"EXCHANGE RATE DYNAMICS AND CURRENCY UNIFICATION: THE OSTMARK - DM RATE"

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Exchange Rate Dynamics and Currency Unification: The Ostmark - DM Rate

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Abstract

This paper studies the exchange rate between the East and West German mark in the period before the German monetary union. We show that standard exchange rate theory contains strong predictions about the dynamics of the exchange rate under these circumstances, and use state space methods to estimate key parameters of the model. A random walk model fits the first half of the data well, during which it was unclear that monetary union would occur. In the second half, when union was expected, the Ostmark rate behaves as a weighted average of fundamentals and the expected terminal exchange rate.

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1. Introduction

The recent events in Eastern Europe have provided economists with a windfall of new opportunities to analyze economic phenomena. The unification of the two Germanies is no exception. Indeed, the events following the collapse of the Berlin Wall and culminating with economic monetary and social union commencing on July 1 1990 allow the study of a rarely observed phenomenon: the behavior of an unregulated market exchange rate in a regime in which it was known to market participants that monetary union would occur at a future fixed date. Standard exchange rate theory contains predictions about the dynamics of the exchange rate in such circumstances, as well as how it should differ from a regime in which no future pegging is anticipated. In this paper, we test some of these implications using daily exchange rate data, spanning August 1989 to June 1990, for the East German mark (Ostmark) traded in West Berlin.

The paper is organized as follows. In Section 2 we discuss some of the historical and institutional aspects of German currency union and the market for East German marks. Two facts are stressed. First, while it was clear after the East German elections in March that monetary union would occur in early July, already in January influential West German newspapers reported that currency union had been discussed in high West German government circles, and that July 1 was a likely date. Second, despite increasing clarity over the rates at which individuals' East German marks were to be converted for DM at the outset of the monetary union, the market exchange rate that would obtain on the final trading day was uncertain.

In Section 3 a standard exchange rate model is used to study the behavior of exchange rate when agents expect monetary union to be introduced at a future date. The salient implication of the model is that the current exchange rate can be expressed as a weighted average of current and expected future fundamentals, and the exchange rate expected to prevail at some future point, with time-varying weights. An expected fixing of the price of foreign exchange has therefore strong implications for the time series behavior of the exchange rate. n Section 4, we discuss how state-space techniques can be used to study whether there was a break in the time series behavior of inter-German exchange rate as currency union became anticipated. Section 5 contains our empirical results. There is some evidence that the time series behavior of the exchange rate did indeed change as suggested by the model. Moreover, we provide estimates of the weight with which the expected market exchange rate on the terminal day of trading entered in the determination of the current exchange rate. Our conclusions are contained in the final section.

2. Institutional Background and the Market for Ostmarks

Under the Communist regime, the currency of the German Democratic Republic (GDR) --the Ostmark (OM)-- was inconvertible, and hence no legal domestic market existed for foreign exchange. Its issue was controlled by the *Staatsbank*, the East German central bank. Officially, the Ostmark was exchanged at par with the Deutschmark, and this 1:1 rate was applied in both merchandise

trade and tourism-related transactions.[1] This rate was widely considered to be overvalued on a purchasing power parity standard (DIW 1986). An indication of this was the deep cutting of export prices quoted in "Valuta Mark" (unit of account in barter trade, equal to 1 Deutschmark) relative to those paid at home. Siebert (1990) suggests that the "foreign exchange coefficient" -- the amount of Ostmark exports required to generate 1 DM of foreign exchange -- at 3 or 4:1 in early 1990. For a detailed analysis of these issues see the report of Sachverständigenrat (1990).

It is an indication of flagging East German economic performance in the mid-1980s that a cash "offshore" market for the Ostmark evolved in West Germany, fed by black market activity and increased tourism permitted by the East German authorities, especially that of East German retirees visiting the West. It was also rumored that on occasion the Communist government itself turned to the West Berlin and Frankfurt markets to obtain necessary foreign exchange.[2] Nonetheless it was illegal for ordinary citizens or visitors to export Ostmarks, and strict penalties were applied to individuals caught dealing in foreign currencies. After the lifting of travel restrictions on GDR citizens, the daily trading volume in Ostmarks market increased markedly. Estimates are difficult to obtain, but roughly 3 billion

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[1]Capital transactions for all practical purposes were impossible. Tourists who were unable to spend the required daily conversion of OM 25 (*Zwangsumtausch*) deposited their funds in an account at the Staatsbank, but this money was not convertible and could not be used for acquiring other assets in the GDR.

