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The Curse of Monctezuma American Silver and Dutch Disease, 1501-1650

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Abstract:

In this paper we argue that the windfall acquisition of precious metals from its American mines in the sixteenth and seventeenth centuries set Spain on the path of economic backwardness, triggering a phenomenon known as the Dutch Disease. Thanks to its newly found wealth, Spain relied on imports rather than develop its own traded goods industries and accumulate the specialized human capital so crucial for succeeding in the nascent trading economy of the modern age. We model the economic conditions in Spain using and open economy general equilibrium framework and lay out an econometric specification to test its predictions using real exchange rate series. We construct these series for four Spanish regions, combining available price data with weight baskets obtained from several primary sources. We identify persistent episodes of real exchange rate appreciation, which are largely consistent with the Dutch Disease hypothesis.

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I. Introduction

According to a popular legend, the dying Aztec emperor Moctezuma used his last breath to utter a curse under which any strangers that plundered the riches of his land would suffer from painful diseases. As in the case of many legends, there is no historical evidence that the curse was actually uttered, and Spanish accounts of the emperor's death actually report that his last wishes were that Hernán Cortés, whom he still considered a god, took care of the upbringing of his children. Today, American college students experience firsthand the curse of Moctezuma when they drink untreated tap water in Mexican tourist resorts, but the brave Spanish lion, for three centuries the master of the land of the eagle and the serpent, may have fallen prey to a far more serious and lasting disease because of the plunder of its treasures.

Spain could, upon entering the last two decades of the sixteenth century, boast an empire on which the sun never set. American silver from Potosí and Zacatecas fueled the war machine and oiled the wheels of power, making it possible for Charles I to humiliate France and seize the crown of the Holy Roman Empire and for Philip II to annex Portugal and its vast dominions, claim the Mediterranean as a Spanish-controlled sea and dream of invading England with the Invincible Armada. Spain commanded more resources than any power of its time and extended its reach over more territory than any other nation in history. The economy flourished under the lead of Castile and Andalusia. The former concentrated more than one half of the Spanish population, served as the center of royal power, hosted the renowned fairs of Medina del Campo and dominated the wool trade, Spain's flagship industry. The latter held a monopoly of trade with the new world, tallying the shipments of precious metals and engrossing the crown's finances by collecting the royal fifth. Yet, less than a century later, Spain had lost Portugal and its empire as well as the Low Countries, its economy was in sharp decline, its technology lagged behind that of the rest of Europe and its population had dropped considerably. France was the new hegemonic power in continental Europe and England ruled the seas. Even the American empire, its principal mines exhausted or no longer profitable, became a reason of concern as the British, the Portuguese and the Dutch challenged time and again the Spanish trade monopoly.

Several reasons are often cited as causing or aggravating the Spanish decline of the seventeenth century, with the failure to control fiscal outlays, the simultaneous and ill-fated involvement in several military fronts, and even Malthusian dynamics[1], ranking as the more important ones. Starting with the *arbitristas*[2] at the end of the sixteenth century, several authors have pointed to the influx of precious metals as a significant source of Spanish economic woes. Either because it allowed Spain to pursue disproportionate imperial adventures, because of the inflation it created or because it fueled widespread speculation in public debt, silver soon joined in as a favorite target of those seeking to explain the dire economic situation. Since Earl Hamilton's study[3], the bullion flows from America into the metropolis have been scrutinized time and again by the scholarly literature[4]; unfortunately, the interest in this topic has all to often drifted in a purely monetary direction, either ignoring or attaching little significance to the effects of the vast silver imports on long term trade and production patterns.

Starting with Corden (1981, 1984) and Corden and Neary (1982), a vast literature has developed on how the discovery of large quantities of tradable natural resources can trigger a process of de-industrialization, known as the Dutch Disease after the impact of the discovery of natural gas on the Dutch economy in the 1970s. Forsyth and Nicholas (1983) have made the case that these dynamics might have indeed been present in the Spanish case, where the natural resource in question happened to have a straightforward use as international currency. Furthermore, Wijnbergen (1984) and Krugman (1987) have shown how, in the presence of an industry learning curve in traditional industrial sectors, the effects of de-industrialization may not be reversible once the natural resources are exhausted or their prices fall below the threshold of profitability. More recently, Asea and Lahiri (1999) have further elaborated on the role of resources booms in slowing human capital accumulation, while Baland and Francois (2000) have linked them to increased rent-seeking activity and the ensuing loss of economic efficiency.

[1] See Rahn Phillips (1987) for a concise overview of Spanish decline and a discussion of a Malthusian framework.

[2] The arbitristas were moral and political writers that flourished at the beginning of the seventeenth century. Their writings (arbitrios) were proposals to the king advocating economic, political and social reform. Hamilton's concluding paragraph in his 1938 article in their respect is worth quoting in full: "In a grave national emergency economists were right, for once, in their diagnoses and prescriptions. With prophetic vision, the Spanish economists of the seventeenth century (Sancho de Moncada, Pedro Fernández Navarrete, Géronimo de Cevallos, José Pellicer de Ossau, Diego Saavedra Fajardo, Francisco Martínez Mata, Miguel Alvarez Osorio y Redín, and many others) denounced most of the evils leading Spain to ruin –such as primogeniture, mortmain, vagabondage, deforestation, redundance of ecclesiastics, contempt for manual labor and arts, indiscriminate alms, monetary chaos, and oppressive taxation. Their reform programme comprised technological education, immigration of artisans, monetary stability, extension of irrigations and improvement of internal waterways. History records few instances of either such able diagnosis of fatal social ills by any group of moral philosophers or of such utter disregard by statesmen of sound advice."

[3] Hamilton (1934).

[4] See Flynn (1978, 1979), Morineau (1985) and Fisher (1989) for just a few selected examples.

The Dutch Disease has several testable implications. The one that has emerged most robust across different models is a real exchange rate appreciation, defined as the rise in the price of non-traded goods relative to traded goods. This phenomenon can be tested for by using only price data, widely available for the relevant period in Spain thanks to the works of Hamilton. In this paper, we develop a general equilibrium model to represent the economic conditions in Spain in the fifteenth and sixteenth centuries and present an econometric specification to tests its predictions; we then construct price indexes for traded and non-traded goods, which we use to assess whether Forsyth and Nicholas's conjecture is supported by the evidence.

We are well aware that, even if the presence of Dutch Disease were confirmed at its strongest, it would be a long shot to blame the decline of Spain only on the switch in trade and production patterns due to a natural resource windfall. The very significance of this phenomenon comes into question when considering the small percentage of national product accounted for by trade in early modern period economies. This criticism, however, ignores the dynamic effects of trade specialization and the associated accumulation of human capital on long run growth[5]. Although the size of international exchanges in any given year may have been small, whatever economic growth European economies experienced in both the short and long run is most likely due to the processes ignited by trade. If, while indulging in the availability of large quantities of bullion, Spain neglected its nascent manufacturing industries and missed out on several decades of specialization, its prospects on the European marketplace after the silver stopped flowing must have been bleak at best.

The ramifications of the silver boom can go far beyond altering the patterns of trade and specialization. Resource abundance has recently been linked to the presence and perpetuation of rent seeking behavior and rent-seeking institutions[6]. Spanish trade was laden with medieval remnants, such as the merchant guilds or *consulados* and the *Mesta*, the powerful association representing transhumant shepherds. The crown, which received the lion's share of American treasure, had no need to strike compromises with its constituencies at large, nor did it have any incentive to strike down long established privileges. Its key ally, the Catholic Church, saw a great expansion in its entitlements, inheriting large fortunes, collecting duties and acting as the

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[5] See Romer (1986) and Romer (1994), two seminal papers in new growth theory, for a detailed analysis of the effects of specialization on economic growth. For a historical analysis of the dynamic effects of trade on the Cantabrian regional economy, see Grafe (2001).

[6] See Tornell and Lane (1999), Baland and Francois (2000), Torvik (2002).

main long term lender through the figure of the *censo,* a form of mortgage. After the flow of mineral wealth subsided, Spain may have found itself with perverse institutions that stifled every attempt at modernization and growth[7].

In this paper we abstract from the rent seeking implications of the natural resource booms to focus on their effects on trade and industrialization patterns. In section II, we survey the economic conditions in sixteenth and seventeenth century Spain, making the case that they reasonably conform to the elements of a Dutch disease scenario. Section III develops a general equilibrium model of resource booms in an open economy and lays out an econometric specification to test its predictions. The main input required by the model is a real exchange rate series, defined as the ratio between an index of prices of traded goods and one of prices of non-traded goods. Section IV deals with the problems involved in the construction of such an index and briefly describes the primary and secondary source data used in its construction. Section V presents the main results, and section VI concludes.

II. Silver and economic conditions in imperial Spain

Silver, the natural resource

The fate of the Spanish empire is closely tied to the flows of American bullion. Figure I shows the evolution of imports of American treasure in real terms, constructed using the data from Chart I in Hamilton (1934) and the silver price index reported in its Appendix VIII[8]. The flow of treasure does not really become important until 1550, but after that date a veritable river of silver ran through Spain. The first large increase comes after 1580, at the same time of the annexation

[7] For a discussion of the negative effect of rent seeking on the accumulation of human capital and economic growth, see Murphy, Shleifer and Vishny (1991, 1993). DeLong and Shleifer (1993) document a relationship between more autocratic types of government and lower urban population growth (which they use as a proxy for economic growth) in the eight centuries preceding the industrial revolution.

[8] There is some question as to the accuracy of the Hamilton data for bullion imports, owing to the fact that it draws exclusively on official documents and is therefore susceptible to underreporting and smuggling. Morineau (1985) has argued that the decline in remittances reported by Hamilton is only an artifice of ever increasing contraband. His competing series, constructed on the basis of journalistic and diplomatic reports published in Dutch gazettes, show a steady flow of bullion throughout the seventeenth century. While the argument is attractive, and Hamilton's figures are bound to suffer from the effects of contraband, Morineau's figures stand in stark contrast with the well documented crisis in American mining after 1620 [Flynn (1982), Andrien (1985)]. Silver yields were rapidly declining because of epidemics among the Indian labor force, increasing production and administrative costs and falling silver prices. Viceregal reports starting in 1629 attest to widespread shortages of mercury, a key element in the production process, and by 1660 mining tax receipts in Peru had fallen by more than a third relative to only a decade earlier. It is difficult to reconcile this evidence with the admittedly informal Dutch gazettes reports.

of Portugal and its vast dominions. Treasure imports peak at the end of the reign of Philip II, thus coinciding with the maximum point of imperial expansion.

[Insert Figure 1 here]

The death of Philip II in 1598 is generally considered the beginning of the Spanish decline, and, as we can see, it is also the beginning of the decline in the flow of bullion. The sharpest decrease comes in the period 1635-1640, at a time when the empire suffered its hardest blow with the independence of Portugal (1640). The Peace of Westfalia in 1648 would mark the official demise of Spain as an European hegemonic power and reduce the Holy Roman Empire to a mere shell. By that time, American treasure was not anymore among the main sources of income.

