rate should equal the ratio of the inflation rates:

$$\frac{E_t}{E_{t-1}} = \frac{P_t^A / P_{t-1}^A}{P_t^B / P_{t-1}^B}$$

Notice that taking logarithms of both absolute and relative PPP and using that $\log(1+x) \approx x$ for small x , we obtain the linearized versions, which are most frequently used given their statistical tractability:

$$e_t = p_t^A - p_t^B \quad [1]$$

⁴⁶ Other theories of exchange rate determination such as liquidity models, the portfolio balance model or micro-foundations based theories can be consulted in the comprehensive review by Sarno and Taylor (2002).

⁴⁷ See Froot and Rogoff (1995), Rogoff (1996) and Sarno and Taylor (2002) for surveys on the PPP hypothesis.

$$e_t - e_{t-1} = (p_t^A - p_{t-1}^A) - (p_t^B - p_{t-1}^B) \rightarrow \Delta e_t = \pi_t^A - \pi_t^B \quad [2]$$

where lowercase letters correspond to the logarithm of the variable and π_t^i is the inflation rate in country i . Notice that PPP is by definition a relationship between monetary variables that move in the proportion necessary to keep all real variables constant. More specifically, defining the *real exchange rate* as the ratio of the price levels in the different countries –this is a relative price, and therefore a real variable usually taken as a measure of relative competitiveness of the products of the two countries– relative PPP says that the real exchange rate between two countries will be constant. Thus, deviations from PPP correspond to changes in the real exchange rate, and therefore to changes in the real side of the economy. As it is, PPP just states that, the real side being constant, the exchange rate should move to keep the relative prices in the two countries constant⁴⁸.

During the 1970s the *monetary* model of the exchange rate emerged as the dominant framework for nominal exchange rate determination⁴⁹. Since the exchange rate between two currencies is the relative price of foreign and domestic money, this price should be determined by the relative supply and demand for these moneys. Thus, the first element of the model must be some structure for the money demand functions in two countries. These are specified to depend on the nominal interest rate and the real income in each country:

$$m_t^A - p_t^A = \alpha_2 y_t^A - \alpha_1 i_t^A \quad [3]$$

$$m_t^B - p_t^B = \alpha_2 y_t^B - \alpha_1 i_t^B \quad [4]$$

where m_t is the money supply, p_t is the price level, i_t is the nominal interest rate, and y_t is the real output. All variables refer to period t and, with the exception of the nominal interest rates, the lowercase letters denote levels in logarithms. Note that the money demand parameters α_1 and α_2 are assumed to be identical across countries.

Secondly, PPP is assumed to hold:

$$e_t = p_t^A - p_t^B \quad [5]$$

where e_t is the nominal exchange rate. Solving [1] and [2] for p_t^A and p_t^B and substituting the resulting expression into [5] yields

$$e_t = (m_t^A - m_t^B) + \alpha_1 (i_t^A - i_t^B) - \alpha_2 (y_t^A - y_t^B) \quad [6]$$

⁴⁸ The main conclusion from recent testing of the PPP hypothesis is that PPP is a valid long run parity condition when applied to exchange rates among major industrialized countries. See Sarno and Taylor (2002).

⁴⁹ See Frenkel (1976), and/or Mussa (1976).

which makes the equilibrium value of the exchange rate a function of relative money supplies, the interest rate spread and relative real output.

As it can be seen, this model is quite general. The only structural relationship assumed is that the (real) demand for money in each country depends on the nominal interest rate and real output. Notice that this formula conveys the conventional relationships that (i) monetary expansions in the country are associated with a depreciation of the exchange rate whereas (ii) real growth is associated with an appreciation of the exchange rate. The influence of the interest rate, however, is contrary to the usual wisdom that an increase in the interest rate tends to appreciate the currency, given that the model abstracts from capital flows⁵⁰.

Why, then, the PPP and the Monetary Model?

