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A SPATIAL PROBIT APPROACH**

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CONTAGIOUS CURRENCY CRISES: A SPATIAL PROBIT APPROACH

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Abstract: We probe the idea that the 1992 currency crisis that affected several European countries was a contagious phenomenon. Using *spatial probit* models, we show that the currency crisis was indeed contagious, with the trade channel favored as the transmission channel. We also test the political channel, but the evidence is hybrid. Contrary to previous work, we find macroeconomic variables to be significant (standard probit is inconsistent and inefficient in the presence of spatial dependence), with poor economic growth playing a significant role. Several European countries had been experiencing poor, even negative, real growth at the time of the crisis.

Keywords: Contagion; Currency crisis; Spatial econometrics; Trade spillover; Political spillover

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1. INTRODUCTION

The spread of currency crises from country to country in the European crisis of 1992-93, in Latin America during 1994 ('Tequilla Hangover') and finally the 'Asian Flu' in 1997 has given rise to a body of literature addressing the question of contagion in foreign currency markets. Although there is no universal definition of contagious currency crisis, the underlying idea hypothesizes that currency crises elsewhere in the world can spread among countries like a contagious disease. Gerlach and Smets (1995), Buiter, Corsetti and Pesenti (1996), Goldfajn and Valdés (1996), Mason (1998), Drazen (1999), Calvo and Mendonza (2000), Corsetti et. al. (2000) and Loisel and Martin (2001) address the question of contagion in different theoretical frameworks. Among others, Eichengreen, Rose and Wyplosz (1996), Sachs, Tornell and Velasco (1996), Kaminsky, Lizondo and Reinhart (1998), Glick and Rose (1998), Kaminsky and Reinhart (2000) and Rijckeghem and Weder (2001) investigate empirically the concept of contagion. For the most part, least squares and standard probit methods yield evidence in favor of contagion, with trade channels favored over macroeconomic factors as transmission channels.

Our empirical contribution is based on spatial probit models, i.e., probit models which explicitly take into account 'spatial' interactions among observed countries. Spatial probit seems particularly well-suited to study contagion, which by definition can only occur if there are interactions among subjects. Even if currency crises are contagious, contagion itself can only occur if there are interactions between countries. Interactions can occur at the foreign trade level (devaluations change the competitiveness of tradeables) or at the 'political' level (membership in institutions such as the European Union, where weakness by one member may have strong repercussions for the remaining members). Our results confirm some previous findings in the literature: spatial probit estimates lend support in favor of the contagion hypothesis with trade channels as primordial transmission mechanisms. Additionally, our contribution highlights the statistical significance that political relationships may have played in Europe, seeming to support the idea introduced by Drazen (1999). We must, however, point out that while it's easy to reach a consensual definition of trade interactions,

it is no trivial task to define, isolate from other interactions (including trade) and measure political interactions. Our results should, therefore, be taken with this caveat. Contrary, in particular, to Glick and Rose (1998), we find evidence that macroeconomic factors were significant explanatory variables. Of all macroeconomic variables, the low real growth rates experienced by several European countries seemed to have played the most significant role. The requirements to maintain a fixed exchange rate seemed to be at odds with the poor economic (growth and unemployment) performance.

The remainder of the paper is organized as follows. Section 2 surveys spatial probit models. Theoretical models of contagious currency crises are reviewed in section 3. Empirical evidence based on spatial probit models is presented in section 4. Section 5 concludes.

2. SPATIAL PROBIT MODELS

In this section, we describe spatial probit models, briefly surveying estimation procedures. Our objective is twofold. First, to familiarize the reader with the econometric techniques, most of which have only recently been developed. Secondly, to lay the foundations necessary to motivate the use of spatial probit models in the analysis of contagious currency crises.