Flynn (1982) traces the increase in the flow of silver from the Indies to the discovery of the mercury amalgam mining process, for which American mines were particularly well suited, and also conveniently located in the vicinity of mercury sources. The reduction in remittances to Spain in the seventeenth century is blamed on reduced profitability, stemming from the decline in purchasing power of silver and ever-increasing costs in the colonies[9].

Silver constitutes a classic tradable booming sector as defined in the theory of Dutch Disease. Rising to prominence after a combination of discoveries of natural resources and technological advances, it met its demise a century later due to continuous erosion in its profitability. Officially, the Crown was entitled to the "royal fifth" of all private imports of treasure. When supplemented with its own mining, the amount of bullion imports under the direct control of the Crown reaches the average of 26% calculated by Hamilton. However, in difficult financial times most of the treasure ended in the hands of the Crown anyway upon being tallied at the Casa de la Contratación, either through lending, voluntary or forced, or outright confiscation. These enormous resources did not prevent the Crown from getting deeper and deeper into debt and declaring bankruptcy in 1556, 1575, 1579, 1607, 1627, 1647 and 1656. The dire situation was prompted by the insolvency of all the Spanish dominions, excluding the Indies. Even the Netherlands, whose revenues were usually greater than any other single source, including remittances from the Indies, were a source of financial drain, as the costs of the military campaigns in the Low Countries far exceeded the income they generated.[10] The Spanish Crown relied on the silver flows as its hard-currency base to incur in high levels of indebtedness, which

[9] Flynn (1982), p. 141; Andrien (1985), p. 61. See also note 8.
[10] Flynn (1982), p. 146

it hoped to pay back with the proceeds of the territories it would conquer with its military campaigns and with the future remittances of American mines. Neither of these prospects materialized and the Spanish imperial adventure quickly gave way to a much starker picture[11].

The trading economy of the Early Modern Age

The bulk of economic activity in Spain took place in Castile, the central heartland where the Crown established its roots during the Moorish wars and where the system of fairs provided the main venue for commercial exchange and credit clearing. Andalusia emerged as a commercial center thanks to the privileged position of its Atlantic ports, right at the gateway of the winds that enabled transatlantic voyages, and to the monopoly of colonial trade granted to Seville, which also housed the Casa de la Contratación, responsible for tallying the bullion remittances. Other important centers of activity where the Mediterranean ports of Barcelona and Valencia, as well as the cities on the Cantabrian shore.

The most important Castilian export was high quality wool from transhumant herds, its production controlled by the powerful institution of the *Mesta* and its distribution monopolized by the *consulado* of Burgos; it was followed by salt, cochineal (a reexport from the Indies), oil, iron, leather manufactures, hides (also an American reexport) and sugar.[12] The imports consisted of textile manufactures, including woolen and linen cloths, cotton manufactures, fish, various spices, tin and metal products, guns and gunpowder, flax and hemp, timber and naval stores, books and paper[13]. Important exports from other regions included wine and olive oil from Andalusia, salt from Ibiza and iron, alum and codfish from the Basque country[14]. Other exports included almonds, oranges, figs, raisins and soap from Andalusia, nuts, legumes, sardines and anchovies from the Mediterranean coast[15] and rice and saffron from Valencia in particular[16].

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[11] This particular course of events may even render moot the debate on the magnitude of the decline in bullion flows for the purposes of our study. The negative outcome of the Crown's military adventures meant that whatever quantities could possibly be extracted form the American mines would have had to be employed in meeting debt payments. While the insufficiency of bullion remittances forced the Crown to declare repeated bankruptcies, a higher flow of silver would have accrued directly to the foreign financiers of the Crown rather than to Spanish nationals.

[12] Lynch (1991), p. 193; Braudel (1972), pp. 122, 228, 695; Rich and Wilson (1967), pp. 160, 182, 184, 280, 291

[13] Lynch (1991), p. 194; Braudel (1972), pp. 155, 228, 243, 381, 420, 425, 448, 590, 608; Rich and Wilson (1967), pp. 157, 177, 159, 162, 163, 169, 173, 174, 178, 192, 287, 288, 421, 553.

[14] Lynch (1991), p. 193; Braudel (1972), pp. 82, 122, 228, 435, 695; Rich and Wilson, pp. 160-162, 184.

[15] Salvador Esteban (1994), p. 37.

[16] Braudel (1972), pp. 42, 82, 119,122, 236, 376, 386, 422, 762, 861; Rich and Wilson (1967), p. 183, Hamilton (1934) p. 233.

As it is easily seen, Spain exported mainly primary commodities, and imported products with high added value, many times manufactured from her own raw materials. Moreover, shipping services had to be purchased from the Dutch and the British, as the Spanish fleets were clearly insufficient and almost exclusively engaged in the trade with the Indies, when not under royal requisition in times of war.[17] This picture of lack of industrialization prompted Kamen's dismissal of the Spanish decline as a mere construction: "It is difficult to see how so an undeveloped nation could have declined before ever becoming rich".[18] As Flynn (1982) points out, it is easy to confuse Spain with its empire; the acquisition of foreign territories didn't mean that industries were flourishing at home. Yet, if decline means the loss of industrial scope, evidence of a decline there is. The fall in population and the disappearance of numerous crafts and industries forced Spain to start importing many commodities in which she was once self-sufficient, such as corn, rice and sugar, or even those she used to provide the world with, such as leather manufactures, iron and alum.[19] Production of fine wool from transhumant flocks declined sharply, spelling the demise of Burgos, the once thriving center of the wool trade[20]. The Basque Country lost its competitiveness in iron goods and even the Newfoundland fisheries, successfully exploited by the Basques during most of the sixteenth century, were lost to the French in the 1580s, never to be recovered[21]. Population fell dramatically, although the exact magnitude of the decline is unclear[22]. Plagues in 1597-1602 and in 1647-52, the expulsion of the moriscos between 1609 and 1614[23], emigration, the demand for manpower of the military campaigns of Olivares and reduction in nuptiality and fertility all contributed to the large demographic changes[24]. Livestock numbers were abruptly reduced, perhaps by as much as 60% between 1600 and 1619 and the size of the fleets trading with America declined significantly between 1575 and 1675[25].

[17] Lynch (1991), p. 196; Hamilton (1938), p. 170.
[18] Kamen (1978), p. 41.
[19] Hamilton (1938), p. 170-172; Rahn Phillips (1987), pp. 542, 545.
[20] Rahn Phillips (1987), pp. 548.
[21] Grafe (2001), p. 61., Rahn Phillips (1987), p. 553.
[22] Hamilton (1938) placed the fall in population at 25% and attributed it almost exclusively to the plague. This figure was picked up by Vicens Vives (1969) in his classic work on Spanish economic history and it remained almost undisputed until very recently. Pérez Moreda (1994), however, showed that Hamilton's figures were taken from the most hardly hit regions, and that the overall population decline attributable to the plague could not exceed, in the worst conceivable case, 8%.
[23] The expulsion of the Moriscos was most relevant in the region of Levant, particularly in Valencia, which expelled some 30,000 families or roughly one third of the population [Rahn Phillips (1987), p.558].
[24] Elliott (1961)
[25] Hamilton (1938), p. 170.

The traditional traded good industries in sixteenth and seventeenth century Spain exhibit a behavior that conforms reasonably to the symptoms predicted by Dutch Disease theory. It was already recognized at the time that foreign goods were taking over markets that had once been served by Spanish industries. Braudel (1972) quotes the Cortes of Valladolid asking the King in 1586 "to tolerate no longer the importing of candles, glass trinkets, jewelry, cutlery and similar objects from foreign countries which are exchanged, although they are useless luxuries, for gold, as if Spaniards were Indians...".[26] From providing to the needs of the domestic economy, generating surpluses for international trade and sustaining vibrant mercantile centers such as Burgos, the Castilian fairs and the Atlantic ports on both Andalusia and the Basque country, Spanish industries gradually fell into stagnation and decline, remarkably when the silver boom was at its peak.

III. Resource booms in an intertemporal open economy model

We have made the case that Spain, in the second half of the sixteenth century, had all the elements needed for the onset of a Dutch Disease process, and by the early seventeenth century was exhibiting some of its characteristic symptoms. We now present a theoretical model and an econometric specification to test more rigorously whether this phenomenon in fact took place and, if so, to quantify its magnitude.

A simple theoretical setup

Dutch Disease models have typically taken the form of partial equilibrium constructs. In their neoclassical versions, such as the original Corden (1981, 1984) and Corden and Neary (1982) works, the economies are resilient in nature, with the effects of the resource boom disappearing as soon as the stimulus is withdrawn. Frameworks that yield lasting effects usually obtain them through ad hoc assumptions, such as the learning curve in Krugman (1987). We now propose a general equilibrium model based on Rebelo and Végh (1995), where lasting adverse effects from a resource boom can be obtained if the temporary nature of the natural resource windfall is incorrectly perceived as permanent by the agents.

Households

The utility function of the representative household is

[26] Braudel (1972), p. 519. The unearthing of the detail is attributed by Braudel to Karl Marx in his *Zur kritik der politischen oekonomie*.

$$U = \sum_{t=0}^{\infty} \beta^t \frac{1}{1-1/\sigma} \left\{ \left[\left(C_t^T\right)^\gamma \left(C_t^{NT}\right)^{1-\gamma} \right]^{1-1/\sigma} - 1 \right\} \quad 0 < \gamma < 1 \tag{1}$$

where C_t^T and C_t^{NT} denote consumption in period t of tradable and non-tradable goods and σ is the intertemporal elasticity of substitution. Households will allocate their labor between the traded and non-traded goods sectors and public employment. Denoting by N_t^i the amount of labor allocated to sector i in period t, and by N the total amount of labor in the economy, we have

$$N_t^T + N_t^{NT} + N_t^G = N \tag{2}$$

Note that no labor is allocated to the extraction of silver. This simplification is warranted by the fact that the main source of manpower for the extraction of its riches was native slave labor. This assumption stands in contrast with classical Dutch Disease models and allows us to obtain more streamlined results.

Traded and non-traded goods are produced according to Cobb-Douglas production functions, using fixed specific capital endowments and time invariant specific productivity factors.

$$Y_t^T = Z^T \left(N_t^T\right)^\alpha K^{1-\alpha} \quad 0 < \alpha < 1 \tag{3}$$

$$Y_t^{NT} = Z^{NT} \left(N_t^{NT}\right)^\eta T^{1-\eta} \quad 0 < \eta < 1 \tag{4}$$

where Y_t^i denotes the output of sector i at time t, and Z^i is the productivity factor for sector i. We also assume that the non-traded goods sector is relatively more labor intensive than the traded goods sector, which implies $\alpha < \eta$. The only public employment is assumed to be in the army, which does not produce any good or service[27].