Cassel (1918) coined the term «purchasing power parity» (PPP) in order to identify the relationship between exchange rates and price levels, although the perception that exchange rates must be related to national price levels has been dated back to the 16th century, in particular to the School of Salamanca in Spain⁵¹.

The genesis of this perception was linked to the development of the quantity theory of money: «In places where money is scarce, goods will be cheaper than in those where the whole mass of money is bigger, and therefore it is lawful to exchange a smaller sum in one country for a larger sum in another»⁵². Notice that a monetary model explanation is already present in that quotation, given the reference to *relative money supplies*. Thus, it seemed that already in those early years the idea that prices were the result of market equilibrium relationships was accepted, and so the exchange rate was naturally interpreted as the relative market price of two currencies.

Presumably, the discovery and relevance of these theories was catalyzed in those early years by the significant impact that large inflows of precious metals –gold and silver coming from America, which Spain was the first European country to receive– had on money supplies and on national prices⁵³. These inflows

⁵⁰ Empirical evidence beyond the late 1970s in the monetary model ceases to provide a good explanation of variations in exchange rate data (see Meese and Rogoff, 1983). Some authors have sought to explain this breakdown on the grounds of econometric misspecification, while others have argued that large current account deficits or surpluses during the period examined generated important wealth effects which are not adequately captured by the model. See Frankel (1986) and Sarno and Taylor (2002).

⁵¹ See Grice-Hutchinson (1952); Einzing (1962); Officer (1982), and Isard (1995).

⁵² Stated in 1594 by Domingo de Ibáñez, as quoted in Officer (1982, p. 32), and Grice-Hutchinson (1952, pp. 57-8).

⁵³ See Isard (1995, p. 57) on this point.

represented an immediate increase in the availability of money –which existed still mostly in the form of coins– and therefore in the money supply within the country. Given that most transactions in the different currencies were driven by trade, the demand for currency depended directly on real output or income –that measures the amount of transactions that take place within the country– and, quite significantly, on the amount of trade between the two countries. The bills of exchange were for all purposes a claim on a country’s national currency. The interest rate, on the other hand, probably played a small role in this demand for money during those years, both from a domestic and from an international point of view. Thus, we expect the monetary model in the 18th century to provide a good explanation for the exchange rate behavior, although we would express it in a slightly modified way. Specifying the demands for national currency as:

$$m_t^A - p_t^A = \alpha_2 y_t^A + \alpha_3 \text{Exports}_t^{A \rightarrow B} - \alpha_1 i_t^A \quad [3b]$$

$$m_t^B - p_t^B = \alpha_2 y_t^B + \alpha_3 \text{Exports}_t^{B \rightarrow A} - \alpha_1 i_t^B \quad [4b]$$

which, coupled with the PPP condition would yield:

$$e_t = (m_t^A - m_t^B) - \alpha_2 (y_t^A - y_t^B) - \alpha_3 \text{TB}_t^{A \rightarrow B} + \alpha_1 (i_t^A - i_t^B) \quad [6b]$$

where, of course, $\text{TB}_t^{A \rightarrow B} = \text{Exports}_t^{A \rightarrow B} - \text{Exports}_t^{B \rightarrow A}$ is the bilateral trade balance, the formula again reflects the conventional wisdom that a positive trade balance tends to appreciate the currency⁵⁴.

Consequently, we believe that the use of data from a period when there was no significant speculative behavior in the foreign exchange market and when the exchange rate was quoted as the result of market forces has the potential of uncovering relationships that may not be so apparent –or for which very long time series may be needed– from the analysis of recent data. Of course, the drawback is the lack of good quality data, as will become clear from our description of the data available.

4.3. The data

We have collected as comprehensive a database as possible on Spanish and British macroeconomic variables during the years going from 1700 to 1819. Our data are available only at the annual frequency, except for the exchange rate itself.

