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Exchange Rate Behavior and Exchange Rate Puzzles: Why the XVIII Century Might Help

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ABSTRACT

This article explores the behavior of exchange rates in Spain during the XVIII century. We posit that exchange rates were the result of both government intervention over nominal values of currencies and the estimate that the market –of bills of exchange- gave to the value of the currency. We analyze the exchange rates quoted in London on three Spanish cities between 1699 and 1826. After a brief overview of the functioning of the Spanish monetary system and of exchange rate determination, we assess the extent to which the exchange rate responded to market fundamentals by testing some theoretical models of exchange rate determination. The results suggest that purchasing power parity held during the XVIII 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 balance between Spain and Great Britain and, maybe, to productivity differentials

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1.Introduction

Mercantilist states in the XVI, XVII and XVIII centuries had the capacity to affect the market exchange rate of a specific currency in an effort to attract inflows of specific currencies, to avoid outflows, or simply as a means to obtain fiscal revenues. Both the "official" value of the currency and the relative prices of gold and silver or silver and copper could be altered. However, experience had shown that the multiple forces in play in the foreign exchange market ended up leading to significantly different exchange rates (Wee, 1981: 375). One of the best descriptions of the workings 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 beat: " […] 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" (Bordázar, 1736: 104)[1].

Following this metaphor, the role of the conductor could not be played exclusively by one nation, but belonged 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 happen 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 for success" (Hirschman, 1999: 98).

Exchange rates in those early centuries were, therefore, the result of confronting the uncontrollable desires of governments to manipulate the relative prices of currencies or precious metals with the estimate that the foreign exchange market made of the "correct" relative prices.

[1] "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 reciproca 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 i baja de punto" Bordázar (1736: 104).

Since purchasing power parity (PPP) was initially formulated in the XVI 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 not strong, and research reporting that PPP fails to hold is by now abundant (Rogoff, 1996, and Froot and Rogoff, 1995). Several explanations have been offered for its apparent breakdown. Both economic – the existence of transportation costs or barriers to trade, the use of nontradables in the construction of price indices, government intervention and speculation in the foreign exchange market – and statistical explanations – the use of data series too short to capture the time series properties of deviations from PPP – have been advanced and tested in order to account for this empirical failure. Explanations based on policy considerations have also been advanced, mostly regarding the different exchange regimes available, and the different degree of exchange rate management implied by the regimes.

Furthermore, the dynamic determination of exchange rates is still an open question. Models –based on general or partial equilibrium analysis– that specify a set of fundamental economic variables that determine exchange rate behavior have been available for decades –see Isard (1995), Obstfeld and Rogoff (1996) or Sarno and Taylor (2002)– but when these models are fit to data, the results are far from encouraging. 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, Obstfeld and Rogoff (2000), comment how this apparent lack of "connection" of the exchange rates with its fundamental variables (which they term the *exchange rate disconnect puzzle*), is one of the remaining major puzzles 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 XVIII century. The XVIII century witnessed two trends that make this time period especially relevant. First, an extraordinary development of the international capital markets –the new "financial architecture" (Neal, 2000:117)- 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 XVII century, and most notably from 1720 to 1790, European governments limited somehow their intervention in monetary affairs, partly to avoid the inflationary episodes that previous interventions had inevitably led to and partly because they found other safer and more stable sources of financing (Bonney, 1995). Pierre Vilar aptly described the European monetary system of the XVIII century: “there are no mutations, people are not betting on sudden movements of the exchange rate and the outflows and inflows of currency are clearly explained by the balances of payments” (Vilar, 1972: 378).

Our choice of Spain also 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 mercury, and the persistence of a trade deficit –resulting from the enormous volume of imports flows into Spain- that could be financed by a large increase of silver production in Mexico (Espina, 2001). 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 since the rate was calculated from the supply and demand of bills of exchange. This is quite important for our purposes, given that it provides us with a market determined value of the exchange rate which we then use in our empirical analysis.

The rest of the article proceeds as follows. In Section 2 we describe the characteristics of the monetary system extant in Spain during the XVIII century. This description is necessary to understand the context in which the exchange rates we analyze were determined. In Section 3 we review the data sources used to construct a database of the exchange rates quoted for different Spanish cities. In Section 4 we carry out an empirical analysis of the exchange rate data that attempts to explain its 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 by Spain during the late XVII and early XVIII centuries had a more intense stabilizing effect on domestic monetary conditions than in the rest of Europe and greatly contributed to the smooth functioning of the international system (Hamilton, 1988: 37). 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 battle (García Guerra, 2000: 34). The pressing financial needs of the Spanish monarchs (of the House of the Austrias) had forced them to continuously issue new *vellón* (an alloy of silver and copper) currency. This led to an unstoppable inflationary process, to the disappearance of silver coins in circulation and to a premium on silver over *vellón* (Motomura, 1997). In 1680, when this premium on silver had reached 275%, a series of deflationary measures aimed at reintroducing silver currency into circulation were undertaken: the nominal value of *vellón* was reduced to half its previous value and the issuing of copper currency with intrinsic value similar to its nominal value was permitted. Later, these measures would be complemented with others more inflationary in nature, but still aimed at the reintroduction of silver currency. In 1686 the weight of the recently issued *reales* was reduced by 25% while keeping their nominal value, and the nominal value of silver coins was increased from 8 to 10 silver *reales*. This 25% revaluation of silver coins was aimed at attracting individuals towards the *cecas*. According to most researchers, this package of measures was quite effective: Vilar called it a "surgical procedure," Dominguez Ortlz mentions how silver "abandoned its hideout and went to the market again" and García de Paso considered it key to understand the "end of monetary disorder in XVII century Castilla" (García de Paso, 2000: 72-73).