The households' budget constraint is

$$Y_t^T + p_t Y_t^{NT} + w_t N_t^G + b_{t-1}(1+r) + s_t(1-\tau_t) = C_t^T + p_t C_t^{NT} + b_t \tag{5}$$

where p_t is the price of non-traded goods in terms of traded goods (the reciprocal of the real exchange rate) in period t, w_t is the wage the government must pay for people to enlist in the army in period t, b_t represents the households' net holdings of foreign assets, r is the

[27] The army is necessary to fight wars, which could be modeled as a lottery with positive payoff only in the event of victory. However, given the insolvency of the Spanish dominions, it is unclear whether this was ever the case. Alternatively, the army can be thought of merely as a requirement for the economy's continued existence.

exogenously given world interest rate, s_t denotes the silver inflow in period t and τ_t is the rate at which silver is taxed. Finally, the no-Ponzi game condition[28] for the households is

$$\lim_{t\to\infty}\frac{b_t}{(1+r)^t}=0 \qquad (6).$$

The government

The government collects taxes on private silver flows, funds its military operations and has access to international financial markets. Its budget constraint is

$$f_{t-1}(1+r)+s_t\tau_t=f_t+w_tN_t^G+G_t \qquad (7)$$

where f_t denotes the government net holdings of foreign assets in period t and G_t represents government expenditures that do not require labor. G_t is assumed to be exogenous and unproductive. The government's no-Ponzi game condition is

$$\lim_{t\to\infty}\frac{f_t}{(1+r)^t}=0 \qquad (8).$$

We assume that the requirements of military labor are set exogenously to the economy, and thus

$$N_t^G=\overline{N}^G \qquad (9).$$

Equilibrium in the goods markets

Assuming all goods are perishable, and thus no inventories are carried over, production of non-traded goods must equal consumption, and production of traded goods must equal their consumption plus the trade balance. That is

$$Y_t^{NT}=C_t^{NT} \qquad (10)$$

$$Y_t^T=C_t^T+TB_t \qquad (11)$$

where TB_t represents the trade surplus in period t. Denoting the sum of private and government foreign assets in the economy by a_t, we can use equations (5), (7) and (10) to derive the aggregate resource constraint of the economy.

$$C_t^T+G_t=Y_t^T+s_t-\left[a_t-a_{t-1}(1+r)\right] \qquad (12).$$

Optimality

[28] A standard boundary condition, the no-Ponzi game or transversality condition precludes household from paying old debt only by new borrowing, thus preventing them from taking an explosive debt path.

Assuming $\beta = \frac{1}{1+r}$ to avoid trends in consumption, the first order conditions for the household maximization problem yield

$$\frac{1-\gamma}{\gamma}\frac{C_t^T}{C_t^{NT}} = p_t \qquad (13)$$

$$p_t \eta Z^{NT}\left(N_t^{NT}\right)^{1-\eta} T^{\eta-1} = \alpha Z^T\left(N_t^T\right)^{\alpha-1} K^{1-\alpha} = w_t \qquad (14)$$

Equation (13) determines the relative consumption levels of traded and non-traded goods given their relative price, and equation (14) states that the value of the marginal productivity of labor must be equal across sectors, and in turn equal to the wage for serving in the army. Moreover, in the steady state any level of foreign assets is consistent with equilibrium.

A boom in natural resources

Starting form an initial situation with no silver flows, imagine that significant silver reserves are discovered in a given period t, guaranteeing a positive flow of bullion between periods t and $t+k$, where $k \in \{0, 1, 2, \ldots, \infty\}$. The present value of the future resource flows evaluated in period t would be given by

$$S = \sum_{i=t}^{t+k}\left(\frac{1}{1+r}\right)^{i-t} s_i \qquad (15).$$

Assuming perfect foresight by all the agents, and given that there are no constraints on the use of financial markets and that the ricardian equivalence holds in this model, the effect of the bullion flows on the economy are equivalent to a one-time infusion of silver equivalent to S. In such an event, consumption of both goods will increase to reflect the expanded household budget constraint. Since non-traded goods must be produced locally, labor must be switched from the traded to the non-traded sector. Physical marginal productivity of labor will increase in the traded sector and decrease in the non-traded sector; since the value of the marginal product of labor must be equal in both sectors by equation (14), w_t and p_t must increase. And by equation (13), consumption of traded goods will expand relatively more than consumption of non-traded goods. The trade balance will fall by the expansion in consumption plus the reduction in production of traded goods, and the trade deficit will be covered with the interest from increased foreign assets. All the effects from the one-time increase in natural resources will be permanent and closely match the symptoms of the Dutch Disease, an increase in wages and in prices of non-traded goods, as well as a contraction in the traded goods sector. However, as our model stands, a resource windfall results in permanently increased consumption and utility. As Wijnbergen (1984) noted, such an outcome can hardly be labeled a "disease".

Misjudging the nature of the windfall

Imagine now that, although the increased flow of silver which started in period t is in effect for a finite number of periods, k, households operate, between periods t and $t+k$, under the incorrect belief that the boom is permanent (i.e., that k equals infinity)[29]. In this case, they will have calculated an incorrect value for S, the present value of the future flows of silver, an error that will be evident when period $t+k$ rolls around and the flows come to an end. The level of consumption between periods t and $t+k$ would have been too high to be supported by the actual level of foreign assets, and consumption of both traded and non-traded goods will have to fall. The magnitude of the fall will be determined by the magnitude of the error in the nature of the windfall, but under the convex utility function we assumed, the temporal path of consumption would have been suboptimal vis-à-vis the perfect foresight scenario. If the error is large enough, consumption could fall to a level lower than the original one. Particularly damaging scenarios can occur when the flow of natural resources is incorrectly forecasted to grow as time passes. In such cases, the initial jump in consumption would be financed by incurring in large foreign indebtedness; when the silver flows fail to materialize, the only options will be large cuts in consumption and, eventually, bankruptcy. The Spanish case, where the silver discoveries prompted large increases in consumption and expenditure, only to be followed by a series of bankruptcies and falling income when the flow of silver eased, seems to echo this last scenario.

Estimating the timing and size of regime changes

The model presented so far predicts discrete jumps in the real exchange rate whenever new information regarding the present value of silver flows is unveiled. We now lay out an econometric specification based on J. D. Hamilton's model of structural change[30], which allows us to estimate the timing and magnitude of any discrete jumps our real exchange rate series may exhibit.

[29] Notice that an unexpected increase in G in period $t+k$ (or the realization that G was in fact much greater than previously believed, perhaps brought about by a bankruptcy) will have the exact same effect as an unexpected decline in the flow of bullion.

[30] Hamilton (1995), Ch. 22.

We define a regime as the agents' perception of the present value of future bullion remittances. This is an unobserved variable, the value of which we would like to infer from our observation of the real exchange rate. For simplicity, we will treat the regime as a discrete-valued variable, focusing only in large changes in agents' perceptions. The relationship between the regime and the real exchange rate stems from our theoretical framework.

Consider the following h^{th} order autoregressive specification

$$y_t - \mu(s_t) = \phi_1\left[y_{t-1} - \mu(s_{t-1})\right] + \phi_2\left[y_{t-2} - \mu(s_{t-2})\right] + \ldots + \phi_h\left[y_{t-h} - \mu(s_{t-h})\right] + \sigma(s_t)\varepsilon_t \qquad (16)$$

The mean and standard deviation of the autoregressive process in each period t depend on the value of s_t, an unobserved, discrete-valued variable which indexes the underlying regime. We assume that the roots of the polynomial $1 - z\phi_1 - z^2\phi_2 - \ldots - z^h\phi_h$ lie outside the unit circle, thus requiring the series under analysis to be covariance stationary once the changes in regime are accounted for. We further assume that s_t takes values in the set $\{1, 2, \ldots, S\}$ according to a first order Markov process with the associated matrix of transition probabilities

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1S} \\ p_{21} & p_{22} & \cdots & p_{2S} \\ \vdots & \vdots & \ddots & \vdots \\ p_{S1} & p_{S2} & \cdots & p_{SS} \end{bmatrix} \qquad (17)$$

where p_{ij} is defined as the probability that $s_t = j$ given that $s_{t-1} = i$, and the sum of each column is equal to 1.

Define $\psi_t = (y_t, y_{t-1}, \ldots, y_{t-m})$ as a vector containing every observation of the real exchange rate through date t. If $s_t = j$, the conditional density of y_t is given by $\eta_{t,j} = f(y_t | \, s_t = j, \, \psi_t; \, \alpha)$, where $\alpha = (\mu_1, \ldots, \mu_S, \sigma_1, \ldots, \sigma_S, \phi_1, \ldots, \phi_h)$ is the vector of parameters characterizing the conditional density. We face the problem of estimating α and making inferences on the value of s_t in each period.

Let Θ be a vector collecting the population parameters α and the transition probabilities p_{ij}, and assume for the moment that Θ is known. Let $P\{s_t = j | \, \psi_t; \, \Theta\}$ be the conditional probability that $s_t = j$ based on data obtained through period t and the knowledge of Θ, and collect the probabilities that s_t equals each possible state j in the $S \times 1$ vector $\hat{\xi}_{t|t}$, which thus represents the inference about the regime in period t using all the information available up to that period.

Given observations through date t, it is possible to make a forecast about the probability of observing each regime at date $t+1$. Collect these forecasts in $\hat{\xi}_{t+1|t}$, a $S \times 1$ vector where the j^{th} element equals $P\{s_{t+1} = j |\ \psi_t; \Theta\}$.

The non-linear filter derived by Hamilton (1989) obtains the optimal inferences and forecasts about s_t by iterating on the following two equations

$$\hat{\xi}_{t|t} = \frac{\left(\hat{\xi}_{t|t-1} \otimes \eta_t\right)}{\mathbf{1}'\left(\hat{\xi}_{t|t-1} \otimes \eta_t\right)} \tag{18}$$

$$\hat{\xi}_{t+1|t} = P\hat{\xi}_{t|t} \tag{19}$$

where $\otimes$ denotes element-by-element multiplication. The algorithm can be started by setting $\hat{\xi}_{1|0}$ equal to any vector of nonnegative constants adding up to unity, or to the vector of unconditional probabilities for each state. The first equation yields the probability that s_t equals each state j at each time t; these are called the filter probabilities. Hamilton (1995) goes on to show that the algorithm also yields the value of the log-likelihood function evaluated at Θ in the form of

$$\ell(\Theta) = \sum_{t=1}^{T} \log f\left(y_t |\ \psi_{t-1}; \Theta\right) = \sum_{t=1}^{T} \log\ \mathbf{1}'\left(\hat{\xi}_{t|t-1} \otimes \eta_t\right) \tag{20}$$

Using numerical methods on equations (20), (18) and (19) it is possible to obtain the maximum likelihood estimates of Θ and their associated filter probabilities.

A further improvement on the inference about s_t obtained through the filter probabilities can be achieved by calculating the so-called smoothed probabilities, which incorporate all the available data rather than only the observations up to period t. The smoothed probabilities can be calculated using Kim's algorithm[31]:

$$\hat{\xi}_{t|T} = \hat{\xi}_{t|t} \otimes \left\{P'\left[\hat{\xi}_{t+1|T} (\div) \hat{\xi}_{t+1|t}\right]\right\} \tag{21}$$

[31] Kim (1993)

where $(\div)$ denotes element-by-element division. The algorithm is started by using $\hat{\xi}_{T|T}$ from the Hamilton filter and the smoothed probabilities are obtained by iterating backwards for $t = T-1,\ T-2,\ ...,\ 1$.