⁵⁴ Notice that the form of the money demands in [3] and [4] is not justified, although similar demands can be derived from more formal models. Our modifications in [3b] and [4b] must be understood as purely *ad hoc*, and assuming, among other things, the existence of only two countries. However, given that exports are a component of output in both countries, the appearance of the trade balance in equation [6b] is natural, considering that the output variable is net of Great Britain-Spain trade.

For the analysis of the models in Subsection 4.2 we use the following variables:

- The price level for Great Britain, P_t^{GB} corresponds to the consumer goods component of the Schumpeter-Gilboy Prices Indices, available from Mitchell (1988).
- E_t is the exchange rate, in pence per *peso*, between Spain and Great Britain. We built a database of exchange rates collecting monthly end-of-period observations of the rates quoted in London for different Spanish cities, obtained from the *Lloyd's List* and the *Course of the Exchange*. We use the longest series available –the exchange rate versus the city of Cádiz, at that time the main commercial port in Spain– and transform the monthly rates into annual using the yearly average.
- The quantity of money in Spain, M_t^{Sp} is proxied as the cumulative sum of the value of silver and gold –in millions of piastres– that entered Spain starting in 1700. The data come from Morineau (1985).
- Similarly, the quantity of money in Great Britain, M_t^{GB} is proxied as the cumulative sum of the value of coinage –silver and gold, in thousands of sterling pounds– issued from 1690 to 1820. The data come from Mitchell (1988)⁵⁵.
- The trade balance between the two countries TB_t^{Sp-GB} has been calculated as the total value of exports from Spain to Great Britain minus the total value of imports. The source, in this case, is Prados (1984, p. 160).
- Real output in both countries, Y_t^{Sp} and Y_t^{GB} , has been proxied by government revenue from income taxes deflated by the price indices. Data on government revenue come from Mitchell (1988) and Merino (1987). We are aware of the coarseness of this proxy, but there is usually a fairly high correlation between output or national income and government revenue, and so we opted for using it⁵⁶.

We have tried to incorporate alternative proxy variables for income and interest rates, but these are either not currently available for a long enough period or the proxy yielded unreasonable results⁵⁷. Thus, our version of the monetary model will only include differential money supplies, differential real output, and the bilateral trade balance.

⁵⁵ An ideal proxy variable for money in Spain and Great Britain would include paper currency and bank deposits. The data for these two concepts are, however, unavailable.

⁵⁶ An alternative proxy for income is the total volume of trade, defined as the sum of exports plus imports. Unfortunately, we have not been able to find comparable data for both countries on total trade.

⁵⁷ For interest rates, only Great Britain has a series of bond yields available, and so we opted for not including it given the lack of an equivalent variable for Spain.

4.4 The Empirical Evidence of PPP and the Monetary Model

We perform now a formal testing of the models outlined in Subsection 4.2.

The first model, PPP, states that there should be a long-run relationship between the exchange rate and the price levels of the two countries. Given the way we measure our exchange rate, the relationship becomes $e_t = p_t^{GB} - p_t^{Sp}$. Notice that this hypothesis also implies relative PPP, or that exchange rate movements should compensate for inflation rate differentials across the two countries.

For the monetary model, the long run relationship that we estimate is

$$e_t = \alpha_m (m_t^{GB} - m_t^{Sp}) - \alpha_{tb} TB_t^{GB-Sp} - \alpha_y (y_t^{GB} - y_t^{Sp}) \quad [7]$$

so that we expect a negative coefficient in the equilibrium relationship of money differentials, and a positive coefficient of both the trade balance and output differentials. We have mentioned before why we do not expect the interest rate to be a significant determinant of money demand, and therefore we decided to eliminate it from equation [7]. Our version of the long run monetary model therefore involves the existence of a stable long run relationship among e_t , $(m_t^{GB} - m_t^{Sp})$, $(y_t^{GB} - y_t^{Sp})$ and TB_t^{GB-Sp} .