Beyond the symbolic character of the reform[2], an important related consequence was the acknowledgement by the Government of the existing pressures on metal coins. It was gold, rather than silver, that 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. Same as with *vellón*, the government acted acknowledging market forces "considering it impossible to

[2] Muñoz de Amador (1755: 8) referred to it as "the most celebrated, which we still call la Baxa de la Moneda (the fall of the currency)".

counter the People in the great importance given to gold and conforming with trade practices"[3] (García Cavallero, 1731: 225). 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" (Hamilton, 1988: 53). The problem came with the subsequent change in the bimetallic rate, that went from 15.45:1 before 1686 to 16.48:1 afterwards. This forced the rate farther from its value in the rest of Europe, thus making Spanish silver more attractive (Hamilton, 1988: 54).

It is important to stress that the monetary reforms of the 1680's were exclusively applied in peninsular *cecas*, not in the American colonies (Santiago, 2003: 209). Domestic monetary difficulties would therefore not be passed onto 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 currency (Vilar, 1972: 337). This system had the disadvantage of duplicating the reference values, especially for international trade. Bordázar 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, 1736: 104). Bordázar himself confirms that the most important international merchants were habitually doing this. The difference between both currencies was around 25% 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 market[4]. The problem, therefore, could be quite efficiently solved by the market and by accounting practices[5].

The arrival of the Borbones at the beginning of the XVIII century did not drastically alter the monetary system, despite the fact that the Succession War led to pressing financial needs that woke up old inflationary temptations. Governments managed to

[3] "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 their increased expenses […] thus turning their *haziendas* to little volume and much value, as gold has. Gold is bought with little thought, becoming so demanded that no practical considerations can avoid its revaluation" (García Cavallero, 1731: 207).

[4] "In trade the old silver is worth 25% more than the new one. Old silver is used in Cadiz and Sevilla whereas new silver is used in Madrid, Bilbao and San Sebastián. With Amsterdam we trade in *ducados* of 357 mrs and the *ducado* is divided in *sueldos* and *dineros*. 1138 *ducados*, 15 *sueldos* and 6 *dineros* from Cadiz or Sevilla are 3131 *florines*, 12 *sueldos* and 8 *dineros* in Amsterdam; the same 1138 *ducados*, 15 *sueldos* and 6 *dineros* from Madrid or Bilbao correspond to 2548 *florines* " (Bordázar, 1736: 99-100).

[5] 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: 70).

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 Felipe V the legitimacy to put an end to the superposition of several monetary systems within the country. Even though separate currencies were kept for internal use, the coinage of currencies different from that of Castilla –which became the official national currency- was discontinued in 1724 (Mateu, 1955). At the same time, the legal circulation of foreign currencies was prohibited. Coinage would exclusively be carried out by the *Casas de Moneda* on behalf of the *Real Hacienda*, which would purchase the metal from individuals, that as a consequence lost the capacity to issue currency (Sadar, 1948: 13). In order to obtain a tighter control, the Treasury General became in charge of appointing the officials for the *cecas* and of covering the coinage expenses while at the same time enjoying the seignorage (Santiago, 2003: 215).

Felipe 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, "plata provincial", different from the old *reales*, "plata nacional", that could be used in the Indias and Spain and were the reference for international trade (Hamilton, 1988: 69, 87). The "plata nacional" was given superior status and the exchange rate between the two was kept approximately at 75%. This policy of a strong trading currency had the objective to avoid "the loss of international prestige of the *real de a ocho*" (Santiago, 2003: 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" (Hamilton, 1988: 86). The only drawback of this policy of a strong currency was suffered by the American colonies, given that the demand for currency generated a recurrent scarcity of precious metal in the Indias[6].

The monetary policy of the Borbones also maintained the inflows of gold into Spain. When in 1686 the relative value of gold was changed, the intention was to adapt 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 on

[6] Gelman 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 that could be sent to Europe (Gelman, 1983: 485-486)

attracting gold, and kept the policy of overvaluation. Between 1686 and 1772 the value of gold in Spain increased by 11.1%, from 16.75:1 to 14.87:1 (Marién, 1788, I: 38-41)[7].

This policy had the problem of reducing the domestic value of silver, with the subsequent incentive to export it. The deficit of the balance of payments that Spain had with the rest of the European countries was accentuated. The peso went through several devaluations: in 1728 a peso contained 24.82 grams of silver whereas after 1777 it only contained 24.44 grams, thus having lost 1.5% of its intrinsic value (Salvucci, 1994: 132). This devaluation was explicitly demanded by Spanish politicians that attempted to slow down the silver "hemorrhage" that Spain was suffering[8]. There were, additionally, 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 XVIII century (Salvucci, 1994: 137).

The devaluation of the provincial silver currency, the one mainly used in Spain, was more severe. The equivalent in grams of silver of the *real de vellón* coined in the kingdom of Castilla between 1688 and 1800 decreased by 29.5%. This reduction was not uniformly done throughout the century. Between 1688 and 1708 the real lost a 20.1%; 5.6% between 1708 and 1738; 3.4% between 1738 and 1778 and, finally, 0.4% between 1778 and 1800 (Feliu, 1991: 20). Thus, the largest devaluations of provincial silver took place during the first decades of the century.

[7] The values in Hamilton (1988: 54, 99) differ slightly, but the trend is similar: 1:16.48 to 1:15.2, an 8,7% revaluation, from 1686 to 1772.

	Marién	Hamilton		
	Spain	Spain	England	France
1685		15,45		
1686	16,75	16,48	15,39	14,91
1726	15,125	16		
1728	16	15,06	15,2	14,6
1730	15,0625			
1737		15,06		
1772	14,875	15,03	15,2	14,63
1779	15,8			
1786	16	16,61	15,2	15,5

[8] 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 towards 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 ouflow of silver (Stein, 1989, Sardá, 1988).

The limited scope of these devaluations was underscored by Sardá, who maintained that the Borbones did not really carry out a policy aimed at stopping the outflows of metal but had fiscal considerations in mind (Sardá, 1948: 17-20). The control that the *Real Hacienda* exerted on the *Casas de Moneda* 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 *marco*, was devoted to favoring the *ceca* officials and to financing technical improvements in the coinage process. The secret devaluation carried out in 1771 and 1786 was intended mainly to finance the technical upgrading of the Spanish mint (Santiago, 2003: 217).