The above specification requires that both the number of states and the number of autoregressive lags be determined prior to estimation. Given the number of states, the number of lags can be determined by using a number of information criteria and verifying the absence of serial correlation in the residuals. Selecting the appropriate number of states is a more complex issue, since some of the parameters in the alternative hypothesis will not be identified under the null, and therefore the standard Wald, likelihood ratio and Lagrange multiplier tests do not have a standard asymptotic distribution. Garcia and Perron (1996) illustrate the implementation of a number of tests that have been suggested for use in these cases, but their size and power remain mostly unknown. Given the particular restrictions that we will later impose on the transition probabilities, the J-test for non-nested hypothesis proposed by Davidson and McKinnon (1981) will be the best suited for model selection in our context.

One potential problem with the above specification is that, in the presence of a highly volatile series, a strong negative autoregressive behavior can be mistaken for a constant alternation between high and low states. Since we want to focus on long-term trends, we would like to impose a restriction that would favor persistent states over short-term fluctuations. One way to achieve this would be to apply a low-frequency filter to the data; this approach, however, has the disadvantage of precluding the estimation of short-term properties of the series, such as the true volatility of each state. An alternative for models with three states or more is to impose a "cycling" restriction, which keeps the data in its original form but requires that after a transition from one state to another, the model has to pass through at least a third state before returning to the original one[32]. This imposes a high cost in terms of likelihood for constant switching and tends to swing the estimates to persistent states, while still allowing us to characterize the short-term behavior of the series.

[32] For example, in a case with three states this can be achieved by setting $p_{12} = p_{23} = p_{31} = 0$.

IV. Constructing price indexes and real exchange rates

As outlined in the previous sections, our inquiry on whether Spain's economic performance is consistent with a process of deindustrialization will revolve around the evaluation of regime changes in real exchange rate series. This is the most robust implication of the class of models that deal with the macroeconomic effects of resource booms in open economies[33], and is very convenient for dealing with developments in a pre-statistical era, for which price data are reasonably available while data on other macroeconomic variables are extremely hard, if not impossible, to unearth. Once alternative explanations are ruled out, a significant decrease in the price ratio of traded to non-traded goods, tantamount to a real exchange rate appreciation, would be a strong indication of the presence of Dutch Disease. Moreover, a reversal of this trend coinciding with the initial indications of the exhaustion of silver or the Crown's bankruptcies would be consistent with the conjecture that Spain misjudged the magnitude of the resources available to her. The first step in our empirical analysis will therefore be to construct price indexes for traded and non-traded goods for the regions in which we wish to conduct our test.

Price data: Hamilton's legacy

The price data for our tests comes from Earl J. Hamilton's American Treasure and the Price Revolution in Spain: 1501-1650 [Hamilton (1934)]. In an effort that spanned over six years, Prof. Hamilton and his wife collected hundreds of thousands of observations from Spanish archives and created price series for 158 different goods across the four regions of Andalusia, New Castile, Old Castile-Leon and Valencia, a geographical classification that we will maintain throughout our analysis. Each observation is the result of no less than three and up to twelve price quotations for each year, adjusted for seasonality and cross-checked with alternative sources for possible alterations due to fraud or embezzlement[34]. These quotations were taken from a vast array of sources, mainly account books from hospitals and monasteries, with

[33] See, for example, Edwards (1984), Fardmanesh (1991), Musonda and Luvanda (1991). For an exception, obtained by imposing learning curves in both the booming and the lagging sectors of the economy, see Torvik (2001).

[34] See Hamilton (1934), pp. 139-151 and appendix I, p. 309, for an explanation of the sources and methods used in compiling the data. Although this description can be less than clear in some aspects, Hamilton's original worksheets, collected in The Earl J. Hamilton Collection at the Rare Book, Manuscript and Special Collections Library at Duke University, allow for a rare glimpse into the mechanics of his work. We surveyed in detail the data sheets and annotations corresponding to American Treasure and the Price Revolution in Spain: 1501-1650, from where we gained some insight into the construction of his series and obtained many of the sources which we later used to construct our consumption baskets.

occasional observations taken from the accounts of royal households or from victualing of ships to fill in gaps.

Coming from such particular institutions, the data differs from the typical household consumption basket in some significant ways. Most notably, we don't have any indication of rent payments, since hospitals and monasteries owned the premises in which they functioned[35]. Hamilton's data are also scarce in textiles, the only usable series being the prices of linen in Old Castile-Leon. Metals are also notoriously scarce in the series. Even wool, Castile's flagship export, registers observations for only the last fifty years of the period.

A first sorting of the data consisted in classifying the 158 goods into traded and non-traded. Although not every single good could be categorized, those who were left out have no bearing in the indexes. Indeed, when a good is not mentioned in the vast literature on modern age trade in Europe, this should be taken as enough indication that its relevance was, at best, very limited. Despite its shortcomings, Hamilton's dataset remains the standard source for Spanish price history. Occasional amendments for particular goods have surfaced, but there is no other data source so comprehensive, both in time and in scope. To this day, the literature on the subject continues to use it as its main reference tool.

The problem of weights: some new data

Hamilton did not concern himself with the problem of weighting, and his indexes are a simple arithmetic mean of all the available prices[36]. Subsequent research has since tried to fill this gap. Brown and Hopkins (1959) provide a first set of consumption weights for Valencia, which was then adopted by Martín Aceña (1992) to calculate his price index for Castile. More recently, Llopis et al. (2000), taking advantage of some consumption studies from families and monasteries to correct some biases in the original Brown and Hopkins series, have proposed a new set of weights including 31 goods. All these works, however, use very rough estimates of the consumption baskets, based mainly on qualitative appreciations. The use of spurious weights, particularly those with no solid quantitative base, can cast serious doubt over the validity of any price index. To correct this shortfall in the literature, we set out to construct new estimates, using

[35] The interested reader can find some isolated observations of rent payments from peasant families to monasteries, the largest landowners of the time, in Brumont (1984), pp. 32-35. These observations, however, are quoted in kind, in terms of different goods and cover only the period from 1550 to 1580, making it virtually impossible to obtain a reliable series from them.

[36] Hamilton (1934), p. 149.

as a starting point the same monasteries, royal households and hospitals from which Hamilton extracted his price series.

After reviewing several account books from institutions in Old Castile, New Castile and Andalusia, we selected those which survived in more complete form. While Hamilton could afford to use fragments to calculate a price average in any given year and control for seasonal variations using the remaining data from other years, a consumption basket that left out any significant length of time within a year would be subject to strong seasonal biases. We therefore compute baskets from those sources for which we have at least one uninterrupted year, and possibly two consecutive years to check for consistency. After selecting the source, all transactions in a given year were entered in a database with fields for the date, the name of the good purchased, the quantity and the total amount paid. Goods were then classified between traded and non-traded and separated into broad expenditure categories. While the quantity purchased was not always contained in the records, only the total expenditure on each good, and not the unit price, is necessary to compute the relative weights[37].

Our results are not exempt from bias. Royal households represent the extreme upper tail of the income distribution, while hospitals and monasteries will exhibit consumption patterns that reflect their specific institutional goals. The best approach to identify the nature of the biases for each kind of institution would be to compare the baskets generated by as many different sources as possible in the same general period and note the differences in the leading goods. While we still don't have enough data to conduct an analysis of this kind, we can nonetheless spot abnormal weights in each basket and identify their potential effect on our results by performing sensitivity analysis[38].

Table 1 reports the consumption baskets obtained from the household of Queen Joanna in Tordesillas (Old Castile) in 1546[39], those presented in Llopis (2000) for rich and poor

[37] This meant that sources that were not useful to Hamilton for constructing price series because only a few years existed could be very useful to us if the records were otherwise complete; this was particularly true for royal households. Also, it is likely that in the future we will be able to use sources discarded by Hamilton, since we don't need a unit price to be present for a record to be considered. On the other hand, we were not able to include books for which only a few months have survived due to the risk of seasonal bias.

[38] For example, the basket computed from the account books of the house of the Hospital de las Cinco Llagas in Seville in 1587 shows that 8.55% of the budget was spent in bread and cereals, a suspiciously low figure given that results from all other sources, including other years from the same hospital, range between 25% and 35%.

[39] Archivo de Simancas, Casas y Sitios Reales 12 (29), Simancas (Valladolid).

households[40], and the weights from the Hospital de las Cinco Llagas in Seville in 1623[41]. For the two baskets that we computed from primary sources, we also report the percentage of each category composed of traded goods. Less complete or reliable sources were used to check the consistency of the computed weights. These include books that report only expenditures on certain categories, such as the kitchen accounts of Hospital de Esgueva for 1659 (Old Castile)[42]; books that report only a summary of expenses aggregated in broad categories, such as the Convento de San Pablo in Toledo (New Castile)[43]; and sources that seemed suspicious because of extremely abnormal weights in some of the leading goods, such as the books of Hospital de las Cinco Llagas in 1587[44]. In a future version of this work, we hope to include the results from the House of Prince Philip, at least four monasteries throughout Castile and more years from Hospital de las Cinco Llagas.

[Insert Table I here]

Although two sets we compiled so far differ between themselves in some significant ways, it must be kept in mind that they represent two very different institutions, one of which was ministering to the poor in the center of colonial trade in the seventeenth century, while the other was providing for a confined queen in the middle of the Castilian plain eighty years before. The series from the household of Queen Joanna is comparable to the Llopis basket for rich households, since they come from roughly the same period, region and social strata. When relevant categories are considered together (such as meat and live animals, or cereal and bread) the weights are roughly in the same range, except for wine (which Llopis estimates at a high 15% of consumption) and textiles (which are somewhat low in our estimates, but perhaps too high in Llopis'). However, our basket exhibits a much more variegated array of goods, enabling us to include more price series into the analysis[45]. While many of these commodities represent small

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[40] The Llopis baskets, which subsume all the previous research in the area, are reproduced here for comparison purposes. It should be noted that both of them add to slightly more than 100%.
[41] Archivo de la Diputación Provincial, Hospitales 114, Sevilla (Sevilla).
[42] Archivo Histórico Municipal, Hospital 120 (313), Valladolid (Valladolid)
[43] Archivo Histórico Nacional, Clero Secular Regular Libros 16026, Madrid.
[44] Archivo de la Diputación Provincial, Hospitales 109, Sevilla (Sevilla)
[45] It must be kept in mind that, while Table 1 reports expenditure categories, our actual consumption baskets consist of individual goods. The basket computed from Queen Joanna's accounts is based on 3583 separate entries for 215 different goods, although many of them appear only once and carry very small weights. Llopis' baskets, in contrast, contain 31 goods for the rich households and 24 for the poor ones.

expenditures, some of them can gain relevance when estimating separate indexes for traded and non-traded goods.

The nuts and bolts of constructing the price indexes

Although we have gathered the price series, sorted them into traded and non-traded goods and obtained consumption baskets, there are still some problems to be dealt with before a usable real exchange rate series can be obtained.

The first problem is designing a procedure to translate the weight baskets yielded by our primary sources into the final basket used to construct the price indexes, since the availability of price series varies significantly across regions. To lessen the effects of asymmetric representation of different categories of goods in our indexes, we used a category-based reweighting procedure. After gathering all the suitable[46] series for a region, we determined the percentage of each of the categories in Table 1 represented by them[47]. We then assigned to each good a weight equal to its raw weight in the primary sources divided by the percentage of its category covered by the available price data, thus increasing the final weight of goods in categories with poor representation. This reweighting procedure rests on the assumption that the prices of goods in the same category tend to fluctuate together; Hamilton (1934) provides some evidence in this respect.