[2]See "Ostmark zum Willkür-Kurs," *Der Spiegel*, 27 November 1989, p. 112-113.

Ostmarks are estimated to have been sold in the ten days following the collapse of the Berlin Wall.[3] Bid and ask prices for 100 OM in West Berlin are plotted in Figure 1.

Although informal and secret official discussions were rumored to have begun already in December 1989, speculations of a monetary union with the GDR can found in the West German press as early as mid-January 1990.[4] It was also clear that the rate of exchange between the two currencies would have considerable ramifications for the outcome of the first free East German parliamentary elections scheduled in mid-March. The going market rate of roughly OM 6:DM 1 was considered too low, implying poverty level wages in the GDR and further stimulating East-West migration; a rate of 1:1, which was demanded by the few voices in favor of immediate economic union in the East, was criticized as too expensive for West Germany as well as potentially inflationary. In the course of his controversial campaign appearances in East Germany on behalf of CDU candidates, West German Chancellor Helmut Kohl explicitly held out the possibility of 1:1 exchange for all Ostmarks in a future monetary union, a suggestion later rejected by the West German central bank, the *Bundesbank*. It is widely agreed that this promise helped to sweep the conservative CDU and its smaller sister parties into power on

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[3] *Ibid*, p.113.

[4] See "DDR: Vormarsch der D-Mark," *Der Spiegel*, January 22, 1990, pp. 92-93, in which direct reference is made to proposals for monetary union under study in the West German Finance Ministry.

March 18. While rumors had surfaced in January that monetary union would occur on July 1, after the March election these speculations were replaced by virtual certainty.

Modalities of the monetary union between East and West Germany were officially embedded in the *Staatsvertrag* (state treaty) signed May 18, 1990 and approved later in the month by the respective national parliaments. As of July 1 1990, the DM became the medium of exchange in the GDR, while the Staatsbank irrevocably transferred its issue rights to the the Bundesbank. All current transactions including wages, salaries, pensions and transfer payments were to be converted at parity. Ostmark assets and liabilities were treated in a differentiated manner. Savings accounts, which constituted the bulk of East German households' wealth, were converted at 1:1 up to OM 4000 for adults, with a OM 2000 limit applying for children aged 15 and younger and OM 6000 for persons aged 60 and over. Beyond this, savings accounts were converted at OM 2:DM 1, as were the deposits of state enterprises and local governments. Foreigners and certain other claimants on the Staatsbank were allowed to convert only at 3:1. In contrast to assets, all domestic debts were converted at a single 2:1 rate.

As in the postwar currency reform of 1948, East German residents were allowed one week to effect their conversions, after which Ostmarks were declared worthless. In order to qualify for conversion, banknotes had to be deposited in savings accounts at local banks. Thus, the cash OM market offered the potential for arbitrage profit for East German residents, who could acquire Ostmarks on the black market and deposit them into their savings accounts for conversion for least at a 2:1 rate, or at parity if

they had not reached their quotas. As Figure 1 shows, there were considerable opportunities for arbitrage for those who were able to obtain, or already possessed, Deutschmarks. On the other hand this arbitrage operation was not riskless in the GDR, even under the "soft" de Mazière government, which was obligated in principle by the state treaty -- at West German behest -- to prosecute currency speculators. There is evidence that bank accounts were monitored and that some prosecution of illegal trading has ensued in the aftermath of monetary union.[5] Despite this, the Ostmark market continued to flourish on both sides of the border, even into the first week of July. In the GDR, police turned a blind eye to street currency dealers, allowing train stations to become literal foreign exchange bazaars. It is sometimes alleged that the market was tolerated to allow the laundering of Ostmark fortunes by those who had reasons to hide them.[6]