The Spanish monetary system went through a major breakthrough in 1780 with the introduction of fiduciary money guaranteed by the Government (Herr, 1977). In order to finance the expenditures of the war against Great Britain, the government authorized the issuing of *vales reales* for a given nominal amount (the first *vales* had a nominal value of 600 *pesos*) that 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* of up to 22%. After the war was over, confidence in the *vales* was regained, and from 1786 on they were exchanged at 1% or 2% 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 positively 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 of 1762 million *reales*, which quickly led to a sharp depreciation[9].

In general, therefore, Spanish monetary system evolved during the XVIII century towards increased stability and uniformity. The new monetary order favored the existence of a strong international currency, although a scarcity was created in the colonies. The outflows of silver, originally caused by the recurring trade balance deficit, were accentuated by the interest to attract gold towards Spain and the Indias. 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 Prince had to adapt to market forces more frequently than he would have desired. In the confrontation between the Prince and the merchants –who usually would have opposite needs- there was still much margin for market forces.

The conclusion from this brief analysis of the monetary reforms in XVIII century Spain seems to be that most of these reforms were consequences of pressures in the exchange rate –i.e., in the relative prices of currencies given their metallic content- and not viceversa. 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 we do that 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 XVIII century: *The Lloyd's List* and the *Course of the Exchange* (University of Leicester and British Library). The financial and commercial information that these periodicals offered has made them a well known source and numerous researchers have used that data to analyze issues related to XVIII century finance and economics (McCusker, 1992; Neal, 1990; Schneider et al., 1991).

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 for these markets, that were in fact very active, is unsettling, since one of the main elements of financial markets is the importance of arbitrage and their inherent multilateral character (Shubert, 1989; Quinn, 1996; Michie, 1998). At the same time, the relevance that Spain had in European trade –especially with Great Britain– assigns to this country a prominent role in the economic context of the period.

[9] In july 1799, when the discount on vales reales was already a 40%, they were recognized as a "true currency" with a discount of 6%. 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% (Herr, 1977: 123).

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 the country with the largest number of cities listed in both publications. (Torres et al. 2003b). This predominance even increased during the last years of the century. While at the beginning of the century three out of seventeen European cities listed were Spanish, at the end of the hundred-year period the Spanish cities listed were five or six (San Sebastián, Coruña, Barcelona, Sevilla, Málaga and Gibraltar) out of a total of twenty five and, at some points, as many as eight.

Similarly, this neglect of Spanish cities does not parallel the strategic role played by Spain in the international capital market. All financial intermediaries needed to be well aware of the behavior of the main Spanish markets, and be able 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 in the international capital market.

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, whereas Bilbao was added in May 1714. The quotes were maintained until 1826, and were only discontinued momentarily during years of war between Spain and Great Britain (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 markets: “Spanish merchants that import goods issue bills against *Madrid, Cádiz and Bilbao, which is where the Spaniards pay*” (Marién, 1788, I: 32, italics added). Given that a significant proportion of Spanish imports were balanced in those three cities, it was natural 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 Madrid (Maixé, 2001).

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 explains the exchange rate in Cádiz 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" (Luque de Leiva, 1780: 105). 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 just natural that the exchange rate decrease and in the second case it will increase, because in this, as in everything, abundance depreciates and scarcity appreciates" (Correo Mercantil, 31-1-1793, f.68). 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 six (Marién, 1788, II: 59). 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% in the case of Madrid-Cádiz and below 1.77% for Madrid-Bilbao, having been on average even smaller during the second half of the century (Torres et al. 2003a). That is, Spanish financial markets behaved much similarly with respect to London throughout the XVIII century, and the existing discrepancies tended to disappear. This tendency came to a sudden stop in the XIX century, as data from the first three decades of the century show. Einzing, 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 8% (Einzing, 1962: 175).

The City, therefore, showed throughout the XVIII 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 publication [10]. The evidence suggests that the exchange rate was quoted in pence per silver *peso*.[11]. This conclusion is confirmed by the examination of manuals for merchants. In one of them, in 1778 we find the quote "Londres gives 39 *dineros* and a half on Cadiz and Madrid for one *peso* of 8 *reales* of old silver" (Savall, 1778: 161); similarly, in 1789, Marién mentions that "in London, a silver *peso* is exchanged for 37 sterling pence" (Marién, 1789, I: 7). These figures are quite close to the average value of the exchange rate on all Spanish cities that we obtain for the whole XVIII century: 38.392. [12]

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 attempts by the government to change the nominal of the currency. However, within those ranges, it seems that indeed quotes on Spanish rates depended very directly on the economic variables behind the market for bills of exchange. Thus, this context provides a much appropriate setting for the analysis of the relationship of the exchange rates to relevant economic fundamentals. We carry out this analysis in the following section.

[10] Spain used three types of currencies for international trade: the silver doblón, 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 and 1 maravedí of old silver10. 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 as currency when moving capital to London, Lisbon, Genoa or Liorna. The silver doblón 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 XVIII century. When trade was established with new areas –Russia, Prussia or Sweden- the currency chosen would be that of the market that functioned as intermediary –Amsterdam, and the silver ducado (Marién, 1788, II:121).

[11] The old silver *peso* was a fourth of a *doblon*, and it was worth 8 old silver *reales* or 15 *reales* and 2 *maravedises de vellón*, 128 *quartos*, 272 old silver *maravedises or* 512 *maravedises de vellón*.

[12] We thank the referees for suggesting us to specify clearly the currency unit to which the quoted exchange rates were referred.

4. Empirical Evidence: The XVIII Century as a Testing Ground for Exchange Rate Models

We carry out in this section an analysis of the exchange rate between the Spanish and the British currencies (*pesos* and pence respectively) in the XVIII century[13]. We describe first the behavior of these rates by means of a simple graphical analysis, trying to identify the periods determined by different economic contexts or events. We then describe the formal models that we build upon, and the econometric methodology used in order to analyze the relationship between XVIII 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 econometric estimation. We also comment on the limitations of the analysis, which point at directions for future research.