Given that the main variables involved in both long run relationships are integrated variables, the correct methodology to be used for the analysis is co-integration. We use Johansen's methodology to detect the existence of a long-run relationship and to estimate the parameters of the relationship. Further details on the methodology can be found in Hamilton (1996).

Results for the testing of PPP appear in Table 1 (co-integration test) and Table 2 (parameter estimates). The results of the co-integration test in Table 1 are indeed very supportive of the PPP hypothesis. There is significant statistical evidence at the 1 per cent confidence level of one single co-integration vector between the exchange rate and the price indices of both countries⁵⁸. We then proceeded to estimate the full error correction model. Results of this estimation appear in Table 2⁵⁹. The results are quite encouraging, although we do not comment on the complete set of parameters, but only on the parameters of the error correction term. These coefficients measure the extent to which each variable reacts to deviations from the implied equilibrium relationship. The coefficients on the price indices are

⁵⁸ Both the trace and the maximum-eigenvalue tests agree. The normalized co-integration vector, that characterizes the long-run equilibrium relationship is quite close to (1,1,-1), which is the value implied by PPP. The coefficient on the British price index is a little too high, but this may be due to the different base year of the two indices. When a constant is included in the co-integrating equation, the coefficients are not statistically different from the PPP-implied (1,1,-1). We have decided to keep the test as it is, for easiness of interpretation.

⁵⁹ The number of lags in the distributed lag dynamic specification have been determined by the lags in the co-integration test (4). For more detailed results of the estimation see Torres *et al.* (2004).

not significantly different from zero, indicating that the movements in prices do not seem to be related to the equilibrium relationship, and are mainly caused by other factors, including some dependence on their own past –coefficients of the lagged terms. However, the adjustment term for the exchange rate is statistically significant and has the right negative sign: when the equilibrium relationship does not hold, for example when the value of the deviation is positive, the exchange rate tends to go down in order to move the system towards the equilibrium rate. The magnitude of the coefficient is small, indicating that the exchange rate moves slowly towards its equilibrium value. Consequently, there is significant evidence that the PPP hypothesis held, in the long run, in the exchange rate between Spain and Great Britain in the first ninety years of the 18th century⁶⁰.

TABLE 1
UNRESTRICTED CO-INTEGRATION FOR THE PPP HYPOTHESIS, 1718-1819*

Unrestricted Co-integrating Coefficients:		
Exchange Rate	Price Spain	Price England
-8.43	-11.21	16.72

1 Co-integrating Equation (Normalized co-integrating coefficients): **

Exchange Rate	Price Spain	Price England
1	1.329	-1.984
	(8.86)	(15.26)

Notes:

* For detailed results on the trace and Max-Eigen tests see Torres *et al.* (2004).

** t-stats in parentheses.

TABLE 2
RESTRICTED ESTIMATION OF ECM FOR THE PPP HYPOTHESIS, 1718-1819**,**

	D(Ex. Rate)	D(Price Sp)	D(Price Eng)
Error Correction Term ***	-0.0023 (-1.83)	0.0017 (0.38)	0.0019 (0.96)
R-squared	0.26	0.15	0.23
Adj. R-squared	0.13	0.002	0.09

Notes:

* For detailed results on the restricted estimation of ECM for PPP see Torres *et al.* (2004).

** Co-integrating vector restricted to satisfy PPP: (1,1,-1).

*** t-stats in parentheses.

⁶⁰ This is in line with prior evidence that movements of the exchange rate towards the PPP value, when significant, are quite slow. See Lothian and Taylor (1996), and Rogoff (1996).

The estimation of the co-integration model above is done with data from 1700 to 1790: years after 1790 cannot be used because of the discontinuities in the exchange rate data⁶¹. We mentioned above that during those years inflation rates differed considerably in the period 1700-1750, whereas they were very similar during the second half of the century. The exchange rate perfectly mimicked the behavior of inflation differentials, which in turn responded to relative money supplies. In that sense, we find a significant relationship of changes in the exchange rate with relative money supplies⁶². Of course, the evidence in the last years of the sample would not be supportive of PPP, since we observe similar inflation rates—some fluctuations are still noticeable—but the exchange rate fluctuated quite wildly. We have already commented how these swings in the exchange rate—and the changes in the real exchange rate that this would induce—parallel the behavior of the bilateral trade balance.