While the last trading day in the Ostmark market was known and determined by the last day of possible conversion, July 7, there was uncertainty over the final market exchange rate that would obtain on that day, since it would be a weighted average of the different conversion rates applied to individuals tendering OM to the Bundesbank. The evolution of the riskiness of OM trading can be seen in the bid-ask spread, which we plot as the log of the ratio of ask to bid prices in Figure 2. That it declines as the

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[5]On July 19, the East German government announced that 200 personal and business (now DM) accounts were under suspicion of illegal foreign exchange trading and had been frozen (*Frankfurter Allgemeine Zeitung*, July 20 1990 p. 11).

[6]See "Schmuggler, Schieber, Spekulanten," *Die Zeit* December 9 1989.

July 1 date approaches reflects decreasing uncertainty associated with taking OM positions.[7]

3. The Model

The discussion of the last section raises the issue of what path the exchange rate should follow when market participants anticipate a monetary union to be introduced at some future date, but the exchange rate expected to prevail in the market on that date is uncertain. In this section we use a simple asset pricing model to analyze the behavior of the exchange in the period before the currency union.

Let e_t denote the natural logarithm of the exchange rate, defined as the domestic currency price of one unit of the foreign currency, x_t the log of some "fundamentals" unobservable to the econometrician, and E_t the expectations operator. The standard semi-reduced form for the exchange rate is given by[8]

$$e_t = \phi + x_t + \lambda(E_t e_{t+1} - e_t) \tag{1}$$

Eq. (1) states that the exchange rate depends on the unobservable fundamentals and the expected capital gain on foreign exchange. If (1) is an inverted money demand equation, x_t might depend on relative economic activity, the interest rate in the FRG (there

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[7]An alternative explanation is that increased liquidity and competition "from the street" by peddlers may have also forced down bid-ask spreads.

[8]See Mussa (1976).

was no real market for cash OM loans), price levels, and relative asset supplies. This equation can be rewritten as

$$e_t = \alpha + (1-\theta)x_t + \theta E_t e_{t+1} \tag{2}$$

where $\alpha = \phi/(1+\lambda)$, $1-\theta = 1/(1+\lambda)$ and $\theta = \lambda/(1+\lambda)$. Eq. (1′) states that the exchange rate is a weighted average of current fundamentals and the exchange rate expected to prevail in the following period.

Iterating forward in time, it is possible to show that

$$e_t = \sum_{i=0}^{n-1} \theta^i [\alpha + (1-\theta)E_t x_{t+i}] + \theta^n E_t e_{t+n} \tag{3}$$

In the standard scenario when no future pegging is expected, (3) is evaluated assuming that lim $n\to\infty$, in which case the last term is assumed to disappear.[9] When considering the time path of the inter-German exchange rate before currency unification, which can be modelled as requiring the exchange rate to reach some uncertain level on the last day of convertibility, is more convenient to work with (3) directly.

Eq. (3) states that the current exchange rate is a weighted average of the expected realizations of the fundamentals between time t and t+n-1, and the exchange rate expected to prevail at

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[9]Whether or not $\lim_{n\to\infty} \theta^n E_t e_{t+n}=0$ depends on the fundamentals. If x_t is borderline non-stationary, which is the case we consider below, this limit is indeed zero.

time t+n. The most interesting parameter in (3) is θ, which measures how strongly the current exchange rate is influenced by the expected future exchange rate. Note that, since $\theta < 1$, the weight attached to the expected future exchange rate is an decreasing function of n. Thus, if agents expected the exchange rate to hit a terminal rate because of the introduction of monetary union, so that $E_t e_{t+n}$ was fixed, the importance of the expected pegging rate would increase as the pegging date came closer in time. We return to this issue below.