4.1 Evolution of Spanish Exchange Rates in London

We show in Figure 1 the evolution of the monthly exchange rate during the complete XVIII 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 sterling* against the *peso* during the XVIII century, a trend that only reverses in the last years of the century. At the end of the XVII century, the exchange rate on Madrid and Cádiz was around 53 pence sterling 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* just halfway through the century. This appreciation of the British currency was especially intense during 1720-1739, which were the years of peaceful Spanish-British relationships, that brough along a continuous increase in their economic linkages, and of the Spanish devaluation of silver at the end of the 1720's. During these first forty years of the century, exchange rates on Spanish cities decreased by 30%, reaching a

[13] "A sterling pound was composed of 20 shillings, each of which corresponded to 12 pence. One pound was equivalent to 95 Spanish *reales* and 22 *maravedies de vellón*. A Spanish *peso* was equivalent to 15 *reales* and 2 *maravedíes de vellón*" (Marién, 1788). London exchange rates on Spanish cities were quoted in pence, so that at the time of Marién writing you needed 36 pence to buy a Spanish *peso*.

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 years the *peso* only lost an average of 0.9% 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% with respect to 1739. Notice that we have stressed especialy the relationship between the bilateral trade and the exchange rates, even though later we will attribute much of the *peso* depreciation in this 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 therefore the pressure for exchange rate depreciation- the new conflict strengthened the pound. Between 1777 and 1785 the peso lost an average of 14.2% in the three Spanish cities, bringing the cumulative depreciation to 55.8% with respect to the levels 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. This was severly 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%. Again, we could see here the effect of the bilateral trade balance, since it is in these years when the Spanish trade deficit starts to improve significantly (see 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% and it was not until a new alliance, which had a balsamic effect on the Spanish economy, was established between Spain and Great Britain that the *peso* recovered and its exchange rate stabilized at around 36.2 pence in 1817.

(Insert Figure 1 here)

The immediate question arises as to the economic causes of this evolution of the exchange rate, especially in regards to the relationship of exchange rates 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 2-4 the evolution of prices –more exactly, inflation rates–, the Spain-Great Britain trade balance and relative money supplies. [14]

The first significant finding, in line with the subsequent statistical analysis, relates inflation rates and the theory of relative purchasing power parity (Section 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 (and this stays for the rest of the sample) the depreciation of the *peso* stops and the exchange rate stabilizes. Knowing that the bilateral trade was basically balanced during those years (see Figure 3), 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

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

money supplies, which is seen to increase significantly (the 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 would be explained in terms of the higher growth of real activity in Great Britain during the second half of the century.[15]

(Insert Figure 2 here)

We now turn to the analysis of the bilateral trade balance between Spain and Great Britain and here the evidence is again quite revealing. During the earlier years, and almost until 1787, trade between the two countries was basically balanced, and no significant deficits or superavits persisted over the years. We did mention before, though, that a (small) chronic deficit between 1750 and 1770 may have accentuated the depreciation of the rate during those 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 years of high Spanish superavits being followed by years of high deficits. We have mentioned earlier 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 superavits came hand in hand with currency appreciations and viceversa. Thus, in a period with more stable money supplies and therefore comparable inflation rates, the value of the exchange rate seemed to be driven by another fundamental variable, the trade balance. Of course, given that inflation rates were similar during these years, 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 productive side, differentials in output growth or productivity, or cost related shocks. These would most likely be a consequence of the profound changes in the productive side that Great Britain was experiencing in the turning of the century.

Finally, Figure 4 shows our proxy of the relative money supply defined as the log of the ratio money supplies in Spain and Great Britain. As we can see, this proxy present

[15] In Section 2 it was mentioned 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

negative values during the sample period which indicates that at the beginning of our period of analysis the money supply in Great Britain was greater than in Spain. The subsequent increase in the relative money supply in Spain is parallel to the inflation differentials shown in Figure 2 and therefore the information in this graph is perfectly consistent with our comments above. 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.

(Insert Figures 3 and 4 here)

Our previous analysis has provided 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 Section 4.4.

4.2 Two 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 rate.[16]

4.2.1 PPP and the Monetary Model of the Exchange Rate

The purchasing power parity (PPP) hypothesis was first formally stated –though hinted at as early as in the 1500's– in the XVII and XVIII century. PPP states that the exchange rate between two currencies should be that which would equate the relative national prices if expressed in a common currency.[17] 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^A_t and P^B_t 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 its relative form, that posits that the changes in the exchange rate should exactly offset the changes in relative prices or, in other words, that the rate of depreciation of the exchange rate should be equal to the relative rates of inflation:

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the exchange rate, so we believe that the inflation differential story is still consistent with the data.

[16] 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).

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

$$e_t = p_t^A - p_t^B \quad (1)$$

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

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: These variables 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 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 constant.[18]

During the 1970s the *monetary* model of the exchange rate emerged as the dominant framework for nominal exchange rate determination at the start of the post-Bretton Woods float regime (Frenkel, 1976; Mussa, 1976). 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 of the 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

[17] See Froot and Rogoff (1995), Rogoff (1996) and Sarno and Taylor (2002) for surveys on the PPP hypothesis.
[18] The main conclusion from recent testing of the PPP hypothesis is that PPP is a valid long run international parity condition when applied to exchange rates among major industrialized countries (see Sarno and Taylor 2002).

interest rates, the lowercase letters denote log levels (Note that the money demand parameters α_1 and α_2 are assumed to be identical across countries).

Secondly, purchasing power parity is assumed to hold:

$$e_t = p_t^A - p_t^B \qquad (5)$$

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

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

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

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 flows.[19]

4.2.2 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 XVI century, in particular to the School of Salamanca in Spain (Grice-Hutchinson, 1952; Einzing, 1962; Officer, 1982; Isard 1995).

