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THE EMPIRICS OF INTERNATIONAL CURRENCIES: NETWORK EXTERNALITIES, HISTORY AND PERSISTENCE*

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Using a new database for the late nineteenth century, when the pound sterling was the world's leading international currency, this article provides evidence on the empirical determinants of international currency status. We report evidence in favour of the search-theoretic models to international currencies. Using a microeconomic model of currency choice, we provide empirical support to strategic externalities. We find strong confirmation of the existence of persistence, but reject the view that the international monetary system was subject to pure path dependency and lock-in effects, suggesting that, even in the absence of WWI, the USD was bound to overtake sterling.

> 'For better or worse – and opinions differ on this – the choice of which language and which currency is made not on merit, or moral worth, but on size.'
> (Kindleberger, 1967, p. 11)

One century ago, the US set up a special expert body, known as the National Monetary Commission, to discuss, among other things, of ways and means of promoting the role of the US dollar as an international currency and facilitating funding of its current account deficit. The US National Monetary Commission led to the creation of the Federal Reserve System and the establishment of a large market of dollar 'acceptances' that promoted foreign holdings of the US currency (Broz, 1997; Meltzer, 2003). In the following decades, the dollar began a gradual ascent that transformed it into a world currency (Eichengreen and Flandreau, 2008).

Recently, the advent of a single European currency, mounting US external indebtedness, and the rise of China have fuelled considerable interest in determining whether the dollar is at risk of losing its international currency role (Chinn and Frankel, forthcoming). Just as one century ago, it is generally agreed that monetary leadership helps to manage external imbalances. In contrast, countries with debts denominated in foreign currency become vulnerable to crises.

Applied research sheds little light on the sources of monetary leadership. In particular, the existing empirical literature does not take advantage of modern theory's

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critical advances. This article brings new methods to bear on this topic and provides the first empirical exploration of the determinants of international currency status. We focus on the late nineteenth century, when the pound sterling was the ruling currency and develop a new empirical model of monetary leadership. Because of free capital mobility and lack of exchange controls, this period provides a natural experiment to study the forces through which international currencies emerge and are sustained.

Our empirics rely on a new dataset described in previous research (Flandreau and Jobst 2005). This database records information on the currencies that were actually traded in every foreign exchange market in 1900 and, thus, captures the phenomenon of foreign circulation. We adapt insights from modern theories of international money to construct a simple model of the determinants of foreign circulation that can be estimated. These theories have three distinct features: they suggest that the emergence of international currencies is predicated on the existence of transaction costs; they emphasise the role of strategic externalities and they usually predict strong persistence in monetary leadership. Our aim is to provide new evidence on the empirical validity of these insights.

The remainder of the article is organised as follows. Section 1 provides an overview of existing theoretical arguments. Section 2 contains a simple empirical study of the determinants of monetary leadership. Section 3 develops a complete empirical model featuring strategic externalities. Section 4 addresses the issue of persistence. We end with general conclusions and speculations for the future.

1. The International Monetary System: Theory

The central motivation of the theory of international currencies is to explain why, in general, a few currencies dominate the international scene, and one member of the group secures pre-eminence (Matsuyama *et al.* 1993): the Dutch guilder in the seventeenth and eighteenth century, the pound sterling in the nineteenth and early twentieth century, and the US dollar since the mid-twentieth century. Following an age old tradition (Menger, 1892, p. 254) theoretical approaches emphasise the role of transaction costs in coordinating agents on a single currency. Agents select as money the assets that entail the smallest difference between the price at which they can be acquired and the price at which they are resold (a difference also known as the bid–ask spread). 'Liquidity' is a primary determinant of the emergence of a given currency.

From this common thread, the literature has provided two alternative emphases that are not mutually exclusive.[1] On the one hand, von Hayek's work on currency competition related 'liquidity' to underlying policies (von Hayek, 1976). For instance, monetary instability creates uncertainty, making agents less willing to accept a currency unless they are provided with a greater margin to cover them against future losses. Currencies whose future is beyond suspicion displace the former ones (Calvo and Vegh, 1992). This does not imply that a single currency dominates but rather, that the number of currencies used internationally is smaller than the number of existing

[1] Ravikumar and Wallace (2001) argue that the framework in Matsuyama *et al.* (1993) is well suited to the study of currency substitution. The two approaches identified below are not mutually exclusive, see e.g. (Craig and Waller, 1999; Engineer, 2000; Head and Shi, 2003; Peterson, 2004).

currencies. Currency substitution should also discipline monetary authorities through the cost it entails in the form of forgone seigniorage. This game-theoretic implication was anticipated by von Hayek (1976, Chap. VIII, p. 48) and is central in modern theories of credibility (Kydland and Prescott, 1977; Barro and Gordon, 1983). Li and Matsui (2005) have provided the first explicit application of this insight to the theory of international currency in the framework of the search-theoretic approach to money.

On the other hand Kindleberger (1967) suggested that transaction costs are determined by market size. Currencies with a large area of circulation are easily resold, for one can conveniently meet some other consenting holder. One implication is that international currencies are valuable because many other parties are using them, generating strategic externalities: 'World efficiency is achieved when all countries learn the same second language' (Kindleberger, 1967, p. 9). This issue was first formally discussed in Krugman (1980); see also Rey (2001). Strategic externalities are captured by positing a unit cost function that is decreasing with the volume of transactions using a given vehicle currency. This creates persistence. Rising trade powers have difficulties pushing their currency to the top, since the established currencies tend to capture the market for new transactions. Therefore 'history' determines current outcomes.[2]

Matsuyama *et al.* (1993) and Kiyotaki and Wright (1993) provide search-theoretic foundations for these insights. Their models focus on the transaction services that currencies provide in an uncertain matching environment. When an opportunity to trade occurs, agents holding the 'wrong' currency suffer a utility loss. Here again, strategic externalities emerge naturally because equilibrium outcomes are influenced by other agents' choices. Depending on the model's parameters, various degrees of persistence are also observed. An alternative interpretation is that of Devereux and Shi (2005) who suggest that real resources must be used to set up permanent 'trading posts' where given currencies can be bought and sold against other ones. Because creating such posts entails fixed costs, certain currencies emerge as vehicles.

2. The International Monetary System: Evidence

2.1. *Exchange Matrices: Theory and Data*

A theory of international circulation explains why certain currencies are traded abroad while others are not. To show how such theories can be tested, we build on Krugman's concept of the 'exchange structure' (Krugman, 1980). Consider a world where there are n countries, each with one currency and one foreign exchange market. Let us call a_{ijkt} the amount of currency i that has been sold against currency j on market k during period t. Recording a_{ijkt} for all i, j and k produces a three-dimensional matrix of dimension $n \times n \times n$. In this framework, a theory of international currencies is a set of arguments explaining why, in equilibrium, a minority of foreign exchange markets and currencies are used ($a_{ijk} > 0$) while the majority is neglected ($a_{ijk} = 0$). In theoretical

[2] Krugman (1980, p. 523) argues that '*it seems clear that history will matter*. Once an exchange structure is established, it will persist... Suppose, for instance, that the currency of an economically dominant country becomes established as vehicle. This role will be self-reinforcing, swelling transactions in the currency etc.' (our italics). Krugman concludes that modern models 'look as if they have something to do with the actual experience of international monetary history'.

studies, we find this general framework simplified in various fashions. Krugman (1980) for instance allowed for only one consolidated market for every currency pair, so that there is just one $k = \bar{k}$. As in a given market exchanging currency i against currency j is the same as exchanging currency j against currency i ($a_{ij\bar{k}} = a_{ji\bar{k}}$), this leaves us with the following diagonal 3×3 matrix (Krugman considers a world with three countries):

$$\Xi = \begin{pmatrix} \otimes & a_{12} & a_{13} \\ & \otimes & a_{23} \\ & & \otimes \end{pmatrix}. \tag{1}$$

Theoretical tractability encourages putting restrictions upon the format of the exchange structure so as to reduce its size. But empirical relevance calls for comprehensiveness. Sheer lack of data, however, is a key challenge. For example, the latest version of the Bank of International Settlements' *Triennial Survey* (the most complete source for bilateral foreign exchange activity), documents 41 independent currencies traded in 52 countries, yielding a total of 42,640 possible cells.[3] But the *Survey* only reports, for every market, the turnover of local currency against a selected list of currencies only (7 out of 40), plus a small number of pairs involving the US$ and the Euro against a third foreign currency (11 out of 780 possible currency pairs). The result is a matrix that contains information along the ij as well as the k dimension but one that is incomplete in both. As evidence from the financial press suggested and interviews with BIS statisticians confirmed, some relevant trades are left out.[4]