Spatial probit models¹ take the general form of

$$y^* = \eta W_{(l)} y^* + X\beta + u, \quad u = \psi W_{(e)} u + \epsilon, \quad \epsilon \sim N(0, I), \quad (1)$$

where y^* is a $nx1$ vector of latent variables, X a nxk matrix of covariates, $W_{(l)}$ and $W_{(e)}$ are nxn spatial lag and error weights matrices, respectively and $\{\eta, \psi\}$ the associated scalar spatial parameters. Since y^* is latent, we cannot estimate (1). What we observe is y , which is related to y^* by

¹ Spatial literature in general is reviewed in a textbook approach by Anselin (1988), and surveyed by Anselin et. al. (1996), Anselin and Bera (1998), Anselin (2001a) and Anselin (2001b).

$$y = \begin{cases} 1, & \text{if } y^* \geq 0 \\ 0, & \text{if } y^* < 0. \end{cases} \quad (2)$$

The spatial weights matrices ($W_{(l)}, W_{(e)}$) are $n \times n$ exogenously specified matrices intended to capture some form of ‘neighborhood.’ For example, each ij -entry, ω_{ij} , might equal 1 if i and j have common physical borders. Closer to our empirical motivation, ω_{ij} may reflect the exports of i to j . By convention, the diagonal elements are set to zero and for computational, ease of interpretation and comparison across models each row is standardized to sum to one. In the above exports example, each ij entry would then represent the relative importance of country j ’s market for i ’s total exports. This allow us to weight currency crises elsewhere (y_{-i}) according to the relative relevance of each foreign market for country i ; countries with a small percentage of country i total exports, despite lost competitiveness by i ’s exportables, should not have an impact as if a large market for i had devalued its currency. Anselin (1988) discusses the specification of weights matrices at further length, including alternative metrics and regularity conditions necessary to evoke asymptotic results.

If $\eta = \psi = 0$, (1) reduces to the standard probit model. Constraining the spatial parameter space in other forms yields three distinct spatial models: lag, error and lag + error. Setting $\eta = 0$ and estimating the other parameters (β, ψ) results in the spatial error model. From an economic perspective, the spatial error model is commonly seen as a nuisance in that it captures autocorrelation in measurement errors, or in the fact that ignored variables spillover across the observations in a spatial manner (Anselin and Bera (1998)). To establish a parallel with more commonly addressed econometric issues, consider heteroskedasticity in standard least squares models. If we knew the explicit heteroskedastic form of the error terms, we would simply reweight to obtain consistent standard errors, ignoring altogether any economic interpretation. Spatial (probit) error models can be seen in the same light, we need to address the non-spherical nature of the covariance matrix to obtain (unbiased and) efficient estimates.

The economic interpretation of the spatial lag model, which results from setting $\psi = 0$ and

estimating (β, η) , is clearly more meaningful. Here, the dependent variable in location i is not only determined by covariates (X) specific to location i , but also by the value of the same dependent variable at other locations. This last fact is particularly suggestive in models of contagion, where the ‘health’ status of other individuals may, if contagious, determined the ‘health’ of individual i . Indeed, the Eichengreen et. al. (1996) definition of currency crises contagion can be formally specified as a spatial probit lag model: “an increase in the probability of a speculative attack on the domestic currency which stems not from domestic “fundamentals” such as money and output but from the existence of a (not necessarily successful) speculative attack elsewhere in the world .” Anselin and Bera (1998) suggest two interpretations of the spatial lag model. Either, it suggests true contagion (spatial spillovers, copy-cattng or diffusion). This requires, however, that the observed spatial units match the true economic units and that the spillover is modeled theoretically. Or, the alternative interpretation results from situations where there is a mismatch between the true spatial scale and the observed one, e.g., census vs. economic units. This last interpretation is hardly the case of currency crises, although the fact that some countries do not have sovereign currencies might legitimate it.

In spatial lag + error models all three parameters (η, ψ, β) are estimated. These models may be viewed in practice (Anselin and Bera (1998)) as resulting from poorly specified lag matrices ($W_{(l)}$) which results in spatial interactions in the error terms that need to be taken into account ($W_{(e)}$). This, of course, is a valid concern in the models that we estimate in the empirical section. In terms of economic interpretations, evidence of true contagion is as in the lag model provided by the statistical significance of η . Notice, however, that we cannot interpret as contagion the significance of the error part (ψ). We should see it in a form similar to the error model interpretation, i.e., as a procedure to further correct for statistical nuisances.

Spatial probit models raise new difficulties that cannot be dealt with standard probit. Only recently have we seen developments in the spatial econometrics literature addressing spatial probit models. Estimation problems arise due to the dependence across observations. Standard probit assumes independence, resulting that we must adjust the estimation procedures for the loss of infor-

mation associated with dependent observations. Indeed, standard probit estimates are inconsistent and inefficient in the presence of spatial dependence (McMillen (1992)). In computational terms, difficulties arise from the fact that we no longer have the product of n independent univariate standard normal probabilities, but instead need to evaluate a n -dimensional multivariate integral to compute the joint probabilities appearing in the likelihood. This can only be dealt with simulation techniques.