A related problem is posed by the choice of a weighting basket over such a long period. Inevitably, the composition of consumption and trade must have changed over a century and a half that saw Spain rising from a loose collection of kingdoms to the world's dominant power and then falling back to a minor role in the geopolitical scene. The use of a single basket for the whole period is bound to do wrong to the variations that surely took place. While at this point we can only rely on the basket from Queen Joanna's household,[48] we are confident that an expanded version of our dataset currently being compiled will allow us to alleviate this problem by using data from several different periods.

[46] We considered a price series suitable if it registered observations for at least 50% of the years in the period.

[47] The categories we used in reweighting differ slightly form the ones presented in Table 1, because in some cases products in different categories could actually represent the same underlying good, such as bread and wheat. In fact, some institutions bought the cereal and baked their own bread, while others elected to purchase the final product. To keep a certain consistency across institutions, we merged the two relevant categories to perform the reweighting. Incidentally, this is also the reason why bread is classified in Table 1 as a traded good.

[48] The basket from the Hospital de las Cinco Llagas, coming from seventeenth century Andalusia, would be a less than appropriate match both for Old and New Castile and for the second half of the sixteenth century, the period we wish to focus on.

The next obstacle is determining the impact of missing price observations, quite pervasive in some periods and regions. While several econometric techniques are available to impute the missing observations, we feel that it is important to first assess the magnitude of the missing data problem and its potential implications. Manski (1995) shows how to obtain lower and upper bounds for the true value of a variable by replacing the missing observations alternatively with their minimum and maximum logically possible values, thus imposing no assumptions at all on the behavior of the unobserved data. Since we are dealing with prices, the minimum and maximum logically possible values are zero and infinity respectively; using them would yield meaningless estimates and, indeed, an upper bound equal to infinity. We shall therefore replace them with some reasonable extreme values. For the purpose of this exercise, we calculate the lower bound by filling any gap with either the last observation before it or the first immediately after it, whichever is lower. Similarly, we calculate the upper bound by using the other value. This procedure assumes that any missing price would have been between the two closest observable prices; although this assumption is bound to be wrong in some instances, the persistent price inflation and the resulting upward trend in prices mean that in most cases we won't be far off the mark. Since the bounds are quite tight in the vast majority of years, a moderate relaxation of this assumption is not likely to have a major effect.

A third issue arises with the choice of the base period. To reduce biases, Hamilton (1934) split the series into three 50-year sub-periods, and calculated index numbers for each of them using averages of the middle decades as base periods to minimize the possibility of picking an abnormal year. The successive literature has consistently followed this practice, although it has tended to rejoin the three sub-periods into one 150-year long series. This procedure has the potential of incurring in considerable biases; however, since we are interested in ratios of index numbers and not in the indexes themselves, our final results would be exempt from any such bias. In fact, both the numerator and the denominator of our ratios would be subject to the same distortion, thus canceling each other out. Also, several test runs have shown that our results are not sensitive to the choice of the base period. We therefore adopted the decade of 1601-1610 as a base, given its relatively central position in the series and the very few missing data instances occurring in it.

A final consideration needs to be made regarding the weights for traded products. Although our sources will yield consumption baskets, the appropriate magnitudes for traded goods need to be augmented by exports to accurately reflect the composition of the basket relevant to the real exchange rate calculations. Given the total lack of itemized trade statistics, we can only experiment with different plausible magnitudes for the main exports, namely wool, wine and oil, and note the resulting variations in the indexes, which fortunately are never large enough to alter our main results.

V. The evolution of the real exchange rate

Armed with price indexes for traded and non-traded goods for each of the four Spanish regions surveyed by Hamilton (1934), we set out to construct real exchange rate series and evaluate the extent to which they are consistent with the presence of Dutch Disease. We express our results as an index of the relative price of traded goods in terms of non-traded goods; a fall in the index indicates a real exchange rate appreciation, the movement predicted by the Dutch Disease model. As our individual price indexes take the form of a lower and an upper bound, so will the relative price indexes. The lower bound on the relative price index for each region is constructed dividing the lower bound on the appropriate traded goods index by the upper bound on the corresponding non-traded goods index. Conversely, the upper bound is constructed dividing the upper bound on the traded goods index by the lower bound on the non-traded goods index.

Geographical subdivisions

As stated briefly in section IV, Hamilton adopted a geographical criterion in his subdivision. Therefore Old Castile and Leon, which occupy the northern plains of the peninsula, are considered a single region, while New Castile, separated from the former two kingdoms by the Sierras of Guadarrama, Galdós and Cata, is treated as a separate unit. Old Castile thrived on the fairs of Medina del Campo, and its wool export market at Burgos concentrated the production of most of Spain. Valladollid and Palencia were also important economic centers. New Castile, with its central position, was a strategic spot for the central administration of the collection of kingdoms that formed Spain. Already during the Reconquista, in the year 1087, the royal capital was transferred from Burgos to the New Castilian town of Toledo, and Philip II would establish it at its definitive site in Madrid in 1561. Andalusia, south of New Castile and separated from it by the Sierra Morena, organized its economic life along the river Guadalquivir, on which Cádiz, Seville and Córdoba, enjoyed the benefits of the Mediterranean climate and of the American trade. Finally, the region of Levant, east of Andalusia and New Castile and separated from them by the Sierra Nevada, featured Valencia as its main city. Omitted from this classification are Galicia, the Basque Country, Navarre, Aragon, Catalonia, Murcia and Extremadura. Nonetheless, the four included regions cover over 60% of the Spanish territory and as much as three fourths of its population and economic life.

Real exchange rate series

Figure 2 shows a 4-year moving average of our estimates of the upper and lower bounds for the real exchange rate in each of the four regions. The solid black line represents the mean value of the bounds. The first striking feature is the high volatility, with the maximum observed values for the real exchange rate being twice as high as the minimum ones in some cases. Some of the troughs coincide exactly with large demographic changes, such as the recurring plagues in the opening years of the seventeenth century; since a fall in population would have the effect of decreasing available labor, thereby increasing the price of non-traded goods, this observation is entirely consistent with our model. Other extreme values are more difficult to explain; while the volatility is undoubtedly linked to the high weight of food staples in the indexes, some of them, such as wheat, fall into the traded category, while others, eminently fresh meats, are non-traded. Bad harvests, a breakdown in trade, a cattle epidemic and many other factors could result in significant movements in the series. Finally, while the sixteenth century was largely free of fiat money driven inflation, seventeenth century monarchs normally resorted to minting copper money, changing the units of account and debasing the currency in ever more desperate attempts to cover fiscal deficits and service their overwhelming debt[49]. These large monetary disturbances may have had diverse effects on different categories of goods, thereby causing large swings in the real exchange rate.

[Insert Figure 2 here]

The thin lines in each picture represent the upper and lower bounds for the real exchange rate, while the solid black line is just their mean value. It is immediately apparent that the Andalusian data are too weak to be useful; there are almost no price observations before 1550, and in the second half of the sixteenth century missing data instances are so pervasive that the bounds are apart beyond any tolerable measure. Not without regret, we need to abandon the study of this

[49] See MacKay (1981). For a comprehensive account of monetary units and changes in their gold content in the sixteenth and seventeenth century, Hamilton (1934) provides a good starting point; however, the successive corrections by Motomura (1994, 1997) must be kept in mind.

region, which held a crucial position in the colonial trading system, until more consistent price series are compiled.

We conducted several test runs of the Markov switching model[50] on the full 150 observations for the three remaining regions, experimenting with different combinations in the number of states and lags. In each case, we failed to obtain consistent results. Specifications with low numbers of states tended to lump together most of the observations in a single state, reserving the remaining ones only for the highest peaks or lower troughs. Specifications with higher number of states tended to exhibit high volatility, predicting changes in regimes at almost every period. These results are likely indications of misspecification, which comes hardly as a surprise; the Spanish economy underwent large fundamental transformations and was subject to major exogenous shocks throughout the period, many of which affected the real exchange rate. In particular, the plagues, fiscal crises, demographic changes and monetary disturbances that became commonplace after 1600 meant that Spain was, in the seventeenth century, a fundamentally different nation than the one that was ruled by Charles I and Philip II[51]. Another likely source of trouble is the low quality of the data in the first quarter of the sixteenth century, a period for which only a small amount of sources survives, and those that do are far less systematic and reliable than comparable ones later on. In order to alleviate the misspecification problems, we concentrate on the years 1531-1600; since the largest silver mines were discovered in the mid-1540s and the fiscal crisis does not become severe until the 1580s (which will also see the first large-scale military disasters), our time frame allows between one to two decades to each side of the period where we expect to identify a Dutch Disease phenomenon.

When estimating the switching regression model on the 1531-1600 subsample, the information criteria[52] and the J-tests select models with three states and no autoregressive lags for New Castile, while three states and two autoregressive lags were selected for Old Castile. In the case of Valencia, the tests point to a one-lag specification under two states and two-lag specification under three states. However, the smoothed probabilities in the two-state models mimic the short-term fluctuations in the series, assigning one state to each single trough observation and the other

[50] All the estimations of the Markov switching model were conducting using professor James D. Hamilton's software, available from http://weber.ucsd.edu/~jhamilto/software.htm

[51] Another problem is our use of a single weighting basket for the whole 150 year period, which is likely to introduce significant biases in the price indexes given these large structural changes.

[52] We used the Akaike Information Criterion and the Bayesian Information Criterion, which yielded concurring results.

state to everything else. This makes us lean towards the three-state specification, which is restricted to identify persistent states and results in much more plausible estimates. We report the estimates for three selected models in Table 2.

[Insert Table 2 here]

Figures 3 to 5 show our results for each of the three regions. In the top panel of each figure we reproduce the real exchange rate series without any filtering or smoothing. In the bottom panel, we report the smoothed probabilities for the process being in each of the three states at each point in time. The solid line represents the probability of the series being in the state with the lowest mean ("low state") and the dotted line represents the probability of it being in the state with the second lowest mean ("medium state"). The probability of being in the state with the highest mean ("high state") is just one minus the other two probabilities. The time scales on both panels are set to coincide with each other, thus allowing the reader to relate the estimated underlying state to the value of the real exchange rate at each point in time.

In figure 3, which presents the results for New Castile, it is immediately apparent that the high state was needed only to accommodate for the peak of 1549, while all the other years correspond the medium and the low states. The low state is in effect between 1550 and 1580; from the estimates in Table 2, it is possible to compute that the real exchange rate during that period is on average 11% lower than in the medium state years. The volatility of the real exchange rate in the low state is less than one half of that in the medium state. These results are strongly consistent with the presence of Dutch Disease between 1550 and 1580; while the real exchange rates on occasion sinks to low values outside this period, the appreciation is nowhere so persistent as during these three decades.

[Insert Figure 3 here]

The results for Old Castile follow a somewhat similar pattern. A high mean, high volatility state is present in the years 1539-1546, while the rest of the period is split between the low and medium state in a fashion similar to the one of New Castile. However, the difference between the low and the medium states is only 4.8%, and the null hypothesis that the difference is different from zero cannot be rejected at a 95% confidence level.