This selection bias is central to all empirical studies of which we are aware. For instance, Krugman (1984) and Rey (2001) discuss the historical relation between trade and currency status but their evidence is limited to two international currencies only. Similarly Frankel *et al.* (1996) and Hartmann (1998) concentrate on explaining the time-series pattern of bid–ask spreads for some leading bilateral foreign exchange markets. They ignore the reasons why a majority of currencies is never used.[5]

Another set of empirical studies analyse the determinants of the currency composition of international reserves. Researchers have studied the effects of factors such as the size of the issuing country and its record of price-level and exchange-rate stability (Dooley *et al.*, 1989; Eichengreen and Frankel, 1996; Eichengreen, 1999; Eichengreen and Mathieson, 2001; Eichengreen, 2005; Chinn and Frankel, forthcoming). Others have looked at the currency of denomination of international bond issues (Eichengreen *et al.*, 2005; Cohen, 2005; Bobba *et al.*, 2007). Finally, Goldberg and Tille (2005) use data on the choice of invoicing currency for 24 countries. All these studies study focus on the choice among international currencies, given that these currencies do exist. But they do not study the reasons why international currencies exist.

[3] $41 \times 40/2 = 820$ currency pairs traded in 52 markets. See BIS (2005).

[4] Currency pairs not documented include 'Nokkie-Stokkie' (Norwegian krone vs. Swedish krona), 'Huf-Puf' (Hungarian forint vs. Polish zloty), 'Kiwie-Aussie' (pretty obvious), and others: See Jennifer Hughes, 'Non-dollar exchange traders hunting value cannot ignore US currency', *Financial Times* (November 17, 2005).

[5] Lyons and Moore (2005) derive conditions under which information asymmetries cause transactions to be concentrated in a handful of currencies.

2.2. *Monetary Status: A Limited-Dependent Analysis*

The database we use here distinguishes currencies with an international circulation from currencies without (Flandreau and Jobst, 2005). In the late nineteenth and early twentieth century every national financial centre featured a foreign exchange market where bankers bought and sold foreign currency 'bills of exchange' or 'foreign exchange' against domestic currency. Foreign exchange market activity was monitored in local bulletins, which reported fixing prices when relevant. We treat these publications like spy-ware devices that inform us whether or not a given foreign exchange route was used. Availability of a quote reveals an underlying flow of transactions. Our exchange structure matrix is thus both complete from an empirical point of view (including virtually all currencies of the world in 1900) but also conceptually superior to that posited by Krugman (1984) since it enables us to identify two different exchange markets for a given trade, corresponding to the home countries of the two currencies involved, which is not the case in Krugman (1984).[6]

One can then construct an *exchange matrix* $\mathbf{\Omega}$, a mapping of the exchange structure whose elements are ones or zeros depending on whether there were active trades or not in the corresponding market. We redefine for every currency pair ij $x_{iji} = x_{jii} = x_{ij,}$ (currency pair ij traded in market i) and $x_{ijj} = x_{jij} = x_{ji,}$ (currency pair ij traded in market j), so that k can be dropped and the three dimensions of the exchange structure boil down to a two-dimensional matrix. Thus:

$$\mathbf{\Omega} = \begin{pmatrix} * & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & * & \dots & \dots & \dots \\ x_{31} & \dots & * & \dots & \dots \\ \dots & \dots & \dots & * & x_{n-1n} \\ x_{n1} & \dots & \dots & \dots & * \end{pmatrix}. \tag{2}$$

The first line of the matrix lists the currencies traded against domestic currency 1 in market 1, the second line those against currency 2 in market 2, and so forth. Explaining why certain currencies circulate abroad, comes to explaining why certain x_{ij} terms equal one while others equal zero.

With 45 countries in our sample, we have 990 currency pairs each potentially traded in two markets giving a total of 1980 observations. The information in the exchange matrix for 1900 is summarised in Figure 1, which aggregates the x_{ij} for all i's, $\forall j$. This gives an indication of the international 'popularity' of alternative currencies, since it shows the number of foreign markets where a given currency is traded. Unsurprisingly, the pound sterling is ranked first.

Our strategy is to relate the availability of a given quote to the value that it creates for users. Calling u_{ij} the value of using currency j in market i, we can write

$$x_{ij} = \begin{cases} 1 & \text{if } u_{ij} > 0, \\ 0 & \text{if } u_{ij} \leq 0. \end{cases} \tag{3}$$

[6] While more general than Krugman's, our way of coding leaves out the possibility of 'Euromarkets', specifically swaps of currency i against currency j in market k. In reality, this does not restrict the analysis, however. Euromarkets emerged in the 1950s in a highly regulated environment. There is no empirical evidence for such markets around 1900. That such markets did not exist in a time when there were few regulations is telling.

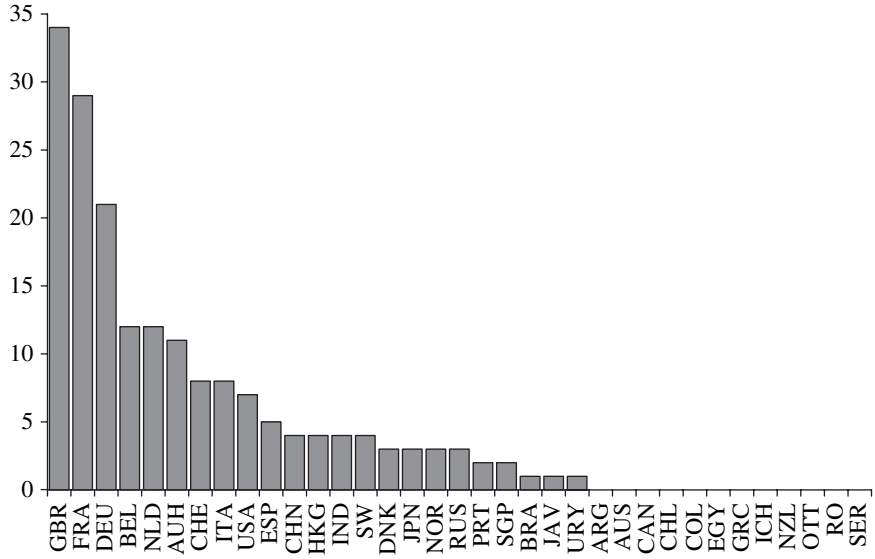

Fig. 1. *Foreign Circulation of Individual Currencies in 1900: Number of Markets Where Given Countries' Currencies are Traded*

Source. Flandreau and Jobst (2005). To facilitate comparison with Figure 5 below and relation with econometric work in Section 4 we have restricted the ranking to countries usable in Section 4. This makes 35 currencies/countries. This is more limited than the sample used in regression analysis in Section 2.

Here u_{ij} may depend on any variable we wish. Calling $\mathbf{y}_{ij}$ the vector of variables influencing u_{ij} and assuming that it is a linear function of its arguments ($\boldsymbol{\beta}$ is a vector of parameters, $\boldsymbol{\eta}_{ij}$ a random shock, F the cumulative distribution of η_{ij}),

$$\Pr(x_{ij} = 1) = \Pr\left(\mathbf{y}_{ij}\boldsymbol{\beta} + \eta_{ij} \geq 0\right) = 1 - F\left(\mathbf{y}_{ij}\boldsymbol{\beta}\right). \tag{4}$$

In any market i, any banker can draw a draft denominated in any foreign currency. Resulting costs can be passed on to customers. The availability of a quote thus reflects that there is a critical number of customers finding enough value in such a service to be prepared to pay for it. We thus need to model the determinants of demand.

On the one hand, there is less demand for trades in foreign currencies with a higher risk of losing value (Li and Matsui, 2005). This may be the case if the issuing country has a high inflation rate, displays exchange-rate volatility, has a high debt burden, a poor reputation, a bad economic record. In the absence of reliable price data for a number of countries in the sample, we capture monetary stability using a gold-standard dummy variable (Bordo and Rockoff, 1996; Flandreau and Zumer, 2004). This takes care not only of foreign exchange stability but also of price stability, since inflation is endogenous in a fixed-exchange-rate system. Consistent with our previous remarks, these variables are supplemented with fiscal and reputation indicators.[7] We proxy the

[7] von Hayek (1976, Chap. VIII, p. 48) was the first to emphasise the limits of 'gold discipline'. See also Flood and Garber (1984).

debt burden using the debt/revenue ratio (Flandreau and Zumer, 2004). We capture reputation using the yield on gold bonds issued in international markets. We measure economic performance using GDP *per capita*. This group of variables is called *macro-economic policy performance* factors.