Currently, there are four techniques available to estimating spatial probit models. McMillen (1992) purposes an EM-algorithm based estimation procedure. The idea is to replace the latent continuous variable with its expected value and then apply standard, well-established continuous variable spatial methods, for example, maximum likelihood estimation. Pinkse and Slade (1998) develop a generalized method of moments (GMM) based procedure applicable only to spatial error models. Similarly to McMillen (1992), LeSage (1999) also replaces the latent continuous variable with its expected value, solving thereafter a spatial continuous model with a Gibbs sampling approach. Following the work of Vijverberg (1997) on the simulation of multivariate normal probabilities of high-order dimension, Beron and Vijverberg (1999) extend the original approach, recursive importance sampling (RIS), to probit models in spatial contexts².

In the next section, we briefly review theoretical work on contagious currency crises, relating it with spatial modeling.

3. CONTAGIOUS CURRENCY CRISES MODELS

We focus our attention on contagious currency crises models, earlier work on currency crises, which includes the seminal work of Krugman (1979) and Obstfeld (1986), is surveyed, for example, in Flood and Marion (1998).

Models of contagious currency crises did not echoed until after the currency crises that affected

² Because of the asymptotic and/or simulation nature of the econometric procedures just described Novo (2001) carries on two Monte Carlo experiments aimed at providing a better small sample understanding of such procedures. Briefly summarizing, all estimation methods, under different data generating processes, tend to underestimate ($bias < 0$) the spatial parameter.

several European countries, one after the other in a very short period of time (September of 1992), raising the contagion hypothesis. In Gerlach and Smets (1995), a speculative attack results in a real depreciation, enhancing competitiveness of the attacked country's exports while affecting negatively trading partners. The latter experience trade deficits, decline in international reserves and ultimately also a currency crisis. An alternative channel of transmission is through the reduction in the price level in the importing countries. The subsequent decline in money demand and exchange for foreign currency fuels the path to a crisis.

Buiter, Corsetti and Pesenti (1996) model contagion with an escape-clause model. In a system of $N + 1$ countries, N peripheral countries peg their currencies to the 'center.' A negative shock to the latter, which does not adjust interest rates, may lead all or some countries to abandon the system. If some abandon, the remaining are less likely to do so because, in the face of the depreciation, the center is likely to then monetarily adjust itself.

Goldfajn and Valdés (1995) focus on the role of illiquidity of financial markets. Financial intermediaries with liquidity problems (e.g. as the result of a banking crisis) liquidate their foreign positions triggering self-fulfilling contagious crises in foreign countries.

Political objectives are often at the heart of selected economic policies. The European Monetary Union (EMU) is clearly more than an economic process of integration; political integration is the driving force beyond the EMU. Feldstein (1997) argues that the political and economic objectives in Europe are actually conflicting. Building upon the importance of political aspects, Drazen (1999) identifies two types of political factors that might help understand contagion. First, incomplete information about government objectives and the aforementioned political nature of the exchange rate regime are potential explanations to the appearance of speculative attacks. Secondly, if maintaining a fixed exchange rate is tied together with achieving political integration within a "club," then a devaluation by one member will increase speculative pressures on the other members ('membership' contagion). Other relevant models include the work of Masson (1998) and Forbes and Rigobon (1999). Masson (1998) redefines contagion suggesting that 'true' contagion is only possible in contexts of multiple equilibria. Forbes and Rigobon (1999) take a more econometric

based approach to show that the cross markets correlation coefficient is a biased measure to identify contagion. Corrections for heteroskedasticity, endogeneity and omitted variables are suggested. Calvo and Mendoza (2000) argue that globalization of securities markets may promote contagion by reducing incentives to gather information and by increasing the number of arbitrary market portfolios. Herd behavior by portfolio managers may generate contagion type of effects. Loisel and Martin (2001) provide a theoretical framework where self-fulfilling expectations generate a currency crisis when workers demand higher wages in the wake of expected devaluations, leading to actual devaluations. Self-fulfilling speculative crisis are more likely the larger the trade links.