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 ..."(Domingo de Ibáñez, written in 1594, as

[19] 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 ground 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).

cited in Officer, 1982: 32, and Grice-Hutchinson, 1952: 57-8). 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 recently discovered America, which Spain was the first European country to receive– had on money supplies and on national prices (see Isard, 1995: 57). These inflows 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 of the 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 XVIII century to provide a good explanation of the exchange rate behavior, although we would express it in a slightly modified way. Specifying the demands for national monies as:

$$m_t^A - p_t^A = \alpha_2 y_t^A + \alpha_3 Exports_t^{A\to B} - \alpha_1 i_t^A \qquad (3b)$$

$$m_t^B - p_t^B = \alpha_2 y_t^B + \alpha_3 Exports_t^{B\to A} - \alpha_1 i_t^B \qquad (4b)$$

which, coupled with the PPP condition would yield:

$$e_t = (m_t^A - m_t^B) - \alpha_2(y_t^A - y_t^B) - \alpha_3 TB_t^{A-B} + \alpha_1(i_t^A - i_t^B) \qquad (6b)$$

where, of course, $TB_t^{A-B} = Exports_t^{A\to B} - Exports_t^{B\to A}$ is the bilateral trade balance and the formula again reflects the conventional wisdom that a positive trade balance tends to appreciate the currency.[20]

[20] 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.

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 it has become clear from our description of the data available.

4.3. The Data

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

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

- The price level for Spain, P_t^{Sp} is a consumer price index for the region of Castilla, constructed by Reher (2001).
- 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 Cadiz, 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 piastras– 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).[21]
- The trade balance between the two countries $TB_t^{Sp\text{-}GB}$ 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: 160).

[21] The 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.

- 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 it.[22]

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 results.[23] Thus, our version of the monetary model will only include differential money supplies, differential real output and the bilateral trade balance.

4.4 The Empirical Evidence of PPP and the Monetary Model

We perform now a formal testing of the models outlined in Section 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

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

so that we would 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 how 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 of the two long run relationships is cointegration. We use Johansen's methodology to detect the existence

[22] An alternative ideal proxy variable 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.

[23] 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.

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 (cointegration test) and Table 2 (parameter estimates). The results of the cointegration test in Table 1 are indeed very supportive of the PPP hypothesis: There is significant statistical evidence (at the 1% confidence level) of one single cointegration vector between the exchange rate and the price indices of both countries.[24] We then proceeded to estimate the full error correction model. Results of this estimation appear in Table 2. The number of lags in the distributed lag dynamic specification have been determined by the lags in the cointegration test (4). 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, $\gamma_{0,i}$. These coefficients measure the extent to which each variable reacts to deviations from the implied equilibrium relationship. The coefficients on the price indices are 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 of course some dependence in their own past (coefficients of the lagged terms). However, the adjustment term for the exchange rate is statistically significant and of the right negative sign: when the equilibrium relationship does not hold, for example when the value of the deviation is positive, then 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 seems to move 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 XVIII century.[25]

(Insert Tables 1 and 2 about here)

The estimation of the cointegration model above is done with data from 1700 to 1790 (years after 1790 cannot be used because of the discontinuities in the exchange

[24] Both the trace and the maximum-eigenvalue tests agree. The normalized cointegration 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 cointegrating 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.

rate data).[26] 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 the differentials in inflation, which in turn, corresponded to the behavior of relative money supplies. In that sense, we find a significant relationship of changes in the exchange rate with relative money supplies. In that sense, we would expect to find a significant relationship of changes in the exchange rate with relative money supplies, and indeed we find that (see Table 5 and comments below). Of course, the evidence in the last years of the sample would not be supportive of PPP, since we observe similar inflation rates (although some fluctuations are apparent) but the exchange rate fluctuated quite wildly. We have already commented above how these swings in the exchange rate – and the changes in the real exchange rate that this would provoke – parallel the behavior of the trade balance between the two countries.

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 countries.[27]

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 (cointegration tests are shown in Table 4). 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, since 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 viceversa. Also, fast economic growth in Spain would tend to appreciate the exchange rate vis a vis the British currency. So far, these results are encouraging and, keeping in mind the

[25] This is in line with previous evidence that movements of the exchange rate towards the PPP value, when significant, are quite slow (see Lothian and Taylor, 1996, and Rogoff, 1996).
[26] 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) suggested by one of the referee since our sample period ends in 1790.
[27] 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 XVIII 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.

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 model is done exclusively on data before 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 cointegration 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 (and in other analyses that we have not included but are available from the authors).

(Insert Tables 3 to 4 about here)

To sum up, the PPP hypothesis holds quite reasonably in XVIII century Spain. Movements in relative prices can explain much of what was going on in exchange rate fluctuations in the early XVIII century, especially knowing 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 during those early years of the century, and no major real shocks seemed to take the real exchange rate out of equilibrium –so that relative prices were mostly constant throughout the century. Once the inflows of money stabilized, inflation rates became quite similar in both countries and the exchange rate tended to stay constant. A noticeable change in the economic context made the exchange rate start fluctuating, and significantly so. When trade balance disequilibria became the rule, the exchange rate started behaving in unison with those balances, depreciating in the face of a trade deficit and appreciating in the context of superavits. This is, of course, good news for a fundamental-based explanation of exchange rate behavior. Demand and supply of the different national currencies –or of bills of exchange– generated by trade flows seemed to be a key determinant of the evolution of exchange rates. The fact that

inflation rates did not differed significantly implies that during those years the fluctuations of the exchange rate would mean similar fluctuations of the real exchange rate, and thus significant real effects would be expected. This is 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 XVIII century corresponded to years of intense and profound changes in the productive structure of Great Britain, thus suggesting that indeed significant changes in the real exchange rate should be expected. The discontinuities in the exchange rate data prevents 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 a vis the sterling pound– during the XVIII century. We started the paper with a review of the monetary system in XVIII century Spain and of how exchange rates were determined in the London exchange. The 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 reactions to market forces rather than active interventions. This would make those years an optimal testing ground for the relationship of exchange rates to economic fundamentals and we carried out a thorough analysis of these relationships, using two well-known models as the framework.