The second group of variables is referred to as *friction* factors which are inspired from search-theoretic approaches. One important ingredient is inventory costs. Kiyotaki and Wright (1989, 1993) allow for heterogeneous costs of holding different currencies. Another important friction is the probability of 'meeting one's match'. This probability falls when agents are somehow 'distant' from one another (Matsuyama *et al.*, 1993; Trejos and Wright, 1996; Ravikumar and Wallace, 2001; Kiyotaki and Moore, 2003) and increases with the size of the trading partners (Zhou, 1997).

A natural way to measure inventory costs is to recognise that 'foreign exchange' was really international credit, so that the opportunity cost is the interest rate. This way of looking at things represents a significant departure from the intuitive 'portfolio' approach that is implicit in much literary discussion. But it is fully in line with the logic of search theoretic approaches that point to a demand for liabilities rather than for assets. Since money is intrinsically useless, agents are only prepared to bear the cost of holding it in return for the liquidity services it will provide. The same rationale would apply, if money were represented by interest bearing denominations that must be borrowed before a transaction occurs, as was indeed the case in the historical setting this article considers.[8]

We next consider information costs. Because foreign exchange bills were private promises to pay certain sums in certain places, issuing them involved an element of uncertainty in that foreign market's conditions cannot be known as well as domestic ones. In addition, this greater uncertainty created more scope for moral hazard. Therefore, frictions were presumably greater for more distant centres than for closer ones. This can be viewed as an equivalent to the bilateral 'distance' discussed in matching models.

Finally, historians usually associate the development of drawing facilities with the existence of substantial trade. From an economic point of view, the logic is that money follows trade. When bilateral trade with a given country is important, drawing a bill payable in its currency is attractive because it finds ready domestic purchasers who need them to settle international transactions. Therefore, bilateral trade with country j as a share of the total trade of country i should increase the probability of finding the currency of country j in market i. Again, this intuition has a natural counterpart in the search-theoretic approach to money.[9]

[8] In his classic study of Renaissance finance, de Roover finds abundant anecdotal evidence of warnings against drawing bills on centres where interest rates are permanently or even temporarily high. For instance, one banker indicated that when interest rates were high in Barcelona, bankers in Florence and elsewhere refrained from drawing on that centre: '*laudiamo la rimessa ma non la tratta*' (we recommend lending to but not drawing from) (de Roover, 1968, pp. 48–9). Flandreau and Gallice (2005) find similar evidence for the late nineteenth century, with bills in leading merchant banks only coming from centers with low short term interest rates.

[9] The study by King *et al.* (1988) of the Hong Kong and Shanghai Banking Corporation (HSBC) in the second half of nineteenth century provides many examples. For instance, the authors explain that one reason why HSBC opened a branch in France (specifically, in the silk processing city of Lyons) was because of the bank's leading role in providing finance to the global silk trade and France's substantial business as both an importer and producer of silk.

Before we turn to the empirical estimation of the model, it is important to explain why we can consistently record short-term commercial interest rates among friction variables, while yields on long-term government bonds are included in the performance indicators. While one might at first sight suspect a strong positive relationship, long and short rates turn out to be only imperfectly correlated empirically. Table 2 reports a correlation coefficient of 0.54. A closer look reveals a more complex logic. If we distinguish between countries whose currencies enjoy at least some degree of international circulation (identified as 'key' and 'intermediary' in the automatic network analysis procedure designed in Flandreau and Jobst (2005) and countries issuing an only locally accepted currency (identified as 'periphery'), we find that the first group sports low short (typically below 5%) as well as low long rates (below 4%). But the second group is a mixed bunch: it includes the British colonies or the Scandinavians with long-term yields as low as those in the first group, as well as countries in Latin America or Japan with much higher government borrowing costs. Short-run commercial rates, on the other hand, are indifferently high (on average 6.8%) in this entire group. Therefore, sound macroeconomic management, leads to low bond yields but does not guarantee low short rates.[10] This makes inference drawn from results obtained when the two variables are put in competition particularly informative.

We now assess the contribution of each group of factors by estimating (4) using logit (Table 1).[11] To make results comparable across different specifications we keep only those observations for which we have information on all explanatory variables. At this stage we ignore simultaneity issues, which will be dealt with in detail in the remainder of the article. Column I reports parameter estimates for the general model. First, the model's fit is satisfactory in terms of both the pseudo-R^2 and the percentage of currencies whose quotation is correctly predicted. Second, we notice a different performance between the two groups of controls identified before. Friction variables perform very well. We observe that low short-term interest rates in the issuing country significantly increase the probability of its currency being traded abroad, that agents appear more willing, other things being equal, to trade currencies issued by geographically close countries, and that a greater bilateral trade with a given country is associated with a greater probability of using its currency. On the other hand, parameters for macroeconomic performance variables are much less satisfactory. Except for the debt burden, all are insignificant and some have the wrong sign.

The two sets of explanatory factors are then tried independently. We first experiment with friction factors alone. They perform essentially as well as the general model. In contrast, when the performance factors are considered independently, the quality of the fit deteriorates markedly. Pseudo-R^2 values are almost three times smaller than in the general model and some bizarre results emerge: for example, a significant large but negative contribution of the gold standard, exactly the opposite of what conventional

[10] The result is that within these groups correlation is lower (0.17 and 0.42 respectively) than in the entire sample, while the overall correlation stems from the fact that we are mixing countries with both low short and long rates with countries with high short and *on average* high long rates.

[11] Probit estimates are similar and can be obtained from the authors.

Table 1

Explaining Foreign Circulation

	General model	Friction	Macro performance		With colonies	Instrument trade
Equation	(I)	(II)	(III*a*)	(III*b*)	(IV)	(V)
'Good housekeeping'						
on gold	−0.33		−0.64*	−0.00	−0.33	
	(−0.89)		(−2.32)	(−0.01)	(−0.89)	
debt burden	−0.14*		−0.00	−0.05*	−0.14*	
	(−2.42)		(−0.03)	(−1.95)	(−2.42)	
long-term interest rate	0.07		−0.72**		0.07	
	(0.60)		(−6.13)		(0.60)	
GDP per capita	−0.15		0.87**	1.51**	−0.15	
	(−0.59)		(4.79)	(8.04)	(−0.59)	
'Matching'						
interest rate	−0.99**	−0.82**			−0.99**	−0.82**
	(−5.65)	(−7.29)			(−5.65)	(−7.70)
distance	−0.76**	−0.76**			−0.76**	−1.04**
	(−6.52)	(−6.59)			(−6.49)	(−9.98)
share in bilateral trade	0.25**	0.27**			0.25**	
	(9.54)	(10.33)			(9.45)	
Controls						
colony					−0.02	
					(−0.02)	
foreign GDP						0.77**
						(9.11)
Coverage†	2.05**	2.01**	1.41**	1.34**	2.05**	1.12**
	(7.27)	(7.25)	(8.27)	(8.12)	(7.26)	(5.53)
constant	4.74	4.30**	−7.20**	−15.09**	4.74	−4.18**
	(1.75)	(3.48)	(−4.50)	(−10.59)	(1.74)	(−2.52)
number of obs.	1,408	1,408	1,408	1,408	1,408	1,408
Pseudo R2	0.59	0.58	0.21	0.16	0.59	0.44
log likelihood	−247.23	−251.57	−470.21	−503.07	−247.23	−333.25
predicted vs. observed						
0 when truly 0	83.66	83.59	83.66	84.16	83.66	82.53
1 when truly 1	10.80	10.87	2.56	1.28	10.80	8.31
1 when truly 0	1.28	1.35	1.28	0.78	1.28	2.41
0 when truly 1	4.26	4.19	12.50	13.78	4.26	6.75

Sources. See text. z-statistics in parentheses, * and ** denote significance at the 5% and 1% levels respectively. Results reported with a coverage factor, introduced to control for the fact that the extensiveness of coverage of the foreign exchange market varied marginally from one national source to the other. Parameter estimates without the coverage factor are identical but coverage improves fit. Results available from the authors. Coverage is measured by the so-called expansiveness factor recommended in network econometrics (Wasserman and Faust, 1994).

views would predict.[12] Finally, the bottom part of the Table shows that this specification has a poor predictive power for quotations.[13]

Two further exercises suggested by earlier readers are also provided. Column IV adds to the general model a colony dummy (=1 when a colony considers quoting its metropolis) in order to assess the potential effect of imperial links. The hypothesis we test is that the existence of an empire favours currency internationalisation; see De Cecco (1974) for a discussion. This variable turns out to have zero contribution and other

[12] The distinction between columns III*a* and III*b* is motivated by the need to deal with possible multicolinearity between debt burdens and reputation, as suggested in Flandreau and Zumer (2004).