The vein of thought common to contagious currency crises models is the idea that what occurs to other countries may play a major role in determining the fate of a country currency exchange rate. The idea of interactions (dependence) is also at the center of spatial models. In particular, the spatial lag model when applied to currency crises states that a crisis in country i is a weighted average of crises (and non-crises) elsewhere ($\eta W_{(l)}y$ of equation (1)), plus country i specific macroeconomic fundamentals ($X\beta$ part of (1)). What and how foreign events spread from country to country is what sets the models apart. Trade channels? Liquidity? Common memberships? Again, each one of these transmission mechanisms can be easily incorporated into a spatial model by means of spatial weights matrices. These are matrices intended to capture notions of ‘neighborhood.’ Trade neighbors? We can built exports, imports or total foreign trade matrices to test for trade transmission channels (a statistically significant η in (1)).

Therefore, it appears to us that spatial modeling provides a natural framework not only to test for contagion, but also to test for the different transmission channels purposed in the literature.

4. ‘SPATIAL’ EMPIRICAL EVIDENCE

This section utilizes the spatial econometrics tools described earlier to analyze the 1992 European currency crisis. The data on currency crises and fundamental macroeconomic variables are the same as in Glick and Rose (1998). In its most general form, the selected regression model is

given by

$$y = \eta W_{(l)} y + \beta_0 + \beta_1 \% \Delta Cred + \beta_2 GovBdg + \beta_3 CAcc + \beta_4 RGrth + \beta_5 M2/Res + \beta_6 Infl + u, \quad u = \psi W_{(e)} u + \epsilon, \quad \epsilon \sim N(0, I), \quad (3)$$

where y is a binary variable taking value 1 for any of the 65 countries which suffered a currency crisis and 0 otherwise, $\% \Delta Cred$ is the annual growth rate of domestic credit, the government budget deficit as a percentage of GDP is $GovBdg$, $CAcc$ stands for current account as a percentage of GDP, $RGrth$ is the growth rate of real GDP, $M2/Res$ represents the ratio of M2 to international reserves, and $Infl$ is the domestic CPI inflation. $W_{(l)}$ and $W_{(e)}$ are exogenously specified $n \times n$ weights matrices, lag and error, respectively. As suggested earlier, to test for sources of transmission, we can specify weights matrices based on different concepts of ‘neighborhood.’ We begin by exogenously specifying matrices based on international trade data. Three matrices are created:

- (i) Exports-based, (W_X). We register at each ij –entry the 1991 exports of i to j ³. As a convention in the literature, we also normalize each row to sum to 1. Therefore, crises or tranquil episodes elsewhere are weighted by the relative importance of country j ’s market to country i .
- (ii) Imports-based, (W_M). To overcome one of Glick and Rose (1998) shortcomings, we create a matrix of the form described in (i), registering instead imports of i from j at each ij –entry.
- (iii) Total international trade-based, (W_T). This matrix adds up exports and imports to form the weights⁴.

Finally, we create weights matrices based on political concepts to formally test the hypothesis of political contagion first suggested by Drazen (1999). Contrary to trade-based weights matrices, political matrices are harder to be of a consensual form. For example, if we consider that Portugal and Germany are political neighbors due to their European Union membership, we may still not be able to isolate the political aspects from other concepts of neighborhood – Germany is the largest

³ Data are taken from the International Monetary Fund (1992) “Directions of Trade Statistics” publication.

⁴ All three matrices are clearly non-symmetrical, reflecting, for example, in case of the United States and Portugal, the fact that Portugal represents a small fraction of the United States total foreign trade, while the United States represent a large fraction of Portugal total foreign trade ($\omega_{ij} \neq \omega_{ji}$).

importer of Portugal. Furthermore, we do not have a formal measure of political interaction as we do, for example, for trade. Despite these limitations, we construct the following matrices:

- (i) W_P . The ij -entry equals 1 if both country i and j are members of at least one of the following organizations: G7, European Union, North American Free Trade Association;
- (ii) W_A . Extends the criterion in (i) to include the following organizations: Asia-Pacific Economic Cooperation (APEC) and Mercusor.

In the present setting, some readers may question why we use a cross-sectional dataset. The temporal dynamics may be considered of surmounting importance; the outbreak of a crisis in a particular country may trigger other crises, suggesting a dynamic chain of events. However, there are also severe data difficulties and arguments that downplay the importance of time. Consider first the data difficulties. Currency crises, however defined, are very short term occurrences, at least traditional fundamental macroeconomic variables do not change (and/or are available) at such timeframes. Take, for example, budget deficits typically measured annually, current accounts quarterly measured. It is, therefore, extremely difficult to explain a short term change in crisis status (0-1) with changes/movements in such variables.