We examine now whether the exchange rate reacted to movements in other fundamental variables by using the data on relative quantities of money, output differentials and the trade balance between the two countries⁶³.

The results of the estimation of this *ad hoc* monetary model are shown in Tables 3 and 4. As we can see, there is some evidence of a long run relationship among the variables—co-integration tests are shown in Table 4⁶⁴. The tests suggest the presence of one long run equilibrium relationship. The results point at a relationship of the exchange rate with these three fundamentals, although one puzzling result appears. The relative money supply term has the opposite sign to what we would expect, whereas the signs of the trade balance and the output differentials are correct. That is, trade surpluses in Spain tended to appreciate the exchange rate, and vice versa. Also, fast economic growth in Spain would tend to appreciate the exchange rate *vis à vis* the British currency. So far, these results are encouraging and, keeping in mind the limitations of the analysis, seem to suggest that exchange rates significantly reacted to fundamental variables in the way we would expect from theoretical considerations.

We do not have, however, an immediately intuitive explanation for the opposite sign of the money differential variable. It has to be said that the estimation of this

⁶¹ In the estimation of the PPP and monetary model we do not take into account a possible structural break in 1797—the bank restriction period—, due to the fact that our sample period ends in 1790.

⁶² See Torres *et al.* (2004) for a more detailed estimation of changes in the exchange rate versus money supply during the period 1701-1805.

⁶³ The collection and use in the statistical analysis of a better proxy for output differentials and one for interest rates becomes a priority for future research. Also, having complete series that cover the entire 18th century would allow for a much more thorough test of the relationship of the exchange rate to fundamentals. As it is now, and with no known sources available to complete the data, the graphical analysis seems to be quite supportive of a fundamental-driven exchange rate, but statistical evidence is only weakly supportive.

⁶⁴ For detailed results of the estimation of the monetary model see Torres *et al.* (2004).

model is done exclusively on data prior to 1800, and in fact the number of included observations is quite restricted by the availability of data on the proxy for real output. When we take out this variable from the system, the sign of the money variable becomes the correct one and that of the trade balance becomes negative. These effects are no doubt caused by the small number of observations –half those available for the testing of PPP– which makes co-integration estimates too unstable. Also, and given the evidence in favor of the effect of the trade balance in the last years of the sample, but knowing that we cannot include those data because of the discontinuities of the exchange rate series, we place considerable caution on the results in Tables 3 and 4 –as in other analyses that we have not included but are available from the authors.

To sum up, the PPP hypothesis holds quite reasonably in 18th century Spain. Movements in relative prices can explain exchange rate fluctuations in the early 18th century, especially taking into account that bilateral trade between the two countries was mainly balanced. Given the inflows of precious metals into Spain during those years, a quantitative-theory-based explanation of the exchange rates was certainly in effect at the beginning of the century, and no major shocks seemed to take the real exchange rate out of equilibrium –relative prices were mostly constant throughout the century. Once the inflows of money became more stable, inflation rates equalized in both countries and the exchange rate stabilized. However, when trade balance disequilibria became the rule, the exchange rate started behaving in unison with those balances, depreciating in the face of deficits and appreciating in the context of surpluses. This is good news for a fundamental-based explanation of exchange rate behavior. Demand and supply of the

TABLE 3
UNRESTRICTED CO-INTEGRATION
FOR MODIFIED MONETARY MODEL, 1752-1797*

Unrestricted Co-integrating Coefficients:			
Exchange Rate	Money Diff	(TB)	Output Diff
3.58	17.18	15.99	16.72
1 Co-integrating Equation (Normalized co-integrating coefficients): **			
Exchange Rate	Money Diff	(TB)	Output Diff
1	4.79 (1.31)	4.46 (1.25)	4.89 (1.11)

Notes:

* For detailed results on the trace and Max-Eigen tests see Torres *et al.* (2004).