To obtain an estimable exchange rate function from (3), we need to solve for the expected future fundamentals by assuming a time series process for x_t. Given the long literature that finds that nominal exchange rates typically are well approximated by random walks, we assume that the fundamentals follow

$$x_t = x_{t-1} + v_t \tag{4}$$

where $v_t \sim N(0,\sigma_v^2)$. Eq. (4) implies that the current value of x_t is the optimal estimate of expected future fundamentals, that is, $E_t x_{t+j} = x_t$, $j > 0$. Using (3) and (4), we therefore have that

$$e_t = \left[\frac{1-\theta^n}{1-\theta}\right](\alpha+(1-\theta)x_t) + \theta^n E_t e_{t+n} \tag{5}$$

Eq. (5) allows us to analyze an expected future pegging of the exchange rate. Assume that the exchange rate will reach an uncertain terminal rate e^* at a certain future date, τ ($\tau > t$). Setting $n = \tau - t$, and using (5), it follows that the path of the exchange rate in the period preceding the pegging is given by

$$e_t = \left\{\alpha\left[\frac{1-\theta^{\tau-t}}{1-\theta}\right] + \theta^{\tau-t}E_t e^*\right\} + (1-\theta^{\tau-t})x_t \qquad (6)$$

for $t \leq \tau$ (and $e_t = e^*$ for $t>\tau$). Equation (6) indicates that before pegging, the exchange rate is a weighted average of the expected terminal exchange rate, and current fundamentals. Furthermore, the weight attached to the expected terminal rate is less than unity, but approaches unity as the terminal date approaches.

To contrast the behavior of the exchange rate in the case in which no future pegging is expected, set $\tau = \infty$, which implies that

$$e_t = \alpha/(1-\theta) + x_t, \qquad (6')$$

If x_t follows a random walk, so will the exchange rate. As comparison of (6) and (6′) reveal, the expectation of a future currency union will have a crucial impact of the stochastic process followed by the observable exchange rate.

4. Econometric Analysis

Estimation

Equation (6) cannot be estimated using standard regression techniques since the expected pegging rate enters, and since data on the fundamentals are unavailable. We consider these complications in order.

First, an assumption is necessary regarding the expectation of the terminal day exchange rate, which is unobservable. Thus, we write

$$E_t e^* = e^* + \varepsilon_t \tag{7}$$

where ε_t is a random variable and represents the expectational error of agents. Eq. (7) contains the assumption that agents' expectations of the pegging rate were on average correct. It also seems likely that as the pegging date approached, market participants were able to predict with increasing precision the terminal exchange rate, that is, the variance of ε_t presumably shrunk as τ-t approached zero. We therefore assume that $\varepsilon_t \sim N(0,(\tau-t)\sigma_\varepsilon^2)$.

Using (6) and (7), our exchange rate equation can be written

$$e_t = \left\{\alpha\left[\frac{1-\theta^{\tau-t}}{1-\theta}\right] + \theta^{\tau-t}e^*\right\} + (1-\theta^{\tau-t})x_t + \theta^{\tau-t}\varepsilon_t \tag{8}$$

A second issue arises from the fact that the fundamentals, x_t, are not observed. The model can, however, be estimated using unobservable components techniques.[10] To see this, note that (8) can be thought of as an observation equation which relates the observed exchange rate to the unobserved fundamentals, and a white noise error. Furthermore, the time series process for the fundamentals in (4) constitutes a transition equation for the state variable. The parameters in the transition equation are time varying (since $\theta^{\tau-t}$ enters), as are the variance of the expectational errors. However, since the pegging date (τ) is not

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[10]See Harvey (1981, 1989).

random, the time variability of the parameters is deterministic and standard state space methods can be used. The second problem is that since x_t is never observed, it is not possible to discriminate between x_t and $x_t-\phi$. This implies that ϕ, and consequently α, are unidentified.[11] However, since our interest is in estimating the importance of the expected pegging rate for the current spot rate, which is captured by θ, and not in the level of x_t, this problem is of only minor consequence.

Let $\eta_t \equiv e_t - E(e_t|e_{t-1},e_{t-2},\ldots,e_0)$ and σ_η^2 be the variance of η_t. The log-likelihood function can be written as (Harvey 1981, p.15)

$$L(\Theta) = -(T/2)\log 2\pi - (1/2)\sum_{t=1}^{T}(\log \sigma_\eta^2 + \eta_t^2/\sigma_\eta^2) \qquad (9)$$

where $\Theta \equiv [\theta\ \sigma_v^2\ \sigma_\varepsilon^2\ e^*]'$ is the vector of unknown parameters, and where η_t and σ_η^2 can be calculated using Kalman filtering. Note that under rational expectations, e^* is identified and can be estimated along with the rest of Θ by maximum likelihood.