[13] As can be calculated from the lower part of the Table, policy performance variables get only 17% of the 1's right while matching 72%.

Table 2

Matrix of Correlations Between Explanatory Variables

	On gold	Debt burden	Long-term int' rate	GDP/cap	Short-term int' rate	Distance	Trade share
On gold	1						
Debt burden	−0.21	1					
Long-term int' rate	−0.52	0.27	1				
GDP/cap	0.45	−0.00	−0.43	1			
Short-term int' rate	−0.17	−0.27	0.54	−0.39	1		
Distance	−0.09	−0.02	0.12	−0.05	0.23	1	
Trade share	0.14	−0.10	−0.24	0.26	−0.27	−0.26	1

Source. Authors' database.

parameter estimates are unaffected. Finally, Column V controls for the possibility that trade is endogenous to quotation; to do so, we substitute for trade the standard variables of the gravity equation. Again, the coefficient on the interest rate remains stable.

Results suggest that friction factors are important. They also rule out the possibility that macroeconomic performance influence currency status through its influence on friction variables. This is demonstrated by the poor empirical record of policy performance when this variable is considered alone and by the correlation matrix in Table 2. We conclude that our evidence strongly supports the 'matching' dimension of modern search-theoretic approaches money.

3. Strategic Externalities: Econometric Evidence

3.1. *A New Empirical Model*

This Section provides an original way of estimating feedbacks between individual choices and aggregate outcomes. This represents both a departure from and an original contribution to existing research. While network externalities are a basic feature of theoretical models of international currencies, they are neglected from empirical studies or handled by inclusion of lagged endogenous variables (Bobba *et al.*, 2007; Chinn and Frankel, forthcoming).

By contrast our empirical model, provides an explicit mechanism through which liquidity externalities arise. As in theoretical models, we assume that the externality appears because whether to use currency j in country i is decided *given others' decisions* (Wright, 1995, 1999). We begin with (4) and call $\mathbf{x}_{ij}^{c}$ the exchange matrix that is equal to $\mathbf{\Omega}$ *except* for term x_{ij}, which has been coded as missing ($\mathbf{x}_{ij}^{c}$ represents other agents' decisions). We can therefore rewrite (4) as

$$\Pr\left(x_{ij}=1\right)=\Pr\left(\mathbf{y}_{ij}\boldsymbol{\beta}+\eta_{ij}\geq 0|\mathbf{x}_{ij}^{c}\right)=\mathbf{\Phi}\left(\mathbf{y}_{ij}\boldsymbol{\beta}+\eta_{ij},\mathbf{x}_{ij}^{c}\right). \tag{5}$$

Function $\mathbf{\Phi}$ is the individual response function corresponding to a Nash strategy. Individual choices influence the response function of others, and equilibrium requires that *ex post* individual strategies be consistent with *ex ante* ones. Individual quoting decisions are jointly determined so that (5) captures the essence of strategic externalities.

Next, we posit that strategic externalities operate via the effect that a large number of foreign quotations for a given currency has on the liquidity of the corresponding country's money market. This approach, motivated by theoretical intuitions already discussed, is also consistent with historical insights. Nishimura (1971) provides narrative evidence that in the late nineteenth century, liquid financial centres did attract foreign exchange business.[14] Experts for the US National Monetary Commission writing *circa* 1910 argued that, barring exchange risk, money interest rates should equalise according to the interest parity condition – but only up to a liquidity premium, which would always be larger for narrower or less liquid markets. Assets that can be bought and sold on broad markets trade at a higher price (or equivalently, have a lower real return).[15] In effect, these writers reasoned in terms of strategic externalities. Interest rates of leading currencies were lower because lots of agents were using them, so that their currencies were more likely to be quoted abroad and this further strengthened their leadership.[16] Figure 2 provides empirical evidence of this relation: the larger the number of foreign quotations a currency received, the lower its interest rate.

Of course causality can run either way or both. We thus complete the empirical model as follows. Let r_{jt} be the interest rate in centre j at a date t. This interest rate can be written in terms of an imaginary, perfectly liquid, short-term financial instrument whose interest rate is a_t. The spread between r_{jt} and a_t is by definition equal to the sum of a liquidity premium and the expected rate of exchange-rate change with respect to the imaginary currency (used as numéraire). The liquidity premium is assumed to depend on two terms, the demand for currency i in the global foreign exchange market (ω_i) and a set of variables that represents local money market development (Y_{1t}). Denoting the liquidity premium by $\pi(\omega_{it}, Y_{1it})$ and the expected depreciation by $\mathrm{E}(\Delta e_{it-1}/e_{it})$, we have

$$r_{it} - a_t = \pi(\omega_{it}, Y_{1it}) + \mathrm{E}(\Delta e_{it+1}/e_{it}). \tag{6}$$

Because of a lack of systematic trends in exchange rates expected depreciation can safely be ignored.[17] The demand for currency i in the global foreign exchange market is the sum of individual demands in local markets weighted by the relative share θ_k of each country. Country k's demand for currency i is a function of its (unobservable) utility u_{ki}. Finally, the interest rate in market i is determined by international demand and domestic factors:

[14] Nishimura shows that, in the late nineteenth century, the share of bills drawn on London from outside the UK vastly surpassed the share drawn from within. King (1936, p. 282) states that Lombard Street, where London's money market was located, 'belonged to all nations'.

[15] 'Thus it is that funds freely move to and fro between London, Paris, Berlin, and Amsterdam, *an exact equality in [interest] rates being prevented by the fact that the discount markets in these cities differ in size*. . . For instance, the Paris discount market is broader than that of Amsterdam, and there is consequently less risk in forwarding funds to Paris for investment than to Amsterdam. That the Paris discount rate should rule somewhat lower than that of Amsterdam is accordingly natural' Jacobs (1910), pp. 7–8; our italics.

[16] Attractive interest rates in London, Jacobs acknowledged, led US bankers to hold London balances even though this would 'add to the importance of London and militate against the development of New York as a financial center' (Jacobs, 1910, p. 13).

[17] Regressions limited to countries on a gold standard were also performed and did not change the results.

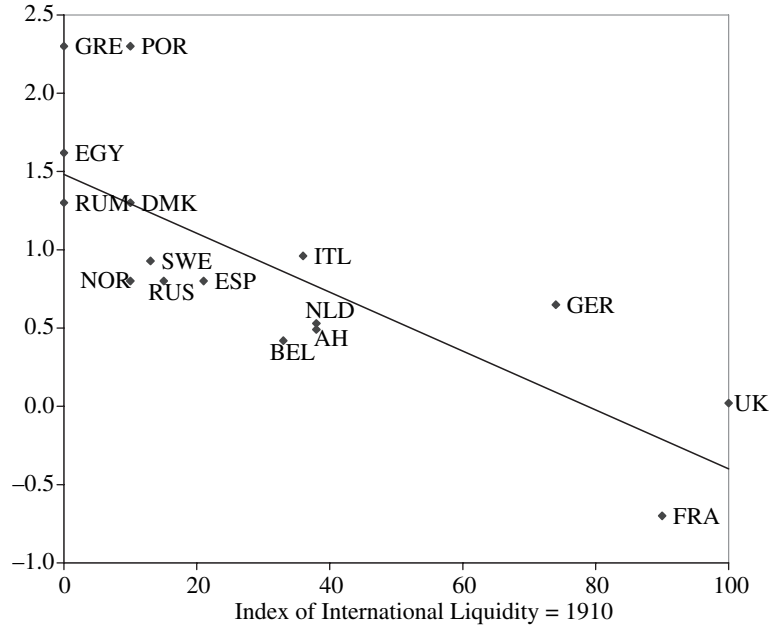

Fig. 2. *Short Term Interest Rate Differentials vs. London and International Liquidity Source.* Authors' database.