As an alternative view to the importance of the time sequence of events, consider the following medical analogy. The outbreak of a particular hitherto unknown disease is detected. Suppose that we know who is infected and who first reported symptoms. Do we know who was first infected? Typically not. Individual immune systems have variable reaction periods. Given that we do not observe this intrinsic characteristic, we may as well ignore the timing and instead consider an approach that tries to answer the question: “Can we establish a relationship between the probability of a particular individual getting infected and the medical status of others in the sample after accounting for other characteristics?”

In the case of the 1992 currency crisis, the fact that Finland was the first to succumb⁵ does not suggest that other countries were not under tremendous speculative attacks. The fact that they resisted longer might only have to do with a larger pool of reserves to draw from or a stronger

⁵ Actually, and in line with our infection vs. symptoms argument, Glick and Rose (1998) also consider Italy as the first victim.

commitment to defend the exchange rate. Thus, the fact that they later collapsed may not be due to other crises, but only because resources were exhausted or the costs too dear⁶. Additionally, it is well documented (Frankel and Rose (1995)) that structural models relating macroeconomic variables with exchange rates have little explanatory power at short and medium horizons. So, given the two arguments, we may choose to ignore the timed sequence of occurrences and instead focus on the fact that, only in the month of September of 1992, 7 European countries suffered a currency crisis, asking the question: “Were currency crises contagious or were all affected countries ‘drinking’ the same contaminated ‘macroeconomic water’? Or, was it a combination of both factors?”

For comparison purposes, it is informative to revisit the work of Glick and Rose (1998). In the last column of Table 1, we report the model estimated by Glick and Rose. A description of the variables was presented earlier. Here, we provide a more detailed description of *trade* as it is the crucial variable in their argument that currency crises are regional because of trade channels. *Trade* attempts to capture the importance of international trade links between Finland (first victim) and other participants. In particular, it expresses the degree to which Finland and another country compete in third countries. The more similar the importance of country k ’s market to both Finland and country i , the higher the value of $trade_i$. The regression results lend support to the hypothesis of contagion through trade channels at the 5% significance level, but not at the 1% level. All macroeconomic variables are statistically insignificant at the 5% level.

Unfortunately, as the authors acknowledge, this approach has several shortcomings that we can easily overcome by estimating spatial models:

- (i) while they *assume* that there is contagion, by taking Finland as the ‘first victim’ and measuring events relatively to Finland, we do not make such assumption. Indeed, the simultaneity of the spatial lag model goes a step further – it also accounts for influences that may push away from such events⁷. Furthermore, while Glick and Rose (1998) assign the same weights for all observations, we assign differential weights through the weights

⁶ Eichengreen et. al. (1996) argue that currency crisis do not have to match actual devaluations. Again, this lends support to the idea that the first victim does not necessarily correspond to the first currency to be attacked.

⁷ For example, the fact that Germany did not suffer a currency crises might have prevented more serious consequences.

matrices;

- (ii) their ‘trade’ measure ignores direct trade between Finland and each of the other sampled countries. Again, the use of the trade-based weights matrix⁸ clearly accounts for such commercial interactions;
- (iii) ‘cascading effects’ are ignored. For example, if a currency crisis spreads quickly from i to j , then the next spillovers may result from both i and j crises. While the previous work is not able to capture such joint effects, we can easily accommodate for cascading effects with spatial lag models.

Additionally, while Glick and Rose (1998) focus their attention on trade based spillovers, we can easily consider other sources of spillovers. In particular, we will explore ‘political’ weight matrices to formally test the hypothesis of Drazen (1999).

As indicated earlier, we extend Glick and Rose (1998) results, overcoming several of their shortcomings. The results for the lag and error models are summarized in Table 1. We estimate using Beron and Vijverberg (1999) recursive importance sampling technique with 2,000 replications to simulate the likelihood function; the dependence across observations built into (3) renders inconsistent and inefficient standard probit estimation (McMillen (1992)).