** t-stats in parentheses.

TABLE 4
UNRESTRICTED ESTIMATION OF ECM
FOR THE MONETARY MODEL, 1752-1797*

Co-integrating Equation**	
Exchange Rate(-1)	1.00
Money Diff(-1)	4.79 (3.66)
LOG(TB(-1))	4.46 (3.54)
LOG(Output Diff(-1))	4.89 (4.39)

Error Correction:	D(Ex. Rate)	D(Money Diff)	D(TB)	D(Output Diff)
Co-intEq1	-0.0086 (-0.42)	0.0334 (2.72)	0.3655 (1.63)	-0.3308 (-3.26)
R-squared	0.67	0.75	0.64	0.73
Adj. R-squared	0.32	0.49	0.26	0.45

Notes:

* For detailed results on the unrestricted estimation of the ECM for the monetary model see Torres *et al.* (2004).

** t-stats in parentheses.

different national currencies –or of bills of exchange– generated by trade flows seemed to be a key determinant of the evolution of exchange rates. Given that inflation rates did not differ significantly, the fluctuations of the nominal exchange rate would imply similar fluctuations of the real exchange rate, and thus significant real effects should be expected. This was not the case in the first half of the century, where the behavior of the exchange rate was in perfect consonance with the value implied by PPP and, therefore, by a constant real exchange rate. We know, however, that the end of the 18th century corresponds to years of intense and profound changes in the productive structure of Great Britain, which may have led to significant changes in the real exchange rate. The discontinuities in the exchange rate data prevent us from a formal statistical testing of this feature, but the examination of the exchange rate and trade data seems to point in that direction and thus suggests fruitful avenues for future research.

5. CONCLUSIONS

We have analyzed the behavior of Spanish exchange rates –*vis à vis* the sterling pound– during the 18th century. We provided an overview of the monetary

system in 18th century Spain and of how exchange rates were determined in the London exchange. Our discussion suggests that during that century exchange rates quoted in the British press were mainly determined by the market of bills of exchange, and that government interventions were reactive to market forces rather than proactive. This makes those years an optimal testing ground for the relationship of exchange rates to economic fundamentals and we carried out an analysis of these relationships, using two well-known models.

The results of the analysis suggest that the evolution of exchange rates during the 18th century, even though not homogeneous throughout the century, could be used as a textbook example. During the first ninety years of the century, the exchange rate behaved according to PPP-considerations, and it very closely mimicked the evolution of inflation differentials. These differentials were most likely a consequence of variations in relative money supplies. We find, therefore, an economic context where increases in the quantity of money generated domestic inflation and the exchange rate moved in order to keep relative price levels constant. The bilateral trade between the two countries was mostly balanced and this put little pressure on the exchange rate. However, in the last years of the century, swings in the exchange rate parallel closely the evolution of the bilateral trade balance, which in fact became much more unstable. These trade-induced fluctuations in the nominal exchange rate led to changes in the real exchange rate, which may have compensated –though our data do not allow for a formal testing– differences in real growth, in productivity or in costs between the two countries. These findings are quite relevant from the methodological point of view. The last point mentioned hints at the strongest conclusion from the historical point of view, a conclusion that opens quite exciting avenues for future research: the changes in the real exchange rate experienced in the last years of the century may have benefited Spain more than was previously thought, since they could be compensating for the productivity and growth differentials with respect to Great Britain.

We believe our paper has given a step ahead in our understanding of the functioning of exchange rates and of the historical circumstances of exchange rate fluctuations. Much work remains to be done, though, especially in data collection and the construction of appropriate measures of 18th century economic variables. The effort seems to be warranted, though, since the scope for potential findings is enormous.

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