$$r_{it} = \gamma_1 \sum_{k \neq i} \theta_k u_{kit} + Y_{1i}\beta_1 + \varepsilon_{it}. \tag{7}$$

This formula can be combined with the 'friction' equation from Section 2 where the value of holding currency j in market i is a function of the interest rate in market j, the share of bilateral trade with j in i's total trade, and bilateral distance. Denoting these latter two exogenous variables by Y_{2ij}, we can write

$$u_{ijt} = \gamma_{jt} r_{jt} + \mathbf{Y}_{2ijt}\boldsymbol{\beta}_2 + \eta_{ijt}. \tag{8}$$

Since $\mathbf{r}_i$ is an $n \times 1$ vector (there are n countries) and since $\mathbf{u}_{ij}$ is a vector of dimension $n(n-1) \times 1$ (there are $n(n-1)$ bilateral exchange markets), we use the transformation matrices $\mathbf{W}$ and $\mathbf{M}$ to write the complete model in structural form as follows (we drop the indices for simplicity):[18]

$$\begin{aligned} \mathbf{r} &= \gamma_1 \mathbf{W}\mathbf{u} + \boldsymbol{Y}_1\boldsymbol{\beta}_1 + \boldsymbol{\varepsilon} \\ \boldsymbol{u} &= \gamma_2 \mathbf{M}\mathbf{r} + \boldsymbol{Y}_2\boldsymbol{\beta}_2 + \boldsymbol{\eta}. \end{aligned} \tag{9}$$

As can be seen, our model allows for two-way influence. The first equation in system (9), or *liquidity schedule*, describes the incidence of greater value of the domestic currency for foreigners on domestic interest rates. The second equation, or *popularity schedule*, describes the incidence of lower domestic rates on the value of holding that

[18] Here $\mathbf{W}$ is a weighting matrix and $\mathbf{M}$ simply assures that all markets for currency j depend on the same interest r_j.

currency for foreigners. System (9) describes the international monetary system that results from a Nash equilibrium. Figure 3 illustrates the equilibrium feedback for a given country. Equilibrium is defined by point *E*.

3.2. *Estimation*

Because of simultaneity, it will not be enough to estimate the second equation using a standard probit method and then estimate the first equation using the predicted utility variable obtained from the first regression. One way of addressing this issue is to think of (9) as a sequential system. At date $t-1$, agents make decisions regarding currency holdings based on the signals they receive (second equation). This determines the demand for each currency in each market and sets period–t interest differentials (first equation). Rewriting (9) with time indices yields

$$\begin{aligned} \mathbf{r}_t &= \gamma_1 \mathbf{W}\mathbf{u}_t + \mathbf{Y}_{1t}\boldsymbol{\beta}_1 + \boldsymbol{\varepsilon}_t \\ \boldsymbol{u}_t &= \gamma_2 \mathbf{M}\mathbf{r}_{t-1} + \mathbf{Y}_{2t}\boldsymbol{\beta}_2 + \boldsymbol{\eta}_t. \end{aligned} \tag{10}$$

Given that ε_t and η_t are well-behaved Gaussian residuals, a straight estimation is possible: first derive a probit estimate of the second equation; then replace $\mathbf{u}_t$ in the first equation by its fitted value and use standard OLS techniques to estimate the equation

$$\mathbf{r}_t = \gamma_1 \mathbf{W}\hat{\mathbf{u}}_t + \mathbf{Y}_{1t}\boldsymbol{\beta}_1 + \boldsymbol{\varepsilon}_t. \tag{11}$$

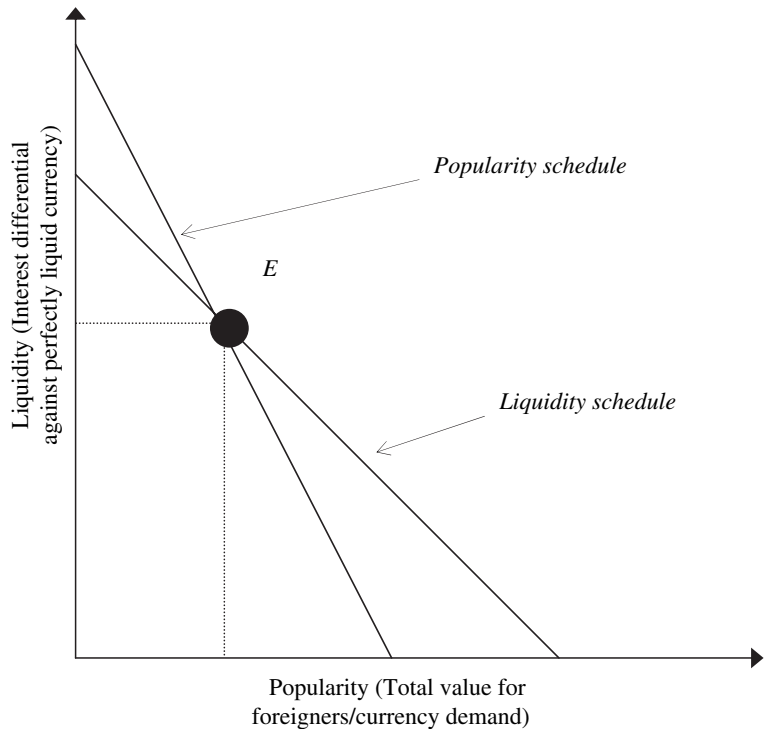

Fig. 3. *Equilibrium Foreign Circulation and Liquidity Premium for Country i's Currency*

However, a superior approach is to recognise that **r** and **u** are simultaneously determined. To take account of simultaneity, the system has to be first estimated in reduced form and in a second step by OLS and probit using the fitted values from the first stage.[19] The resulting estimation strategy, known as two-stage probit least squares (or 2SPLS), produces robust estimates (Maddala, 1983).[20]

Results are reported in Table 3.[21] For domestic variables ($\mathbf{Y}_1$) we used GDP per capita (a measure of domestic financial development) and a democracy index. Neo-institutional perspectives have emphasised the role of democratic institutions, parliamentary control of the executive, and the rule of law in financial development (North and Weingast, 1989). Democracy is therefore a natural proxy for these factors.[22]

Table 3 presents estimates for (I) the 'naïve' model that ignores that **r** and **u** are jointly determined, (II) the sequential model that assumes agents decide on foreign currency trading for 1900 based on signals received in 1890 (thus setting 1900 interest rates), and (III) the more sophisticated 2SPLS model. There is little difference between the output of the naïve and sequential models. However, compared to columns I and II, 2SPLS estimation gives an enhanced effect of interest rate on the utility of holding the corresponding currency ($\gamma_2 = -0.52$ instead of -0.31 and -0.36). The effect of the popularity of a given currency on interest rates, by contrast, is similar across equations ($\gamma_1 = -0.87$, -0.91 and -1.09).

The important conclusion to draw from these exercises is that we find evidence of the two-way causality (from transaction costs to holding behaviour and from holding behaviour to transaction costs) that is a central feature of modern models of international currencies. There are strategic externalities, and they matter, just as theory predicts.

4. Persistence

4.1. *Testing for Path Dependency*

One critical implication of strategic externalities is the emergence of persistence. To see how it arises in our framework, consider the following thought experiment. Starting from equilibrium at *E*, the economy experiences an increase of its total exports. The

[19] For this we must first rewrite the system in reduced form. Because e and h are i.i.d., an unbiased estimation of the reduced-form system is feasible using maximum likelihood techniques. This provides fitted values of $\hat{\mathbf{r}}$ and $\hat{\mathbf{u}}$ that are orthogonal to residuals; then $\hat{\mathbf{r}}$ and $\hat{\mathbf{u}}$ can be plugged back into the structural system (8). The second step in this approach involves OLS estimation of the first equation and probit estimation of the second equation.

[20] Standard errors ought to be adjusted. The method in Maddala (1983, pp. 244–5), however, is not feasible, due to the weighing matrices. Instead, we calculated confidence intervals using bootstrapping with 1000 replications. Table 3 below reports the 2.5 and 97.5 percentiles of the simulated coefficients, thus giving an equivalent to a 95% confidence interval.