The results of the analysis suggest that the evolution of exchange rates during the XVIII 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 would generate domestic inflation, and the exchange rate would move in order to keep relative price levels constant. The bilateral trade between the two countries was mostly balanced, and little pressure seemed to come from there in the early years. However, in the last years of the century, swings in the exchange rate seem to 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 been trying to compensate – though our data do not allow for a formal testing- differences in real growth or productivity / costs between the two countries. These findings are quite relevant from the methodological point of view, but maybe 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 that Great Britain was undergoing.

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

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Figure 1: Exchange Rate British currency/ Spanish currency

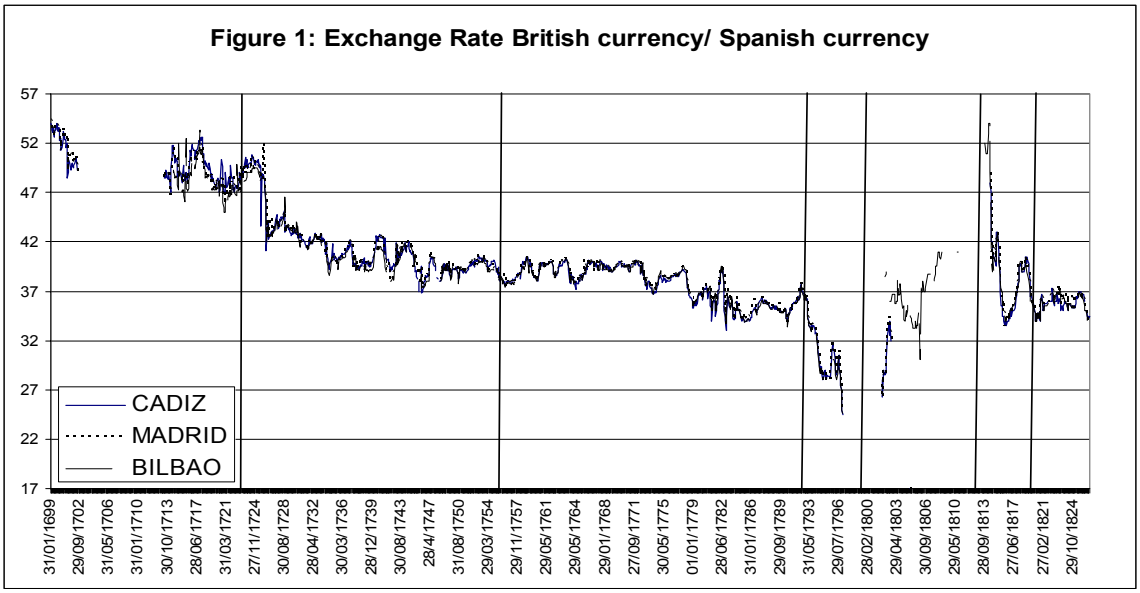

Figure 2: (smoothed) Inflation rates

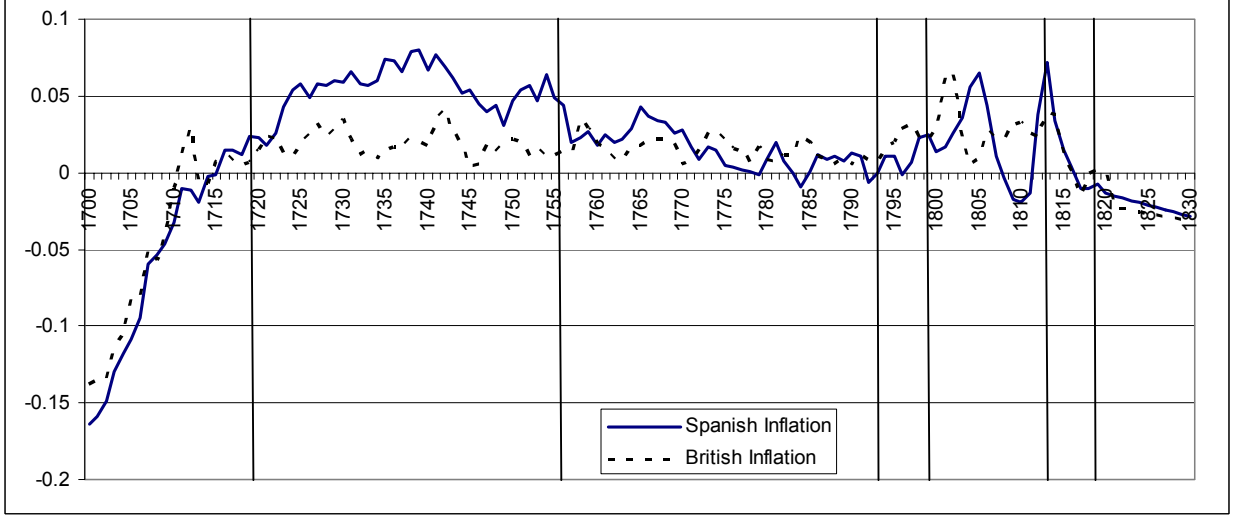

Figure 3: Bilateral Trade Balance Spain-Great Britain

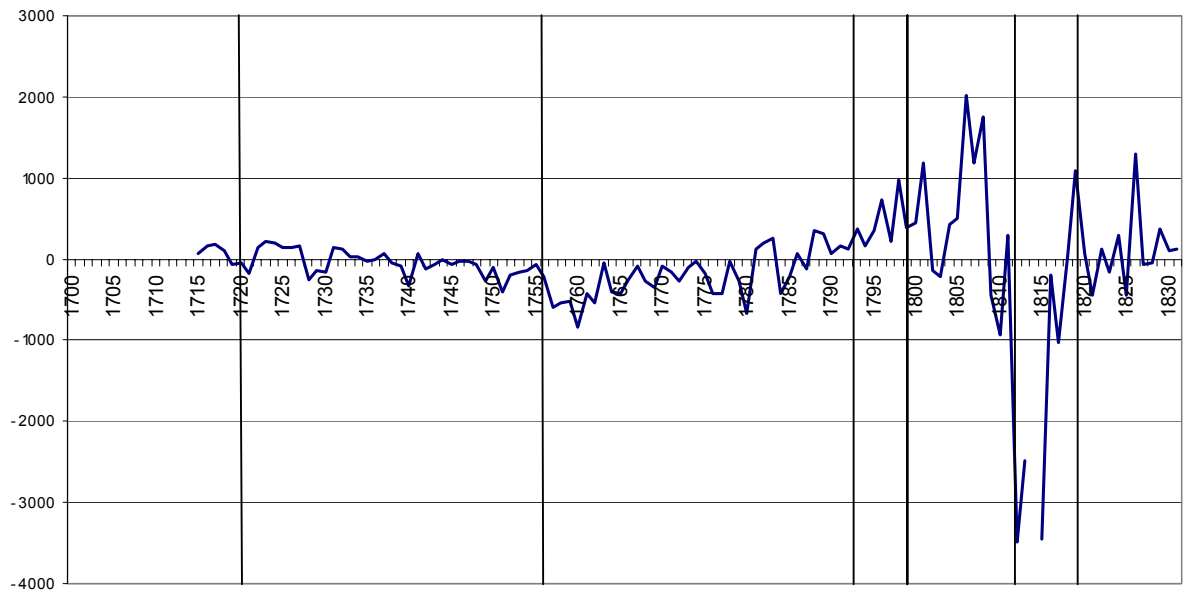

Figure 4: Proxy of (log)ratios of Money Supply

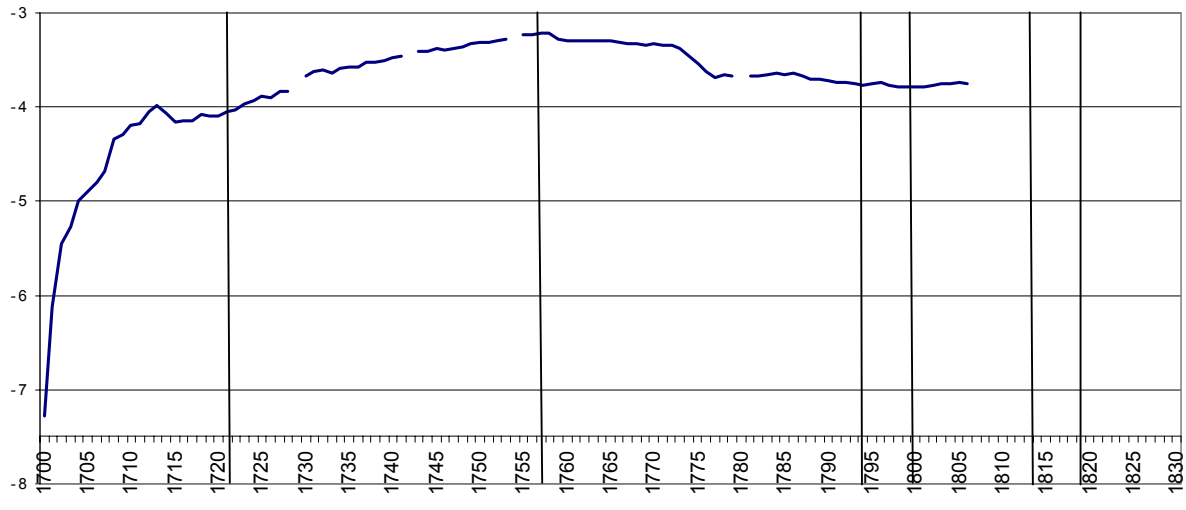

Table 1. Unrestricted Cointegration Rank Test for the PPP Hypothesis, 1718-1819

Trace Test

Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	5% CV	1% CV
None **	0.280552	34.79415	24.31	29.75
At most 1	0.095421	8.123199	12.53	16.31
At most 2	7.91E-07	6.41E-05	3.84	6.51

*(**) denotes rejection of the hypothesis at the 5%(1%) level

MAX-EIGEN TEST

Hypothesized No of CE(s)	Eigenvalue	Max-eigen Test Statistic	5% CV	1% CV