[Insert Figure 4 here]

Valencia, the final region, exhibits a different behavior. There are no outlying observations, and therefore no need to use a state to account for them. However, the real exchange rate hovers around different values before and after the appreciation episode. Thus, the series starts in a medium state, falls into a low state around 1554, and switches to a high state in 1577. In the low state, the real exchange rate is on average 14.2% lower than in the medium state, and 25% lower than in the high state. The volatility does not change from state to state. These results are again consistent with a period of Dutch Disease between 1554 and 1577. This episode of real exchange rate appreciation, while a few years shorter on each end, is consistent with the ones estimated for New and Old Castile.

[Insert Figure 5 here]

VI. Conclusions

Soon after discovering the large mines of Potosí and Zacatecas, Spain embarked in a thorough expansionist program, as reflected in the ever increasing size of the Spanish government under Charles I and Philip II and its pervasiveness through all aspects of economic life[53]. The already indebted crown resorted to creative finance to transform the expected revenues from the Indies into powerful armies and fleets with which to project its power over the known world and be the first to reach the yet unknown. Fueled by American treasure, this drive dwarfed any other factors that might explain our observations in the movements of the real exchange rate during the time period under examination. Large demographic changes or monetary disturbances, the main contender when it comes to persistent changes in the real exchange rate, came too late as to possibly have any impact. When it was clear that the magnitude of the flows of American minerals had been miscalculated, Spain was repeatedly forced to declare bankruptcy, and found herself with an economic structure ill suited for its new reality. While we have not established a causal relationship between the imports of bullion and the movements in relative prices, we believe that the synchronization between them helps to build a compelling case supporting our hypothesis.

The heterogeneity of the price data across the different regions prevented us from constructing standardized indexes, as the choice of goods included in each case was necessarily dictated by the availability of the relevant series. The baskets we used, while based on the same fundamental

[53] Ulloa (1977), the classic account on the finances of Philip II, is an excellent source on the impact of taxes and public debt on the economy of the kingdom.

weights, vary substantially across regions, reflecting the surviving price series in each case. These differences are particularly noticeable in the case of non-traded goods. This shortfall, however, doubles as a sui generis robustness test, lending further support to our results as the increase in the relative price of non-traded goods is consistent across regions despite the variations in the baskets.

Scholars and conventional wisdom alike have long set the death of Philip II in 1598 as the beginning of Spain's long decline. Contemporary writers, however, were well aware that something in the inner workings of the empire had been wrong since much earlier. Writing in 1600, González de Cellorigo looked at what he saw as the main reason of the already apparent downturn in the fate of the kingdom: "Our Spain has set her eyes so strongly on the business of the Indies, from where she obtains gold and silver, that she has forsaken the care of her own kingdoms; and if she could indeed command all the gold and silver that her nationals keep discovering in the new world, this would not render her as rich and powerful as she would have otherwise been"[54].

[54] González de Cellorigo (1991), p. 50. The translation is our own.

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Table 1

Category	Queen Joanna (1546) Percentage of Expenditures	Queen Joanna (1546) Percentage Traded	Llopis poor Percentage of Expenditures	Llopis rich Percentage of Expenditures	Cinco Llagas (1623) Percentage of Expenditures	Cinco Llagas (1623) Percentage Traded
Meat	12.92%	0.00%	17.00%	19.00%	7.90%	0.00%
Live Animals	5.85%	0.00%	2.00%	3.50%	32.30%	0.00%
Animal Products	4.00%	45.96%	4.00%	6.75%	1.35%	38.78%
Cereals	17.45%	100.00%	45.90%	31.00%	25.39%	100.00%
Bread	18.23%	100.00%			0.00%	
Fruit	4.09%	28.94%	1.00%	2.00%	1.45%	53.80%
Vegetables and Legumes	2.22%	58.21%	0.50%	0.50%	0.73%	87.83%
Plants and Herbs					0.34%	0.27%
Vegetable Products	7.42%	35.21%	1.50%	3.00%	5.16%	76.80%
Medicines	0.64%	100.00%			0.69%	20.20%
Fish	4.51%	92.28%	2.50%	4.00%	4.99%	87.80%
Wine and Vinegar	10.02%	100.00%	16.00%	15.00%	3.32%	100.00%
Spices	1.00%	100.00%	0.10%	0.50%	2.27%	100.00%
Elaborated Foods	0.46%	10.61%			0.06%	9.04%
Manufactures	5.47%	99.27%	1.50%	4.75%	3.41%	90.77%
Textiles	1.44%	100.00%	10.00%	16.00%	7.57%	100.00%
Fuels and Minerals	2.65%	41.21%			2.52%	79.74%
Miscellaneous	1.62%	8.18%			0.02%	91.33%
Construction					0.54%	80.99%

Table 2

Region	New Castile	Old Castile	Valencia
States	3	3	3
Lags	0	2	2
μ_1	1.400 (0.251)	1.276 (0.096)	0.939 (0.026)
μ_2	1.068 (0.025)	1.024 (0.034)	1.075 (0.024)
μ_3	0.950 (0.019)	0.974 (0.014)	0.806 (0.029)
σ_1	0.063 (0.064)	0.037 (0.019)	0.008 (0.009)
σ_2	0.020 (0.005)	0.005 (0.001)	0.009 (0.003)
σ_3	0.008 (0.002)	0.004 (0.001)	0.009 (0.003)
ϕ_1		0.513 (0.132)	0.389 (0.127)
ϕ_2		-0.259 (0.108)	-0.180 (0.128)
p_{11}	0.444 (0.512)	0.865 (0.116)	0.979 (0.026)
p_{21}	0.030 (0.033)	0.033 (0.043)	0.023 (0.035)
p_{32}	0.047 (0.038)	0.037 (0.030)	0.020 (0.020)
Log L	106.681	135.606	123.728
N	70	70	70
K	9	11	11
B statistic	0.85 (0.468)	0.97 (0.300)	0.37 (0.999)
J2	0.017	0.173	
J3	0.069	0.950	

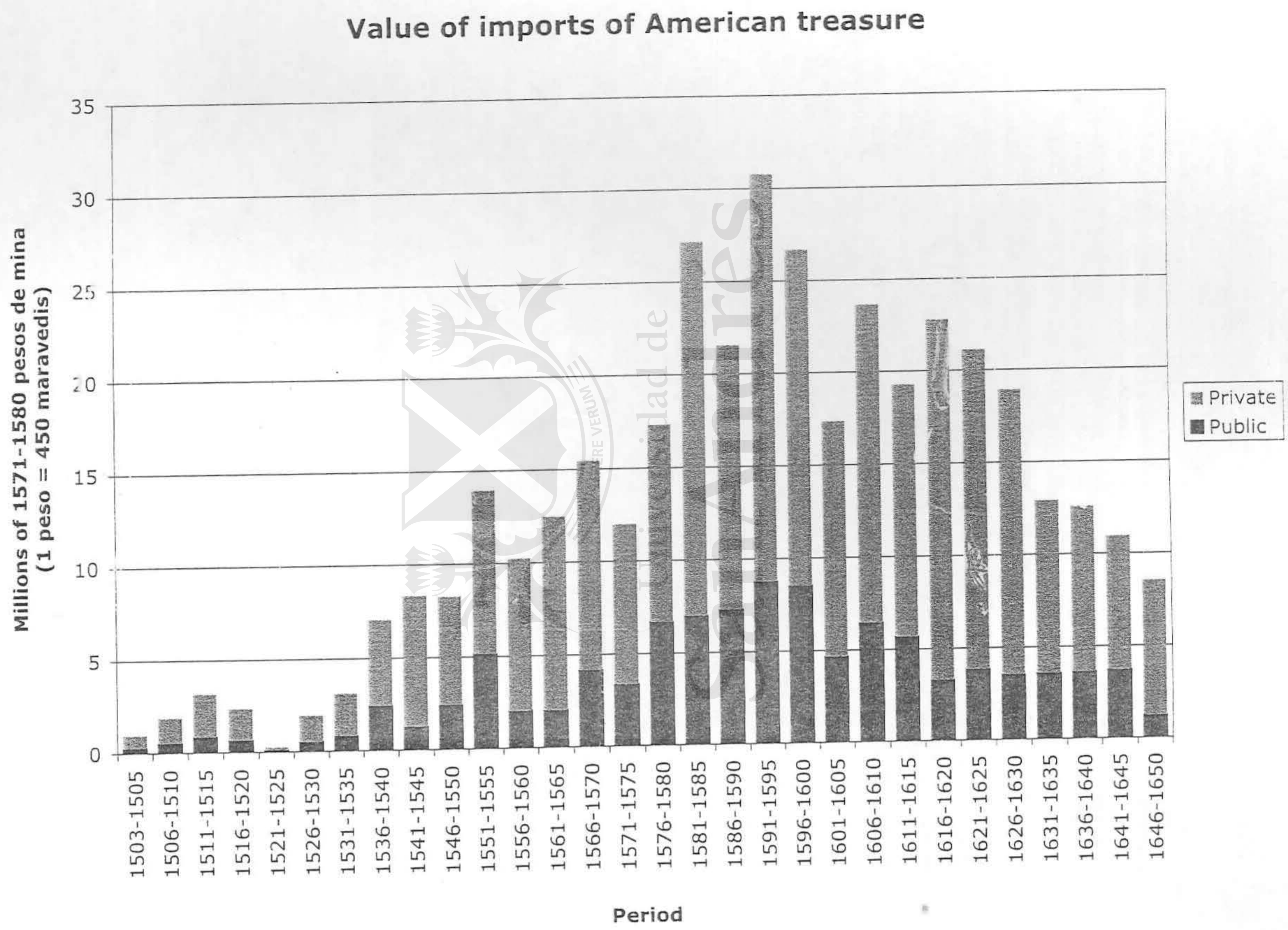
Models are estimated with the restriction $p_{12} = p_{23} = p_{31} = 0$.

Figures in parenthesis for the parameter estimates are standard errors.

Figures in parenthesis for Bartlett's statistic are p-values. Bartlett's statistic is used to test the null hypothesis that a series is white noise. We use it on the model's residuals to check that no serial correlation remains.