Let’s focus first on the spatial lag model. This model formally tests the definition of contagion put forward by Eichengreen et. al. (1996). Table 1 reports evidence of contagion, mainly through trade channels. Regardless of the trade weights matrix, the (statistical and economic) significance of crises elsewhere in the world is unequivocal; point estimates of the spatial lag parameter range from 0.3171 to 0.3825⁹. Political contagion is not supported for the case of W_P , but it is when we use W_A . At the bottom of Table 1, we report the likelihood values for each estimated model. In the specific case of the lag model, there is no significant difference across trade-based models, as well as for the political-based ones. Comparing across trade and political transmission channels, the latter seems to have a slight edge over the former¹⁰. Relatively to Glick and Rose (1998), we

⁸ We created three matrices based on exports, imports and total foreign trade data.

⁹ The parameter space is given by $1/\omega_{min} < \eta < 1/\omega_{max}$, where the ω ’s are the smallest and largest eigenvalues of W . For W standardized, $\omega_{max} = 1$, but $\omega_{min} > -1$ (Anselin (1980)).

Spatial Lag and Error Models											
	W_X		W_M		W_T		W_P		W_A		G & R
	Lag	Error	Lag	Error	Lag	Error	Lag	Error	Lag	Error	
Intercept	-0.6340	-1.7130	-0.8491	-1.6548	-0.7900	-1.6647	-1.8642	-1.7706	-1.7622	-1.7564	-2.6921
	0.1957	0.1476	0.1815	0.1436	0.1872	0.1440	0.1657	0.1489	0.1738	0.1541	1.4461
%Δ Credit	0.0036	0.0021	0.0061	0.0024	0.0046	0.0022	0.00154	0.0050	0.0025	0.0046	0.0192
	0.0045	0.0022	0.0051	0.0024	0.0049	0.0023	0.0026	0.0038	0.0035	0.0037	0.0166
Govt. Budget	-0.0923	-0.0955	-0.0889	-0.0987	-0.0907	-0.0984	-0.1520	-0.0409	-0.1234	-0.0529	-0.1121
	0.0272	0.0257	0.0266	0.0257	0.0268	0.0258	0.0354	0.0240	0.0341	0.0243	0.1432
Current Acct	0.0429	0.0540	0.0440	0.0575	0.0437	0.0569	0.0935	0.0222	0.0773	0.0248	0.0071
	0.0149	0.0149	0.0150	0.0149	0.0149	0.0149	0.0210	0.0147	0.0192	0.0149	0.0663
Real Growth	-0.1247	-0.1225	-0.1235	-0.1256	-0.1230	-0.1247	-0.1566	-0.1517	-0.1413	-0.1479	-0.2618
	0.0205	0.0185	0.0203	0.0186	0.0204	0.0185	0.0237	0.0206	0.0241	0.0200	0.1628
M2/Reserves	-0.0299	-0.0220	-0.0273	-0.0233	-0.0295	-0.0233	-0.0145	-0.0234	-0.0141	-0.0196	0.0285
	0.0070	0.0067	0.0067	0.0063	0.0068	0.0065	0.0057	0.0055	0.0061	0.0054	0.0298
Inflation	-0.0788	-0.0771	-0.0717	-0.0794	-0.0731	-0.0790	-0.1101	-0.0787	-0.0932	-0.0787	-0.1254
	0.0130	0.0125	0.0119	0.0127	0.0122	0.0126	0.0216	0.0117	0.0215	0.0117	0.0954
Trade											5.4577
											2.5801
	η	ψ	η	ψ	η	ψ	η	ψ	η	ψ	
Spatial	0.3825	0.2983	0.3171	0.2482	0.3325	0.2578	0.0064	0.5480	0.1582	0.5046	
	0.0473	0.0570	0.0504	0.0547	0.0493	0.0546	0.0503	0.0351	0.0430	0.0397	
Likelihood	4.1091	3.8519	3.9430	3.7986	3.9819	3.8122	5.0488	3.7099	5.1309	3.6257	

TABLE 1 — CURRENCY CRISES CONTAGION EVIDENCE

Estimates based on Beron & Vijverberg (1999) algorithm. Standard errors reported underneath point estimates. Data are taken from Glick and Rose (1998). *Trade* is a weighted average of the importance of exports to country k for Finland and i (Glick and Rose (1998), p. 9). All other variables are defined in the text. Point estimates in *italic* are statistically insignificant at the 5% level, while **boldface** indicates insignificance at the 1% level.

now have that some macroeconomic variables are statistically significant. This result may not be surprising in the light that standard probit estimates are inconsistent and inefficient in the presence of spatial dependence. It also implies that currency crisis are not exclusively explained by contagion, but that domestic macroeconomic fundamentals played a role in the outbreak of currency crises. The annual growth rate of domestic credit does not (statistically) increase the probability of a currency crisis for all specifications. For particular specifications, other variables are also statistically insignificant, but in general they are significant. While higher government budget deficits and lower rates of economic growth increase the probability of a crisis, as predicted by economic theory, we have three counterintuitive results¹⁰. Higher current account surpluses, M2/Reserves ratios and inflation reduce the probability of currency crises.