None **	0.280552	26.67095	17.89	22.99
At most 1	0.095421	8.123135	11.44	15.69
At most 2	7.91E-07	6.41E-05	3.84	6.51

*(**) denotes rejection of the hypothesis at the 5%(1%) level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

Exchange Rate	**Price Spain**	**Price England**
-8.429538	-11.20622	16.72433

1 Cointegrating Equation (Normalized cointegrating coefficients):

Exchange Rate	**Price Spain**	**Price England**
1	1.329	-1.984
	(0.15)	(0.13)

Standard error in parentheses

Table 2. Restricted Estimation of ECM for the PPP Hypothesis, 1718-1819

Error Correction:	D(Ex. Rate)	D(Price Sp)	D(Price Eng)
Error Correction Term	**-0.002338**	**0.001723**	**0.001895**
	[-1.82540]	**[0.37870]**	**[0.96492]**
D(Exchange Rate (-1))	0.201956	0.146979	0.028620
	[1.55544]	[0.31867]	[0.14377]
D(Exchange Rate (-2))	-0.162379	-0.457775	-0.237767
	[-1.22965]	[-0.97588]	[-1.17436]
D(Exchange Rate (-3))	0.177736	-0.010453	-0.076548
	[1.48843]	[-0.02464]	[-0.41811]
D(Exchange Rate (-4))	0.190289	-0.896945	-0.068811
	[1.37580]	[-1.82558]	[-0.32449]
D(Price Sp (-1))	-0.010421	-0.151004	-0.034131
	[-0.30827]	[-1.25746]	[-0.65850]
D(Price Sp (-2))	0.054499	-0.193126	0.012886
	[1.60124]	[-1.59735]	[0.24693]
D(Price Sp (-3))	0.015743	-0.088076	0.085298
	[0.45605]	[-0.71825]	[1.61162]
D(Price Sp (-4))	-0.064609	0.107896	0.025938
	[-1.92283]	[0.90395]	[0.50347]
D(Price Eng (-1))	0.032173	0.220705	-0.044071
	[0.41222]	[0.79605]	[-0.36829]
D(Price Eng (-2))	-0.040111	-0.239703	-0.251181
	[-0.53128]	[-0.89377]	[-2.16993]
D(Price Eng (-3))	0.053560	0.395796	-0.140224
	[0.72635]	[1.51102]	[-1.24031]
D(Price Eng (-4))	0.115295	-0.054200	-0.375844
	[1.52599]	[-0.20195]	[-3.24452]
R-squared	0.256825	0.151433	0.229727
Adj. R-squared	0.125676	0.001686	0.093797