[21] To perform the matrix operations we need fully symmetric information, i.e. every quoting country must also be included as quoted country. This reduces the number of observations slightly compared to regressions in Section 2.

[22] We use the index of democracy of the Polyarchy dataset developed by Vanhanen (2000), available at http://new.prio.no/CSCW-Datasets/Data-on-Governance/The-Polyarchy-dataset/. The macro policy variables have previously been shown not to explain currency circulation and can thus be used to identify the interest rate equation.

Table 3

Estimating Strategic Externalities

Equation		(I) 'Naive' Probit – OLS	(II) Sequential model	(III) Two stage Probit
r	u	−1.09	−0.87	−0.91
		(−7.10)	(−4.72)	(−2.83)
				[−1.25, −0.50]
	GDP per	0.27	0.19	0.15
	capita	(0.68)	(0.38)	(0.25)
				[−0.22, 0.55]
	democracy	−0.10	−0.13	−0.09
	index	(−1.39)	(−1.46)	(−0.82)
				[−0.15, −0.04]
	constant	2.27	3.36	3.59
		(0.77)	(0.91)	(0.78)
				[0.30, 6.76]
	observations	35	35	35
	adjusted R^2	0.68	0.51	0.33
u	r	−0.36	−0.31	−0.52
		(−7.06)	(−6.78)	(−8.12)
				[−0.69, −0.36]
	distance	−0.46	−0.38	−0.44
		(−6.91)	(−5.64	(−6.28)
				[−0.56, −0.31]
	share	0.15	0.16	0.15
		(11.54)	(12.36)	(10.94)
				[0.11, 0.23]
	coverage	1.13	1.17	1.24
		(6.92)	(7.04)	(7.09)
				[0.90, 1.70]
	constant	2.09	1.03	2.70
		(3.12)	(1.61)	(3.73)
				[1.32, 3.93]
	observations	1,190	1,190	1,190
	log likelihood	−205.2	−207.0	−195.0

Source. See text. t and z-statistics in parentheses, bootstrapping 95% confidence intervals (defined by the 2.5 and 97.5 percentiles) in brackets (see footnote 19).

result is that the value of holding its currency abroad is enhanced. This boosts international demand for its money, causing further declines of its interest rate and so forth. The long-run effect depends on the product of parameters γ_1 and γ_2. Assuming for simplicity that $\gamma_1\gamma_2 > 0$ (as we have found is the case), two economically relevant regimes are distinguished.[23]

If $0 < \gamma_1\gamma_2 < 1$ there will be persistence but no path dependence. The economy converges toward a new equilibrium but, while the process lasts, the country has higher interest rates and lower popularity *than is warranted by the long-run equilibrium.* Formerly minor trading powers, for instance, drag the anchor of their previous insignificance and experience a delayed rise to monetary leadership (Figure 4*a*).

If $\gamma_1\gamma_2 > 1$ then the dynamics are explosive and lock-in (a specific instance of path dependency) emerges. Interest-rate declines fuel an expansion of foreign

[23] We neglect here the degenerate regime where $\gamma_1\gamma_2 = 1$, since it is statistically unimportant.

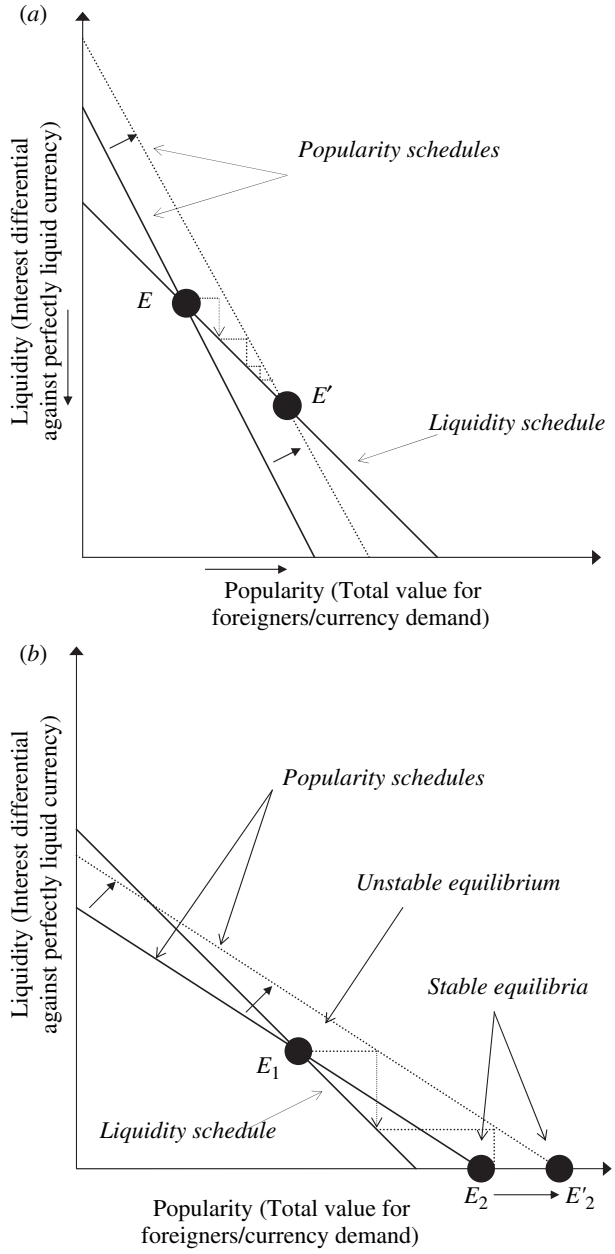

Fig. 4. (*a*) *Currency Status and Persistence: Stable Dynamics* $(0 < \gamma_1\gamma_2 < 1)$ (*b*) *Currency Status and Lock-in: Unstable Dynamics* $(1 < \gamma_1\gamma_2)$

holdings, which encourages reduction in liquidity premiums until they become zero and the greatest possible number of foreigners hold the currency. Moreover, there are no compensating forces and important currencies assume monopoly power while unimportant ones go the other way. Escape from such equilibrium is delayed

and brutal. Intuitively, it arises when the liquidity-popularity feedback is 'big enough' (formally, when their product is greater than 1: Figure 4*b*).[24]

As observed (Table 3, column III) $\gamma_1\gamma_2 = 0.463$. Bootstrapping (see footnote 21 for details) gives a 95% confidence interval of [0.22, 0.72]. This means that the product of coefficients is larger than zero but smaller than 1. The empirical evidence thus suggests that there is substantial persistence but no lock-in effects.

4.2. *A Counter-factual Assessment*

It is interesting to delve further into the matter and provide an estimation of the actual contribution of history to a given international monetary system – in this instance that of 1900. One way to do this involves recognising that, in our approach, the vehicles of persistence are interest rates and the value of holding given currencies. It is therefore possible to define two vectors that register the effect of past 'events' as the difference between the actual values and long-run equilibrium values. As indicated, a country whose formerly small trading power has increased encounters higher interest rates and lower value for its currency than it 'ought to'. We define these vectors as $\boldsymbol{\varepsilon}_{Ht}$ and $\boldsymbol{\eta}_{Ht}$, respectively. Formally

$$\begin{aligned} \boldsymbol{\varepsilon}_H &= \mathbf{r} - \mathbf{r}_E \\ \boldsymbol{\eta}_H &= \mathbf{u} - \mathbf{u}_E. \end{aligned} \tag{12}$$

where $\mathbf{r}_E$ and $\mathbf{u}_E$ are defined as solutions to (hats denote estimated parameters from Table 3)

$$\begin{aligned} \mathbf{r}_E &= \hat{\gamma}_1 \mathbf{W}\mathbf{u}_E + \mathbf{Y}_1\hat{\boldsymbol{\beta}}_1 \\ \mathbf{u}_E &= \hat{\gamma}_2 \mathbf{M}\mathbf{r}_E + \mathbf{Y}_2\hat{\boldsymbol{\beta}}_2. \end{aligned} \tag{13}$$

Because persistence acts in a symmetrical fashion for interest rates and the value of holding a given currency (as seen in Figure 4*a*), one need only examine persistence in a single dimension. We thus consider the matter by performing the intuitively appealing comparison between the actual popularity of currencies in 1900 (measured by the number of quotes each received in foreign markets) and equilibrium popularity (measured by computing the counterfactual, 'history free' numbers for quotes each currency ought to have received as a solution to (13)).