By the definition of contagion that we have been using (Eichengreen et. al. (1996)), we clearly want to estimate spatial lag models (eventually, spatial lag + error models). However, given that we have no guarantee that the data generating process is best described by the lag model and, furthermore, the error model in conjunction with the lag model may provide important information in the estimation of the lag + error models, we proceed by estimating error models. The results, also reported in Table 1, contrast somewhat with the ones reported for the lag model. In particular, now political ‘spatial’ dependence plays a much stronger role than ‘trade.’ While the coefficient on the spatial error dependence for political matrices exceeds 0.50, it is in the 0.25 to 0.30 range for the trade weight matrices. The values and statistical significance of the macroeconomic variables do not differ much from the ones reported in the lag model. Also noteworthy is the fact all error models have slightly lower likelihood values (e.g., 4.1091 vs. 3.8519) than the lag models. We take this as the first sign that the inclusion of currency crises elsewhere in the world as an explanatory variable might be appropriate. That is, the information provided by the lag and error models may indicate that currency crises are contagious, with trade channels playing a larger role as the transmission mechanism. We shall see if the estimation of the spatial lag + error models changes

¹⁰ Notice that the point estimate signs are the same as in Glick and Rose (1998), except for M2/Reserves ratio. Take, for example, the case of inflation. Inflation in the ‘crisis’ countries was on average lower than in the ‘non-crisis’ countries – the negative coefficient may be capturing such data feature. A similar line of argument applies to the other counter intuitive results.

our view.

The observation that trade based weights are always statistically significant in the lag model and that political based weights matrices carry more influence in the error model suggests that we estimate lag + error models using a mixture of those matrices. Thus, in Table 2, we report the results of 6 lag + error models always using trade matrices for the lag part and political matrices for the error part. The results confirm previous findings in the literature. First, we find clear evidence of contagion – all 6 point estimates on the coefficient of spatial lag dependence are statistically significant. Second, and as a sequence of the first observation, trade is a statistical significant transmission channel. Third, the coefficient of spatial error dependence is statistically significant (point estimates exceeding 0.23). Thus, we find evidence that the errors are politically correlated across countries. Although we cannot interpret this evidence as suggesting political contagion (that’s only captured in the ‘contagion’ coefficient, η , on crises elsewhere), it is indicative that currency crises seem to have a spatial pattern that stems from political interactions (common memberships). In terms of the macroeconomic fundamentals, all variables, with the exception of real economic growth, are now insignificant at the 5% level. This result may actually appropriately reflect the fact that in 1992 countries like the United Kingdom, Sweden and Finland observed negative real growth, while quite a few other European countries experienced almost zero real growth, leading markets to punish inconsistent macroeconomic policies (the burden of maintaining a fixed exchange rate vs. low growth, high unemployment). Although not reported here, we run a new set of regressions reversing the role of the matrices, i.e., political matrices are now ‘lag’ and trade matrices ‘error.’ The results support political contagion for the W_A matrix¹¹ with some evidence that there might be other factors left in the error term that are correlated across nations by trade channels. The likelihood values are always slightly smaller (by approximately 0.45) than the values reported in Table 2.

The final task that we face is to decide which model best describes the data generating process. At the bottom of Table 2, we report likelihood ratio test statistics. First, notice that all test

¹¹ Point estimates for W_P are statistically insignificant, a result resembling the estimation of the lag model (Table 1).