Data

The data were obtained from the *Frankfurter Allgemeine Zeitung*, which published DM bid and ask prices reported by banks in both West Berlin and Frankfurt for the previous day's cash transactions (*Freiverkehr*) for 100 Ostmarks. They span the period

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[11]Indeed, if (1) had been of the form $e_t=\alpha+\beta x_t+\lambda(E_t e_{t+1}-e_t)$, it would also have been impossible to identify β.

August 31 1989 to June 20 1990. Bid prices were used for the analysis. In the final calendar week before the monetary union, the newspaper suspended publication of these numbers, ostensibly because the reporting banks refused to provide them.[12] The West Berlin rate was chosen for this analysis due to higher liquidity and increased competition in this market, especially after November 9.

5. Results

Here we present estimates of the exchange rate model, consisting of the observation and transition equations in (8) and (4), and values of the log-likelihood function for the alternative random walk model in (6′) and (4) for three sample periods. Since press reports speculating that the DM would be introduced in GDR in summer made their first appearance in January, the change from the random walk to the anticipated pegging model in (8) is likely to have occurred roughly in the middle of our sample. We therefore split the sample in half with a break point of January 24/25, and estimated both models for the full sample period and both sub-periods. Since daily data are used, observations for weekends and holidays are missing.[13] To accommodate the missing data, we employed the technique suggested by Harvey (1989, p.145).

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[12]This could imply, among other things, that the OM/DM exchange rate in the West had fallen below OM 2:DM 1, as last minute arbitrage occurred on the accounts of East German residents whose quotas had not yet been exhausted. See "Schwarzmarkt mit Ost-Mark," *Frankfurter Allgemeine Zeitung* July 5, 1990, p. 20.

[13]In the first (second) part of the sample there are 147 (147) observations and 48 (52) missing observations.

The results in Table 1 indicate that θ is precisely estimated. Given the interpretation above, they yield the implicit weights attached by the model to the future pegging rate, $\theta^{t-\tau}$. For the second sample estimate θ=0.988, the weight attached to the expected pegging rate two weeks before July 7 is roughly 0.83. It falls to 0.70 for June 7, to 0.34 for April 7. At mid-sample (January 24), the weight falls to 0.17, with the remaining 0.83 falling on the fundamentals.

Eq. (1) also allows us to educe λ from the θ-estimates presented in Table 1 as $\lambda=\theta^i/(1-\theta^i)$, where i is the number of days spanning the interval. If (1) derives from an inverted money demand function, λ can be interpreted as an interest or nominal rate of return elasticity. Measuring the relevant rate of return on a per annum basis, we calculate λ=0.01235 for the latter half of the sample versus 1.99×10^{-13} for the first half.[14]

Estimates of σ_ε^2 and σ_v^2 imply that the variance of the innovation to the fundamentals is roughly 300-500 times greater than that of the expectational error.[15] The point estimate of the final day market exchange bid rate e^*, exp(3.65)=38.53, is consistent with the final observations of the bid price on June 20

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[14]For θ=0.923, $\lambda=\theta^i/(1-\theta^i)=0.923^{365}/(1-0.923^{365})=1.99\times10^{-13}$; for θ=0.988, $\lambda=\theta^i/(1-\theta^i)=0.988^{365}/(1-0.988^{365})=0.01235$.