Figure 5 displays the results. The US, a rising trade power, was penalised during its ascendancy and received substantially fewer quotes than if history had not taken place. Conversely, several European countries were actually much more popular than in the history-free scenario and may be seen as benefiting from history. The most striking example is France, a former world-class trade leader, which received about 25% more quotes than it would have *sans* history.

Another finding from this exercise is that while in the history-free scenario the US dollar enjoys a significantly larger circulation, it is still far from the leading position of sterling. We interpret this as resulting from its geographical position, somewhat off the course of the bulk of international trade that was taking place in Europe. In a last step

[24] For convenience, Figures 4(*a*) and (*b*) illustrate what happens when $\gamma_1 = 1$ so that $\gamma_1\gamma_2 > 1$ boils down to $\gamma_2 > \gamma_1$.

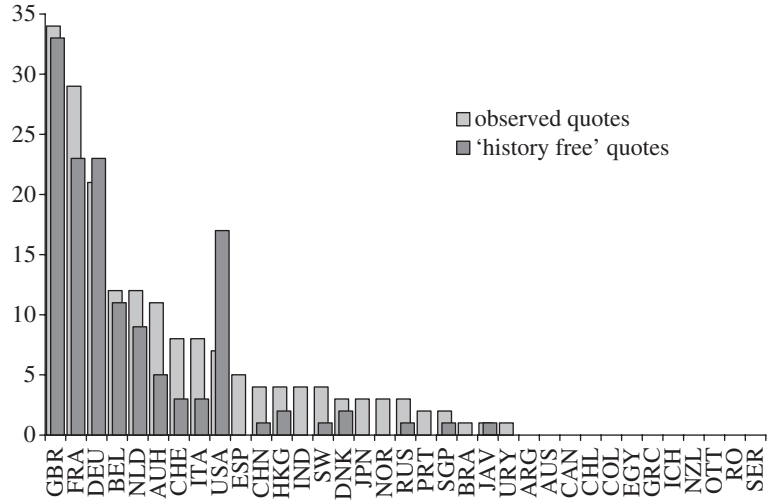

Fig. 5. *History Measured: Actual Versus Counterfactual Number of Foreign Markets Where Currencies Circulated in 1900*

Source. See text. Counterfactual is obtained by computing the long run 'history free' equilibrium.

we can therefore ask how large a shock to the fundamentals – in the instance, a proportional increase in the share of the US in world trade – would have had to be to propel the US dollar to the position it actually attained later in the twentieth century.[25] Figure 6 shows the relation between trade share and currency status. To overtake the franc or the mark, the US trade within our sample would have had to increase from about 11–2% to about 15–6%. After attaining that level, the effect of further increases in trade levels off.

An interesting feature of Figure 6 is its characteristic sigmoid pattern. It shows that in our model, monetary influence does not provide a linear response to an increase in economic influence. This is because, although in the model the utility of holding a currency is determined in a linear system of equations (9), the worldwide popularity the dollar is determined by n demand functions (n being the number of countries in the world), which are non-linear in the explanatory variables (probit functions). This is what generates the 'contagious' pattern exhibited in Figure 6. Intuitively, for every single country there is an area where marginal increases in trade serve to win new foreign holders, fuelling lower interest rates and further equilibrium use of the currency. We conclude that loose reference to 'tipping points' and 'network externalities' and their effect on persistence and lock-in effects may be misleading without due reference to more explicit microeconomic foundations as we provided here.

[25] To be precise, the share in the total trade of the 35 countries in the sample. To simulate the increase in the US trade share, we increased trade in all bilateral pairs that include the US while leaving trade among all other pairs of countries constant. In a gravity model of international trade, this would be the consequence of an increase in US GDP. Of course, we can think of alternative scenarios. For instance, we could have increased US market share in selected countries or continents and would have obtained different results, as currency circulation depends on the bilateral trade links and not on the share in world trade directly.

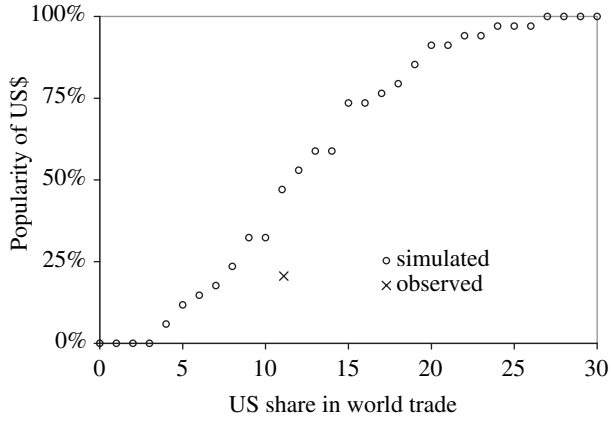

Fig. 6. *Simulating an Increase in US Trade and its Effects on the International Circulation of the Dollar*

Sources. See text.

4.3. *Extensions*

We can think of several extensions: empirical, analytical and normative. The empirical extension would be to extend our framework to consider additional historical periods.. For instance, if technological progress induces smaller distance frictions then the scope for strategic externalities might be increased. 'Persistence' could very well be historically dependent.

An analytical extension would be to adapt the framework under study to take into account alternative forms of persistence that could be tested against one another; David (1985) notes that declining average costs, if supplemented with switching costs could generate pure lock-in effects. This is unlike what happens in our model. But suppose that establishing a new local market or 'trading post' for a given currency involves paying a set-up cost. Then the scope for persistence would increase.[26]

Finally, it would be interesting to provide normative assessments. Persistence may induce the world economy to deviate from its 'optimal' trajectory; see David (1985) and Leibowitz and Margolis (1990) for controversial discussions of this point in a different context. The evidence we reported of a long-run association between international currencies and trade shares suggests that the resulting diseconomy might not be so large, at least in the year 1900. We also observe that the economy that suffered the biggest disadvantage from persistence (the US) was prepared to subsidise the implementation of correctives, as the setting up the National Monetary Commission suggests.

5. Conclusions

This article provides the first empirical model of the determinants of international currency status. We do this in the context of the late nineteenth-century international

[26] In the cross-section that we have considered, such a dynamic feature cannot be identified but it could be dealt with if more periods are considered.

monetary system. In line with the prediction of Charles Kindleberger, we did not find much evidence that currencies become international as a result of the issuing country's moral worth. In contrast, we found evidence of the importance of size, distance and inventory costs, evidence that is consistent with the prediction of search-theoretic models of international currencies. Moreover, we reported strong evidence of strategic externalities: currencies become international on account of their low liquidity premia and (conversely) had low liquidity premia on account of their international circulation. Such feedback, we explained, has the potential for creating persistence.

We then estimated the size of this feedback and found it too small to generate strict path dependency. Nonetheless, persistence was found to be sizeable. Concrete evidence was provided by comparing observed monetary status in the late nineteenth century with its history-free, counterfactual equilibrium. We found that, in the late nineteenth century, history benefited mostly European countries and disadvantaged the US. Our model suggests imputing this to Europe's earlier lead in international trade.

The evidence in this article thus leads to conclusions related to Kindleberger's insight that size is everything. Our findings strongly support his notion that, over the very long run, economic mass and thus the share in international trade is a powerful driver of international monetary leadership. This simple insight, for which we reported abundant evidence, should go a long way toward explaining why it is the US dollar, not the pound sterling, that is the main international currency today. The implication must be that money and trade are complements.

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References

Barro, R.J. and Gordon, D.B. (1983). 'Rules, discretion and reputation in a model of monetary policy', *Journal of Monetary Economics*, vol. 12(1), pp. 101–21.
Bank of International Settlements (BIS) (2005). *Triennial Central Bank Survey*, Basel: BIS.
Bobba, M., della Corte, G., Powell, A. (2007), 'On the determinants of international currency choice: will the Euro dominate the world?', Working Paper, Inter-American Development Bank, June.
Bordo, M. and Rockoff, H. (1996). 'The gold standard as a good housekeeping seal of approval', *Journal of Economic History*, vol. 56(2), pp. 389–428.
Broz, L. (1997). *International Origins of the Federal Reserve System*, Ithaca: Cornell University Press.
Calvo, G.A. and Vegh, C. (1992). 'Currency substitution in developing countries: an introduction', IMF Working Paper No. 92/40.
Chinn, M. and Frankel J. (forthcoming). 'The euro may over the next 15 years surpass the dollar as leading international currency', *International Finance*.
Cohen, B. (2005). 'Currency choice in international bond issuance', *BIS Quarterly Review*, (June), pp. 53–66.
Craig, B. and Waller, C. J. (1999). 'Currency portfolios and nominal exchange rates in a dual currency search economy', Federal Reserve Bank of Cleveland, Working Paper No. 9916.
David, P.A. (1985). 'Clio and the economics of QWERTY', *American Economic Review*, vol. 75(2), pp. 332–7.
De Cecco, M. (1974). *Money and Empire: the International Gold Standard, 1890–1914*, Oxford: Blackwell.
de Roover, R.A. (1968). *The Bruges Money Market around 1400*, Brussels: Paleis der Academiën.
Devereux M.B. and Shi, S. (2005). 'Vehicle currency', mimeo, University of British Columbia.
Dooley, M, Lizondo, P. and Mathieson D. (1989). 'The currency composition of foreign exchange reserves', *IMF Staff Papers*, vol. 36(2) (June), pp. 385–434.