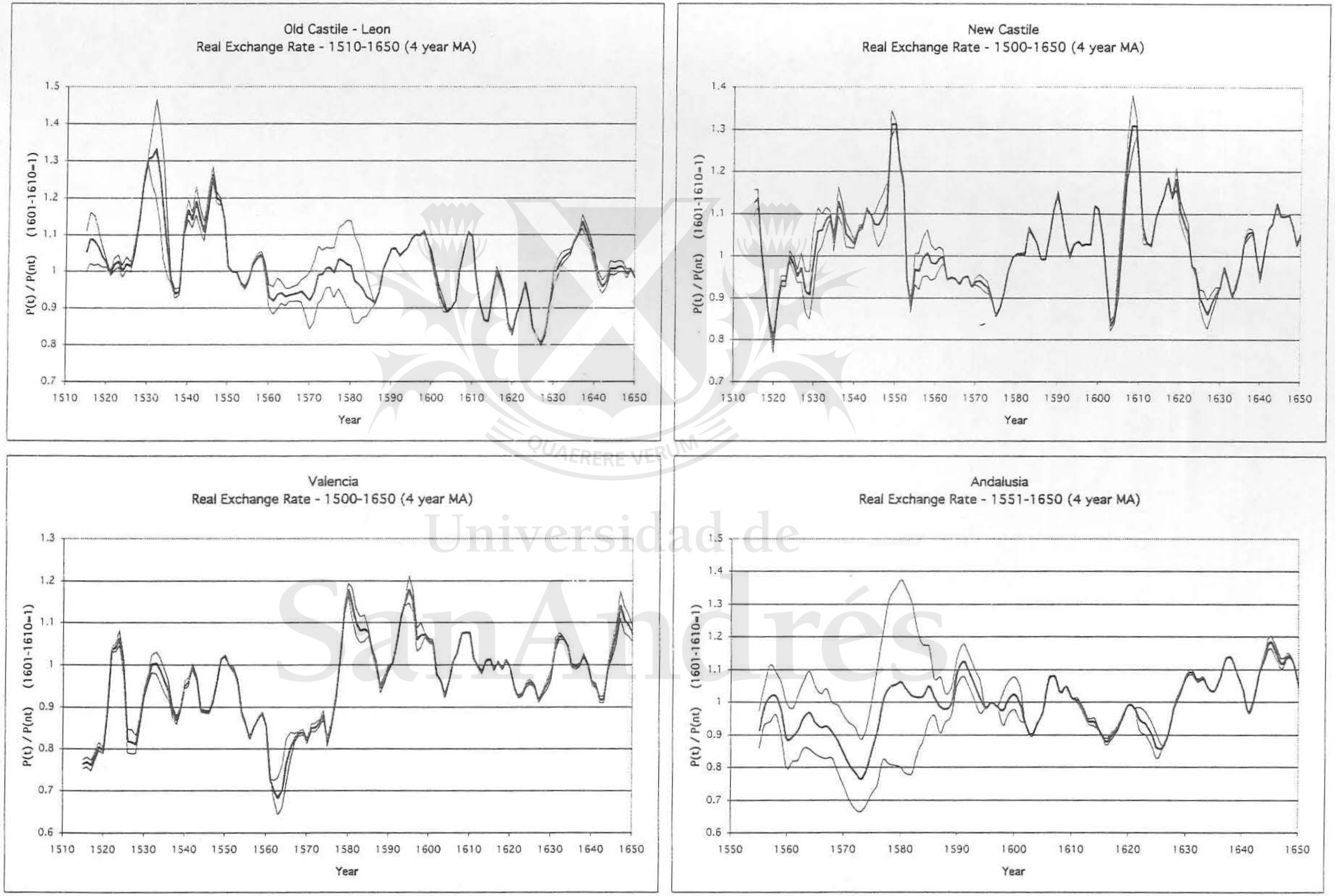
J2 is the p-value for the J-test for a two-state null hypothesis versus a 3-state alternative hypothesis. J3 is the p-value for the converse test. Values are not reported for the Valencian model because the estimation for the 2-states model yields non-persistent states.

Figure 1



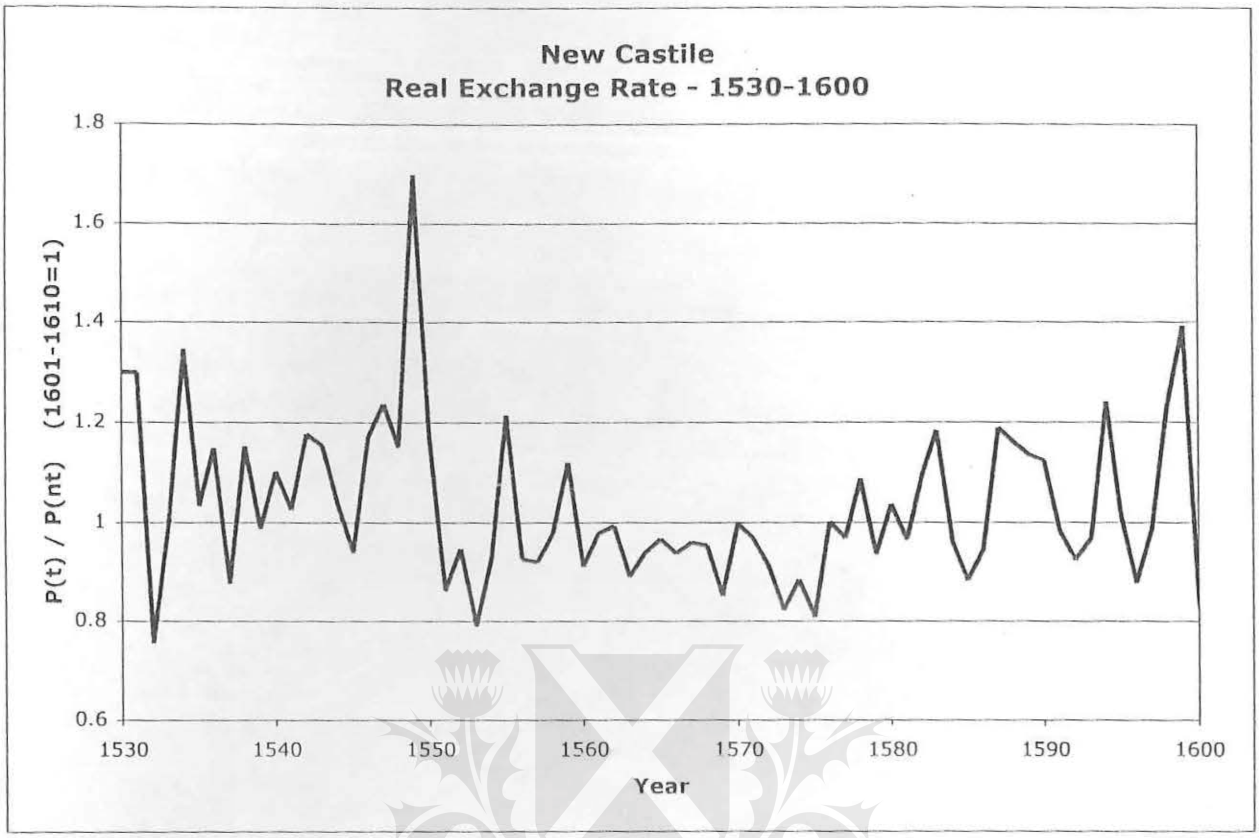
Value of imports of American treasure
Millions of 1571-1580 pesos de mina
(1 peso = 450 maravedis)
0
5
10
15
20
25
30
35
1503-1505
1506-1510
1511-1515
1516-1520
1521-1525
1526-1530
1531-1535
1536-1540
1541-1545
1546-1550
1551-1555
1556-1560
1561-1565
1566-1570
1571-1575
1576-1580
1581-1585
1586-1590
1591-1595
1596-1600
1601-1605
1606-1610
1611-1615
1616-1620
1621-1625
1626-1630
1631-1635
1636-1640
1641-1645
1646-1650
Period
Private
Public

Figure 2

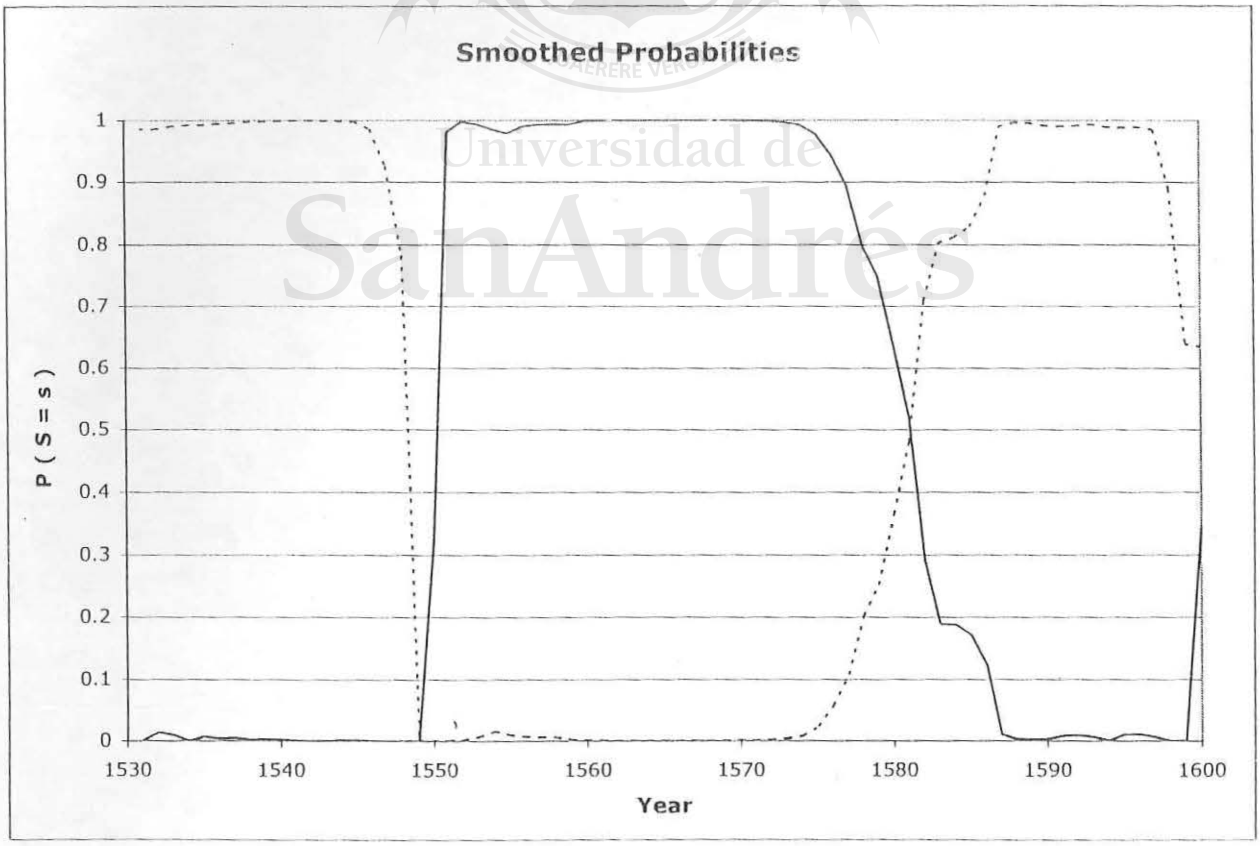


Old Castile - Leon
Real Exchange Rate - 1510-1650 (4 year MA)
New Castile
Real Exchange Rate - 1500-1650 (4 year MA)
Valencia
Real Exchange Rate - 1500-1650 (4 year MA)
Andalusia
Real Exchange Rate - 1551-1650 (4 year MA)
P(t) / P(nt) (1601-1610=1)
Year