[15]The reader should be warned against overinterpretation of these variances, since their magnitudes are only estimable under a normalization assumption. For example, σ_v^2 can only be identified as long as the coefficient on x_t in (1) is unity.

of 33.[16]

The pattern of the estimates support the hypothesis that there was a regime change over the sample, as discussed in Section 2. From Table 1, the first period (August 31-January 24) seems to fit the random walk model; using a likelihood ratio test, we cannot reject the null hypothesis that the exchange rate behaves as if generated by the random walk model ($\chi^2(3)=1.92$, $p=0.589$. In contrast, the second period (January 25 - June 20) decisively rejects the null of the random walk model in favor of the anticipated monetary union model (2) and (6) ($\chi^2(3)=13.06$, $p=0.0045$). There is also some evidence of a structural break in the sample. When a single random walk was estimated over the entire sample, a test for structural stability at the midpoint was only marginally accepted ($\chi^2(1)=3.08$, $p=0.0793$). On the other hand, when the expected future peg model was estimated for the full sample, structural stability over the two subperiods is accepted ($\chi^2(4)=7.26$ $p=0.1228$). The data therefore cannot reject that even as early as September, traders who bought and sold Ostmarks on the West Berlin market were anticipating a currency union, although it is difficult to imagine that they correctly anticipated the pegging date that far in advance, which is a maintained hypothesis of our model. This interpretation is indeed compatible with the data presented in Figure 1.

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[16]It is however, considerably lower than the ask price of DM 53.6/OM 100 (OM 1.9/DM 1) rumored in the article "Schwarzmarkt mit Ost-Mark," *Frankfurter Allgemeine Zeitung* July 5, 1990, p. 20.

6. Concluding Remarks

Using daily data on the "offshore" rate for East German Ostmarks, state space methods allow us to estimate a simple model of the Ostmark-Deutschmark exchange rate as it was traded prior to monetary union. The model predicts that the behavior of the exchange rate is contingent on whether market participants anticipate a future pegging of the exchange rate (monetary union). The historical account of the period suggests that the prospect of monetary union, perhaps always considered remotely possible, made its first appearance in the public discussion in mid-January 1990. From January on, monetary union became increasingly likely, especially after the mid-March elections and the impending collapse of the East German economy.

We have uncovered evidence that the random walk exchange rate model is at best appropriate for the initial half of the data sample, a period during which it was unclear that monetary union would occur. Exchange rate theory predicts that in the second half, however, that the Ostmark rate would behave as a weighted average of "fundamentals" predicted by exchange rate theory and the expectation of the market exchange rate prevailing on the last day of the Ostmark market's existence; as the date of monetary union approaches, the importance of the latter increases geometrically. We find little evidence to contradict this prediction. We are also unable, however, to reject that the expected future peg regime prevailed across the entire sample, a possibility which cannot be ruled *a priori*.

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Table 1.

Results For State-Space Models
Maximum Likelihood Estimates

$$e_t = \theta^{\tau-t} e^* + (1-\theta^{\tau-t}) x_t + \theta^{\tau-t} \varepsilon_t$$

$$x_t = x_{t-1} + v_t$$

Estimate of:	θ	e^*	$\sigma_v^2 x10^5$	$\sigma_\varepsilon^2 x10^5$	Log-likelihood
Full sample[a]	0.972 (115.0)	3.65 (15.1)	248.3	0.563	250.03
Log-likelihood for random walk model:				240.45	
First half[b]	0.923 (12.5)	2.04 (1.87)	378.6	0.376	113.56
Log-likelihood for random walk model:				112.60	
Second half[c]	0.988 (98.5)	3.60 (29.9)	382.2	1.129	132.84
Log-likelihood for random walk model:				126.31	

Notes:
Asymptotic t-statistics in parentheses.
a: August 31, 1989 - June 20, 1990.
b: August 31, 1989 - January 24, 1990.
c: January 25, 1990 - June 20, 1990.