Eichengreen, B. (1999). 'The euro as an international currency', *Journal of the Japanese and International Economies*, vol. 12(4), pp. 483–506.
Eichengreen, B. (2005). 'Sterling's past, dollar's future: historical perspectives on reserve currency status', NBER Working Paper, No. 11336.
Eichengreen, B. and Flandreau, M. (2008), 'The rise and fall of the dollar (or when did the dollar replace sterling as the leading reserve currency?)', CEPR Discussion Paper No. DP6869, April.
Eichengreen, B. and Frankel, J. (1996). 'The SDR, reserve currencies, and the future of the international monetary system', in (M. Mussa, J. Boughton, and P. Isard, eds.), *The Future of the SDR in Light of Changes in the Internatioal Financial System*, pp. 337–77, Washington, DC: IMF.
Eichengreen, B., Hausmann, R. and Panizza, U. (2005). 'The mystery of original sin', in (B. Eichengreen and R. Hausmann, eds.), *Other People's Money: Debt Denomination and Financial Instability in Emerging Market Economies*, pp. 233–65, Chicago: University of Chicago Press.
Eichengreen B. and Mathieson, D. (2001). 'The currency composition of international reserves: retrospect and prospect', in (C. Wyplosz, ed.), *The Impact of EMU on Europe and the Developing Countries*, pp. 269–93, Oxford: Oxford University Press.
Engineer, M. (2000). 'Currency transaction costs and competing currencies', *Journal of International Economics*, vol. 52(1), pp. 113–36.
Flandreau, M. and Gallice, F. (2005). 'Paris, London and the international money market: lessons from Paribas 1885–1913', in (Y. Cassis and E. Bussière, eds.), *London and Paris as International Financial Centres in the Twentieth Century*, pp. 78–106, Oxford: Oxford University Press.
Flandreau, M. and Jobst, C. (2005). 'The ties that divide: a network analysis of the international monetary system 1890–1910', *Journal of Economic History*, vol. 65(4), pp. 977–1007.
Flandreau, M. and Zumer, F. (2004). *The Making of Global Finance 1880–1914*, OECD Development Center monograph, Paris: OECD.
Flood, R. and Garber, P. (1984). 'Gold monetization and gold discipline', *Journal of Political Economy*, vol. 92(1), pp. 90–107.
Frankel, J., Galli, G. and Giovannini, A. (1996). *The Microstructure of Foreign Exchange Markets*, Chicago: University of Chicago Press.
Goldberg, L. and Tille, C. (2005). 'Vehicle currency use in international trade', Federal Reserve Bank of New York Staff Report No. 200.
Hartmann, P. (1998). *Currency Competition and Foreign Exchange Markets: The Dollar, the Yen and the Euro*, Cambridge: Cambridge University Press.
Head, A. and Shi, S. (2003). 'A fundamental theory of exchange rates and direct currency trades', *Journal of Monetary Economics*, vol. 50(7), pp. 1555–91.
Jacobs, L. (1910). *Bank Acceptances*, Publications of the National Monetary Commission, Vol. 20(3), [US] 61st Cong., 2d Sess. Senate Doc. 569, Washington, DC: Government Printing Office.
Kindleberger, C. (1967). *The Politics of International Money and World Language* (Essays in International Finance, No. 61), Princeton: Princeton University Press.
King, F.H., King, C.E. and King, D.J. (1988). *The Hongkong Bank in Late Imperial China, 1864–1902: On an Even Keel*, New York: Cambridge University Press.
King, W.T.C. (1936). *History of the London Discount Market*, London: Routledge.
Kiyotaki, N. and Moore, J. (2003). 'A cost of unified currency', in (P. Mizen, ed.), *Central Banks, Monetary Theory and Policy: Essays in Honour of Charles Goodhart*, Vol. 1, pp. 247–55, Cheltenham: Edward Elgar.
Kiyotaki, N. and Wright, R. (1989) 'On money as a medium of exchange', *Journal of Political Economy*, vol. 97(4), pp. 927–54.
Kiyotaki, N. and Wright, R. (1993). 'A search-theoretic approach to monetary economics', *American Economic Review*, vol. 83(1), pp. 63–77.
Krugman, P. R. (1980). 'Vehicle currencies and the structure of international exchange', *Journal of Money, Credit and Banking*, vol. 12(3), pp. 513–26.
Krugman, P. R. (1984). 'The international role of the dollar: theory and prospect', in (J.F.O. Bilson and R.C. Marston, eds.), *Exchange Rate Theory and Practice*, pp. 261–78, Chicago: University of Chicago Press.
Kydland, F.E. and Prescott, E.C. (1977). 'Rules rather than discretion: the inconsistency of optimal plans', *Journal of Political Economy*, vol. 85(3), pp. 473–91.
Leibowitz, S.J. and Margolis, S.E. (1990). 'The fable of the keys', *Journal of Law & Economics*, vol. 33(1), pp. 1–25.
Li, Y. and Matsui, A. (2005). 'A theory of international currency and seigniorage competition', CEPR Discussion Paper No. 5529.
Lyons, R. and Moore, J. (2005). 'An information approach to international currencies', NBER Working Paper, No. 11220.
Maddala, G.S. (1983). *Limited-Dependent and Qualitative Variables in Econometrics*, Cambridge: Cambridge University Press.
Matsuyama K., Kiyotaki, N. and Matsui, A. (1993). 'Toward a theory of international currency', *Review of Economic Studies*, vol. 60(2), pp. 283–307.

Meltzer, A.H. (2003). *A History of the Federal Reserve*, vol 1: *1913–1951*, Chicago: Chicago University Press.
Menger, K. (1892). 'On the origins of money', Economic Journal, vol. 2(6), pp. 239–55.
Nishimura, S. (1971). *The Decline of Inland Bills of Exchange in the London Money Market, 1855–1913*, Cambridge: Cambridge University Press.
North, D.C. and Weingast, B. (1989). 'Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England', *Journal of Economic History*, vol. 49(4), pp. 803–32.
Peterson, B. (2004). 'The effects of trade linkages on dollarization', CEPR Discussion Paper No. 5529.
Ravikumar, B. and Wallace, N. (2001). 'A benefit of uniform currency?', Pennsylvania State University, manuscript.
Rey, H. (2001). 'International trade and currency exchange', *Review of Economic Studies*, vol. 68(2), pp. 443–64.
Trejos, A. and Wright, R. (1996). 'Search-theoretic models of international currency', *Proceedings*, Federal Reserve Bank of St. Louis, May, pp. 117–32.
Vanhanen, T. (2000). 'A new dataset for measuring democracy, 1810–1998', *Journal of Peace Research*, vol. 37(2), pp. 251–65.
von Hayek, F.A. (1976). *Denationalization of Money, The Argument Refined*, 2nd ed., London: Institute of Economic Affairs, 1990.
Wasserman, S. and Faust, K. (1994). *Social Network Analysis. Methods and Applications*, Cambridge: Cambridge University Press.
Wright, R. (1995). 'Search, evolution and money', *Journal of Economic Dynamics and Control*, vol. 19(1–2), pp. 181–206.
Wright, R. (1999). 'A note on asymmetric and mixed strategy equilibria in the search-theoretic model of fiat money', *Economic Theory*, vol. 14(2), pp. 463–71.
Zhou, R. (1997). 'Currency exchange in a random search model', *Review of Economic Studies*, vol. 64(2), pp. 289–310.