Figure 3

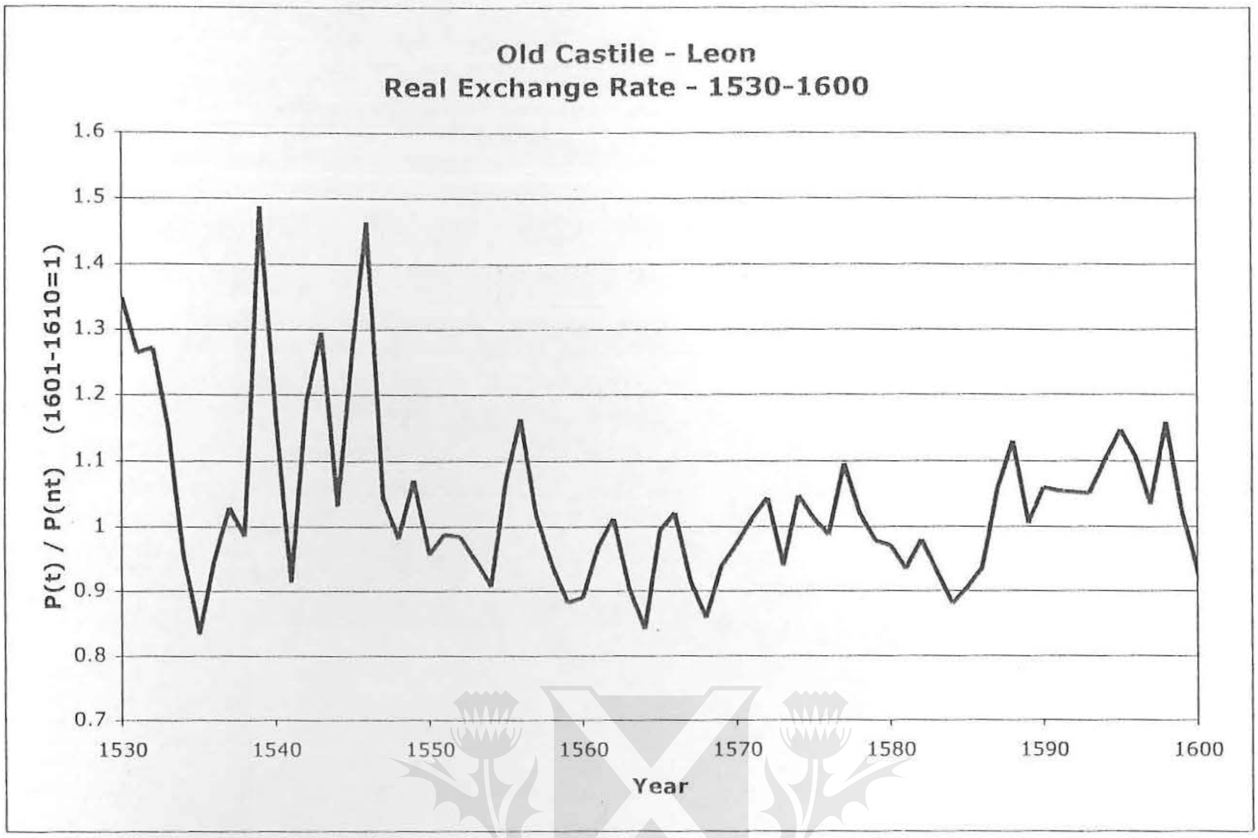


New Castile
Real Exchange Rate - 1530-1600
P(t) / P(nt) (1601-1610=1)
1.8
1.6
1.4
1.2
1
0.8
0.6
1530
1540
1550
1560
1570
1580
1590
1600
Year



Smoothed Probabilities
P (S = s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1530
1540
1550
1560
1570
1580
1590
1600
Year

Figure 4


Old Castile - Leon
Real Exchange Rate - 1530-1600
P(t) / P(nt) (1601-1610=1)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
1530
1540
1550
1560
1570
1580
1590
1600
Year

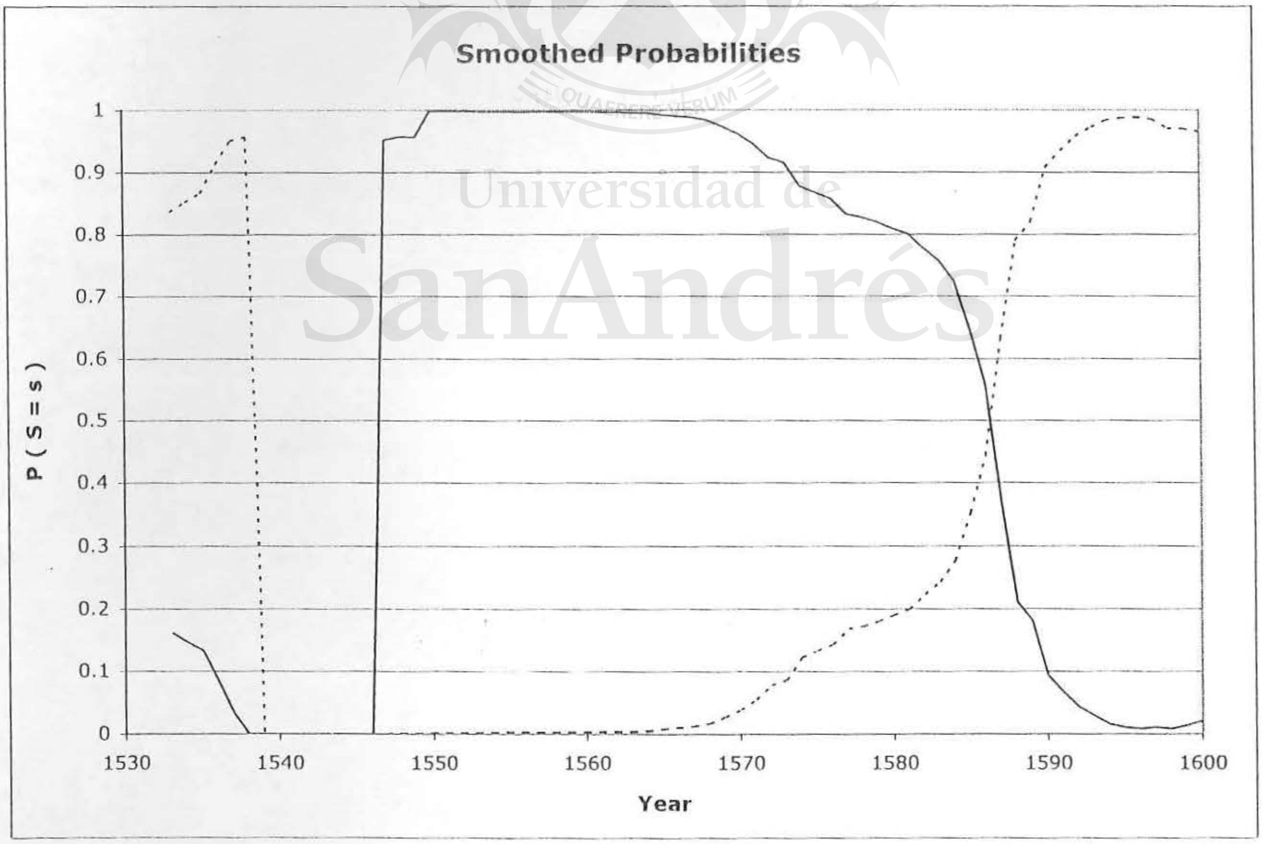
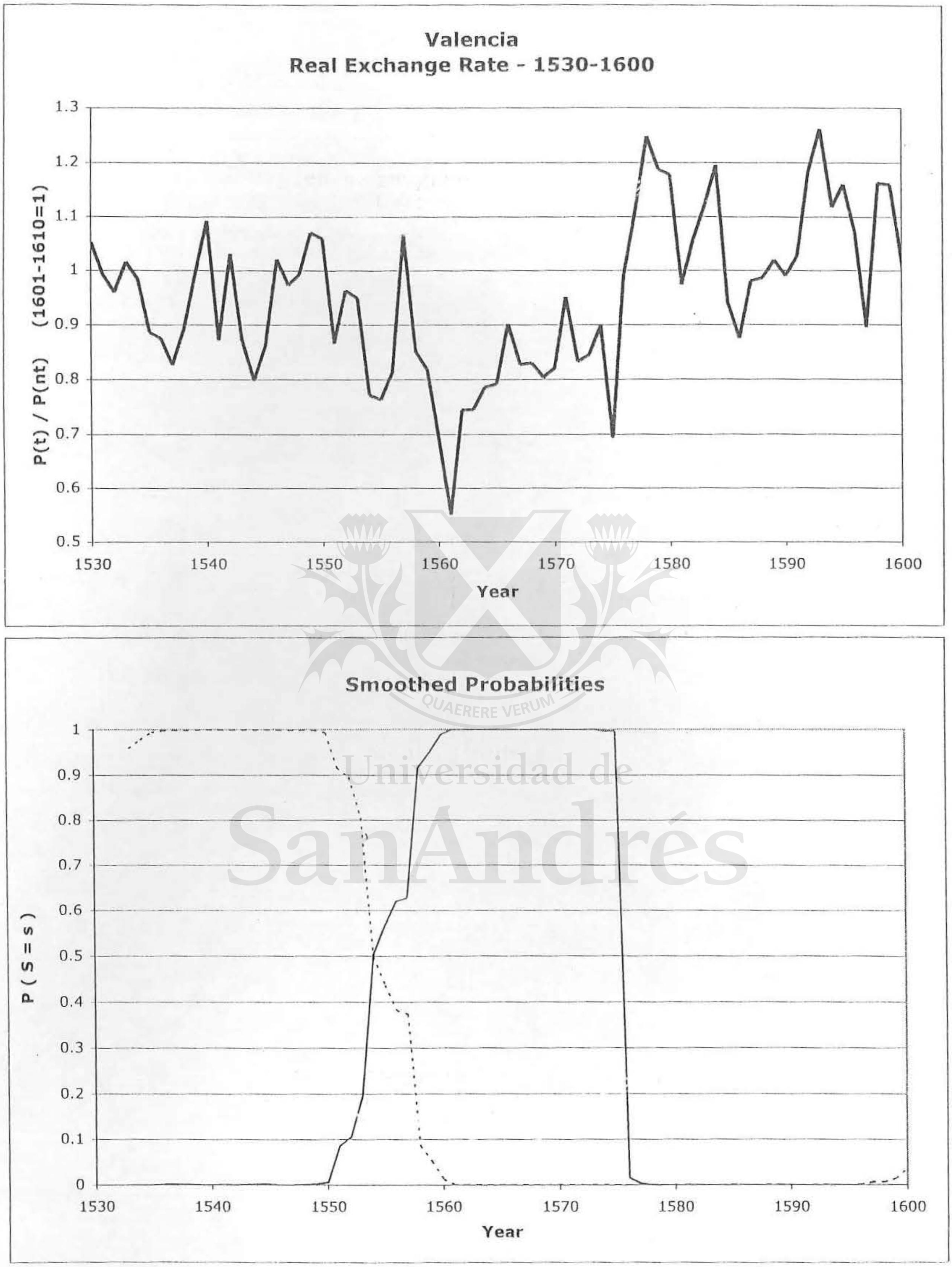

Smoothed Probabilities
P (S = s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1530
1540
1550
1560
1570
1580
1590
1600
Year

Figure 5


Valencia
Real Exchange Rate - 1530-1600
P(t) / P(nt) (1601-1610=1)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
1530
1540
1550
1560
1570
1580
1590
1600
Year
Smoothed Probabilities
P (S = s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1530
1540
1550
1560
1570
1580
1590
1600
Year