FIGURE 1: LOGARITHM OF THE DM/OM RATE

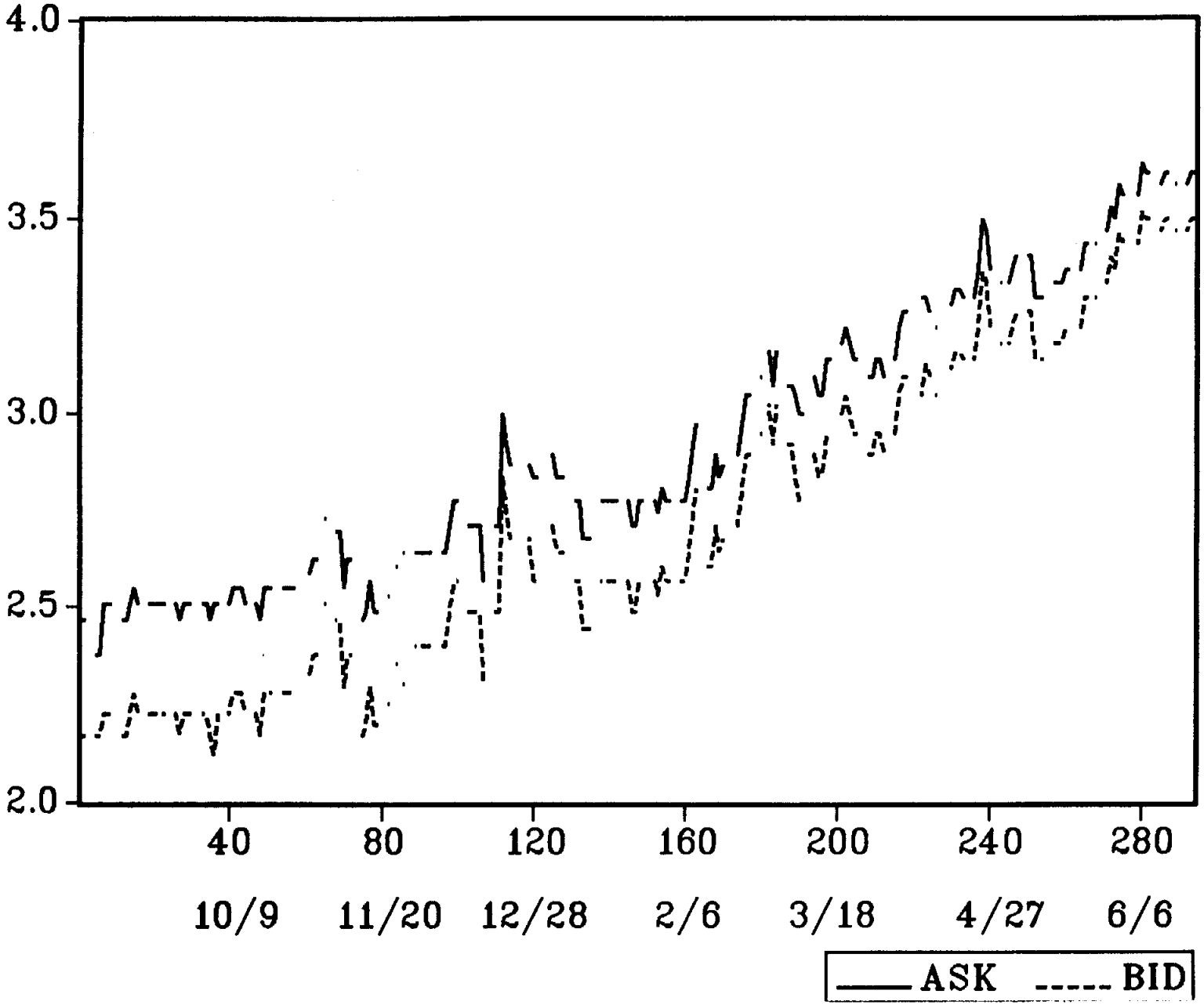
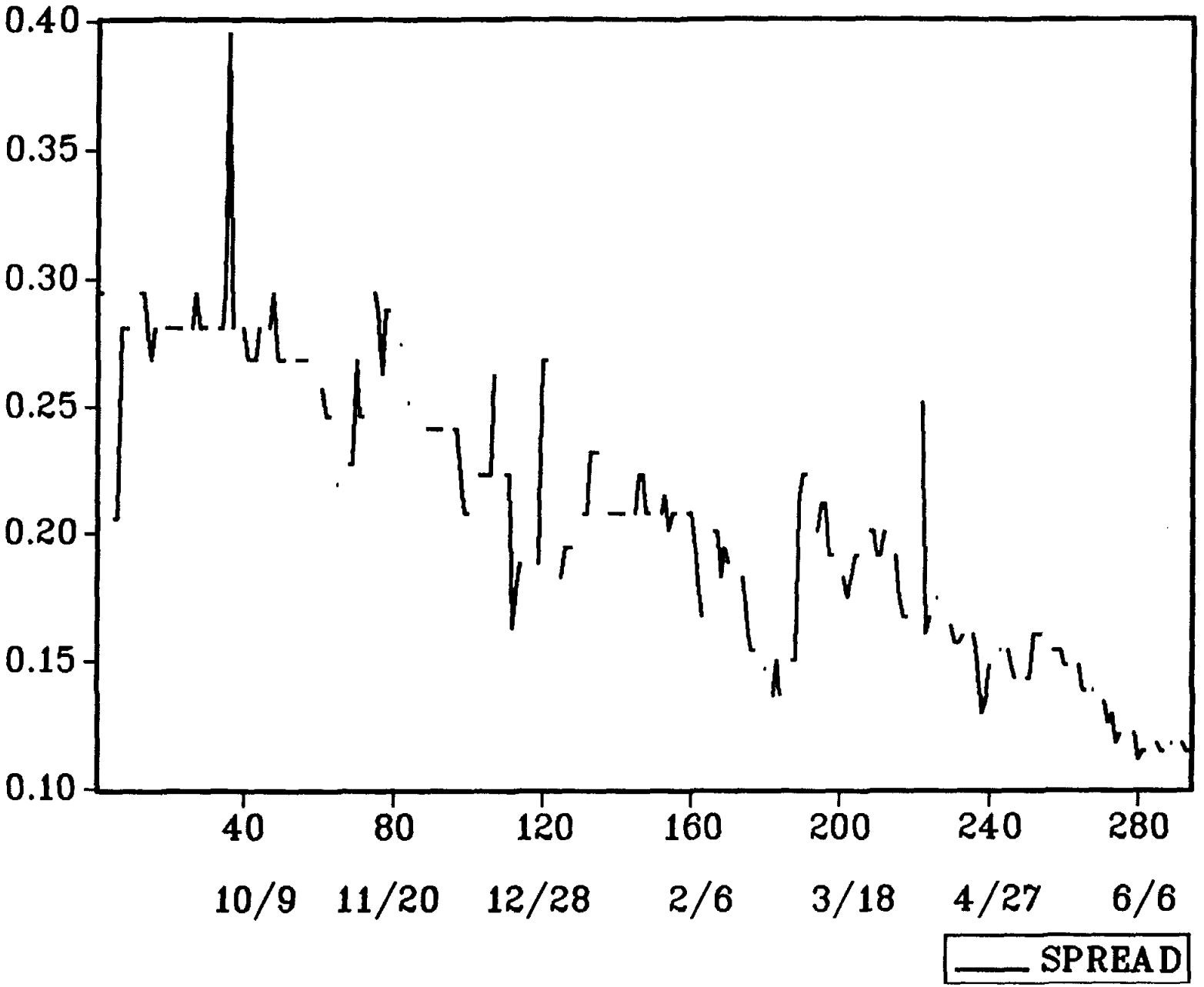


FIGURE 2: LOGARITHM OF BID-ASK SPREAD



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90/33 OB	Caren SIEHL, David BOWEN and Christine PEARSON	"The Role of Rites of Integration in Service Delivery", March 1990.

90/34 FIN/EP	Jean DERMINE	"The Gains from European Banking Integration, a Call for a Pro-Active Competition Policy", April 1990.
90/35 EP	Jae Won PARK	"Changing Uncertainty and the Time-Varying Risk Premia in the Term Structure of Nominal Interest Rates", December 1988, Revised March 1990.
90/36 TM	Arnoud DE MEYER	"An Empirical Investigation of Manufacturing Strategies in European Industry", April 1990.
90/37 TM/OB/SM	William CATS-BARIL	"Executive Information Systems: Developing an Approach to Open the Possibles", April 1990.
90/38 MKT	Wilfried VANHONACKER	"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models", (Revised February 1990).
90/39 TM	Louis LE BLANC and Tawfik JELASSI	"An Evaluation and Selection Methodology for Expert System Shells", May 1990.
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