Cointegration Restrictions:

Cointegrating Eq:	CointEq1
Exchange Rate (-1)	1.000000
Price Level Spain (-1)	1.000000
Price Level England (-1)	-1.000000

Table 3. Unrestricted Cointegration Rank Test for the Modified Monetary Model, 1752-1797

TRACE Test

Hypothesized No of CE(s)	Eigenvalue	Trace Statistic	5% CV	1% CV
None **	0.752383	71.47769	39.89	45.58
At most 1 *	0.442803	26.80979	24.31	29.75
At most 2	0.219484	8.095037	12.53	16.31
At most 3	0.005156	0.165427	3.84	6.51

*(**) denotes rejection of the hypothesis at the 5%(1%) level

MAX-EIGEN TEST

Hypothesized No of CE(s)	Eigenvalue	Max-eigen Test Statistic	5% CV	1% CV
None **	0.752383	44.66790	23.80	28.82
At most 1 *	0.442803	18.71475	17.89	22.99
At most 2	0.219484	7.929610	11.44	15.69
At most 3	0.005156	0.165427	3.84	6.51

*(**) denotes rejection of the hypothesis at the 5%(1%) level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

Exchange Rate	**Money Diff**	**TB**	**Output Diff**
3.587945	17.18407	15.98568	17.53607

1 Cointegrating Equation (Normalized cointegrating coefficients):

Exchange Rate	**Money Diff**	**TB**	**Output Diff**
1	4.789391	4.455387	4.887496
	(1.31013)	(1.25840)	(1.11346)

Table 4. Unrestricted Estimation of ECM for the Monetary Model, 1752-1797

Cointegrating Equation	CointEq1
Exchange Rate(-1)	**1.000000**
Money Diff(-1)	**4.789391**
	[3.65567]
LOG(TB(-1))	**4.455387**
	[3.54052]
LOG(Output Diff(-1))	**4.887496**
	[4.38945]

t-statistics in [ ]

Error Correction:	D(Ex. Rate)	D(Money Diff)	D(TB)	D(Output Diff)
CointEq1	**-0.008561**	**0.033356**	**0.365505**	**-0.330793**
	[-0.41621]	**[2.71612]**	**1.63164]**	**[-3.26177]**
D(Ex. Rate (-1))	0.378882	-0.259011	1.005572	5.204366
	[1.32940]	[-1.52221]	[0.32399]	[3.70379]
D(Ex. Rate (-2))	-0.157422	-0.446870	0.227959	4.629856
	[-0.38404]	[-1.82599]	[0.05107]	[2.29091]
D(Ex. Rate (-3))	-0.066949	-0.650240	-5.752051	3.417725
	[-0.18336]	[-2.98291]	[-1.44659]	[1.89857]
D(Ex. Rate (-4))	0.403087	-0.269451	6.248517	3.267653
	[0.92947]	[-1.04069]	[1.32304]	[1.52827]
D(Money Diff (-1))	0.038606	0.533198	-3.820744	-0.327285
	[0.11507]	[2.66199]	[-1.04574]	[-0.19786]
D(Money Diff (-2))	-0.365193	0.024650	5.422112	1.607227
	[-0.92684]	[0.10479]	[1.26361]	[0.82735]
D(Money Diff (-3))	0.162365	0.038225	-8.003904	2.592954
	[0.41319]	[0.16293]	[-1.87032]	[1.33836]
D(Money Diff (-4))	0.223381	-0.550979	3.529118	2.377122
	[0.61759]	[-2.55148]	[0.89594]	[1.33300]
D(TB(-1))	-0.071433	-0.114576	-1.843831	1.449917
	[-0.86524]	[-2.32455]	[-2.05079]	[3.56213]
D(TB(-2))	-0.086844	-0.123785	-1.663058	0.847033
	[-1.13972]	[-2.72102]	[-2.00414]	[2.25469]
D(TB(-3))	-0.044749	-0.075708	-0.864732	0.363410
	[-0.92530]	[-2.62206]	[-1.64186]	[1.52412]
D(TB(-4))	-0.030276	-0.012030	-0.045198	0.078513
	[-0.92536]	[-0.61586]	[-0.12685]	[0.48671]
D(Output Diff(-1))	-0.017047	-0.098025	-1.651804	0.897987
	[-0.23294]	[-2.24356]	[-2.07260]	[2.48882]
D(Output Diff(-2))	-0.145029	-0.063037	-1.096228	0.938650
	[-1.69220]	[-1.23196]	[-1.17451]	[2.22140]
D(Output Diff(-3))	-0.101044	-0.112154	-0.900414	0.623140
	[-1.50491]	[-2.79782]	[-1.23141]	[1.88241]
D(Output Diff(-4))	-0.018974	-0.007396	-0.295899	0.459521
	[-0.27692]	[-0.18080]	[-0.39655]	[1.36026]
R-squared	0.672455	0.752393	0.642806	0.731572
Adj. R-squared	0.323073	0.488279	0.261798	0.445248

Table 5. Simple Regression: Changes in the Exchange Rate vs. Money Supply, 1701-1805

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	-0.297930	0.188821	-1.577840	0.1185
Ex_rate(-1)	0.095842	0.056663	1.691448	0.0946
Money Diff.(-1)	-0.017478	0.007255	-2.409097	0.0183
R-squared	0.128368	Mean dependent var		-0.009487
Adjusted R-squared	0.106847	S.D. dependent var		0.041775
S.E. of regression	0.039481	Akaike info criterion		-3.590955

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