	Spatial Lag + Error Model					
	W_X		W_M		W_T	
	W_P	W_A	W_P	W_A	W_P	W_A
Intercept	<i>-0.6716</i>	<i>-0.6564</i>	-0.8746	-0.8730	<i>-0.7203</i>	<i>-0.7079</i>
	0.4871	0.4915	0.4320	0.4383	0.4665	0.4771
%Δ Credit	<i>0.0049</i>	<i>0.0048</i>	<i>0.0081</i>	<i>0.0076</i>	<i>0.0073</i>	<i>0.0070</i>
	0.0054	0.0052	0.0058	0.0054	0.0056	0.0054
Govt. Budget	<i>0.0579</i>	<i>0.0489</i>	<i>0.0532</i>	<i>0.0426</i>	<i>0.0488</i>	<i>0.0392</i>
	0.0436	0.0426	0.0421	0.0417	0.0431	0.0426
Current Acct	<i>-0.0212</i>	<i>-0.0236</i>	<i>-0.0112</i>	<i>-0.0139</i>	<i>-0.0145</i>	<i>-0.0173</i>
	0.0247	0.0237	0.0241	0.0226	0.0249	0.0239
Real Growth	-0.1474	-0.1420	-0.1617	-0.1546	-0.1573	-0.1510
	0.0500	0.0486	0.0484	0.0470	0.0500	0.0488
M2/Reserves	<i>-0.0339</i>	<i>-0.0346</i>	<i>-0.0268</i>	<i>-0.0270</i>	-0.0330	-0.0334
	0.0173	0.0170	0.0156	0.0153	0.0161	0.0158
Inflation	<i>-0.0647</i>	<i>-0.0681</i>	<i>-0.0513</i>	<i>-0.0525</i>	<i>-0.0599</i>	<i>-0.0633</i>
	0.0354	0.0382	0.0258	0.0276	0.0334	0.0369
Trade Contagion (η)	0.5639	0.5666	0.5659	0.5696	0.5681	0.5707
	0.0552	0.0539	0.0532	0.0525	0.0537	0.0530
Pol. Spatial Dep. (ψ)	0.2703	0.2564	0.2630	0.2475	0.2494	0.2344
	0.0902	0.0905	0.0791	0.0815	0.0841	0.0865
Likelihood	6.3950	6.3698	6.2647	6.2365	6.2883	6.2609
L'hood Ratio Test						
$2(l(\cdot, \eta, \psi) - l(\cdot, \psi))$	5.0862	5.0358	4.9322	4.8758	4.9522	4.8974
$2(l(\cdot, \eta, \psi) - l(\cdot, \eta))$	4.5718	4.5214	4.6434	4.5870	4.6128	4.5580

TABLE 2 — CURRENCY CRISES CONTAGION EVIDENCE

Estimates based on Beron & Vijverberg (1999) algorithm. Standard errors reported underneath point estimates. Data are taken from Glick and Rose (1998). Depending on the column where the point estimates are reported, the lag matrix is one of W_X , W_M , or W_T and the error matrix is either W_P or W_A . Variables in *italic* are statistically insignificant at the 5% level, while **boldface** indicates insignificance at the 1% level.

statistics exceed the χ_1^2 critical value at the 5% significance level, i.e., the lag + error models are favored over both the lag and the error models. Therefore, we are lead to conclude that the inclusion of crises elsewhere as an explanatory variable for domestic crises is appropriate. From both Tables 1 and 2, we conclude that (i) currency crises are contagious and (ii) trade is a primordial transmission channel. Furthermore, our research provides statistical evidence that common political membership might have played a somewhat substantive role. This can be seen not only in the lag model (Table 1, W_A), but also in the evidence not reported herein, but referred to in the text.

5. CONCLUSION

We demonstrated that spatial probit models constitute a natural framework to analyze contagious phenomena. Furthermore, if there is spatial dependence, which is expected in the present setting, econometric issues such as inconsistency and inefficiency are dealt with by estimating spatial probit models. Therefore, the estimation of spatial probit models allowed us to overcome several of the shortcomings present in the previous contagious currency crises empirical literature.

Our empirical results seem to lend support to the hypothesis that currency crises are contagious. Not only is there direct evidence from spatial lag + error and lag models, which formalize the definition of contagion, but also indirect evidence provided by spatial error models. The choice of a predominant transmission channel points towards trade interactions. Additionally, our research is the first to present statistical evidence that political membership contagion may have also played a role in the propagation of currency crises in Europe during 1992. The difficulties encountered in specifying consensual political weights matrices hinders our evidence, however. Contrasting with previous findings, we find evidence that macroeconomic fundamental variables also contributed, either positively or negatively, towards the observed crisis outcomes, with poor growth playing a particularly significant role.

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