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An Eclectic Approach to Real Exchange Rate

Determination

Susana G. Cerveró

July 1999

Abstract

We present a model of bilateral real exchange rate determination based on different theories that can be combined into a common statistical framework. Although eclectic, the approach is successfully used to shape a final specification which performs surprisingly well when out of sample exercises are carried out. Among the desirable features of the model there is the achievement of a high level of cross-currency consistency and the full interpretation of the coefficients from an economic point of view. Joint estimation by SURE, through the extraction of relevant interrelations among currencies, turns out to be an optimal tool to compute their historical fair values.

JEL: C3; F3

Keywords: Real Exchange Rates, SURE, Fair Value

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1 Introduction

In this paper we present a model of real exchange rate determination based on a combination of theories. Six bilateral exchange rates, with the US\$ as the numeraire, are determined in a specification in which all regressors can be endowed with an economic interpretation. The final structure is estimated with a technique that permits us to solve the cross-currency consistency problem as well as to capture the relevant relations across currencies. Simulation techniques prove this model to respond sensibly to out of sample exercises.

This paper is organized as follows. Section 2 presents the basic real exchange rate decomposition that underlies the statistical framework. Section 3 studies in depth the sources of trends in the real exchange rate determination. All the theoretical background is finally summarized in an econometric model presented in Section 4. Section 5 covers an important issue related to real exchange rate modeling: the cross-currency consistency. Finally, the estimated new model is presented in Section 6.

2 Real exchange rate decomposition

The real exchange rate is a measure of one country's overall price relative to another country's. The standard expression for the (log) real exchange rate (q_t) is :

$$q_t = s_t - p_t^* + p_t \tag{1}$$

where s_t is the (log) nominal spot exchange rate, defined as the foreign currency price of a unit of home currency, lower letters denote logarithms of the variables, p_t, p_t^* represent price levels and an asterisk denotes a foreign magnitude. Real exchange rate *appreciations* are reflected in increases of q_t .

In computational terms, different prices' indices can be chosen to deflate the nominal exchange rate (consumer price index, wholesale price index, production prices, GDP defla-

tor ...), but all of them can be thought of as a convex combination of traded and non-traded goods prices:

$$p_t = (1 - \alpha)p_t^T + \alpha p_t^{NT}$$

$$p_t^* = (1 - \alpha^*)p_t^{T*} + \alpha^* p_t^{NT*}$$

Superscripts indicate whether the variable is defined for traded or for non-traded goods, α and α^* are the share of non-traded goods in the domestic and foreign price index respectively. They would be related to consumer tastes in each country.

Substituting these expressions in 1 and rearranging terms we get,

$$q_t = [(s_t - p_t^{T*} + p_t^T)] + [\alpha^*(p_t^{T*} - p_t^{NT*}) - \alpha(p_t^T - p_t^{NT})] \quad (2)$$

Equation 2 indicates that the real exchange rate¹ is composed of two parts. The first one is the relative price of traded goods between countries (the well-known purchasing power parity applied to traded goods). This component is related to the international competitiveness of the country and will hold as far as goods traded in international markets are perfect substitutes. The second one is the relative price differential of traded to non-traded goods between the home and foreign country. There is still a third source of long-run movements in the real exchange rate, namely different time-varying weights used to construct the overall prices in the home country and abroad. Now we proceed to explain in greater detail each of these forces.

¹Though both the real exchange rate and the deflator is expressed in logs, for exposure reasons we will obviate it.

3 Sources of trends in the long-run real exchange rate

3.1 Imperfect substitutability of traded goods prices

Most studies on real exchange rate determination have focused on the role of the non-traded goods component, *assuming* that, to a certain degree, price for tradable goods equalize across countries (see De Gregorio, Giovanni and Kruger (1994), De Gregorio and Wolf (1994) or Obstfeld and Rogoff (1995) among others). The drastic version of PPP for tradable goods would require the first term in equation 2 to be constant; a softer version would require it to be simply $I(0)$ ². Different studies have shown how the adjustment to equilibrium in PPP-based equations is very slow. A quicker adjustment could be obtained either by expanding the sample considerably and working with very long time windows or, alternatively, by considering a panel data set for the recent floating period.

We have performed some analysis to find out whether PPP for tradable goods can be accepted for the G7 countries. The data base was obtained from an annual OECD data set that allowed the differentiation between tradables and non tradables: The International Sectoral Database. We follow Canzoneri et al. (1996) in the differentiation between tradable and non-tradable sectors. In the first category we include the ‘manufacturing’ sector and the ‘agriculture, hunting, forestry and fishing’ sector. The second category is made up of the ‘wholesale and retail trade, restaurants and hotels’ sector, the ‘transport, storage and communication’ sector, the ‘finance, insurance, real state and business services’ sector, the ‘community, social and personal service’ sector and the ‘non-market service’ sector.

Deflators for both sectors were constructed from aggregate real and nominal output data. Bilateral exchange rates with respect to the dollar were obtained from the IMF³. We tested whether $s_t - p_t^{T*} + p_t^T$ showed mean reversion for each of the the G7 countries. Our

²A series is said to be integrated of order zero $I(0)$ if it is covariance-stationary (its mean will not depend on time)

³See data Appendix

results, in line with those of Canzoneri, suggest the rejection of the drastic and the soft version of PPP for tradables. Thus we should consider the absence of perfect substitution for tradable goods across the countries as a potential source of real exchange rate movements. Figures 1 to 6 in the last appendix plot the real exchange rate deflated with the total deflator (tradable and non-tradable prices are included)⁴, and the real exchange rate deflated with the tradable goods price only. In almost all cases (France, Germany, Japan and United Kingdom) most of the movement in the real exchange rate is accounted for by the movements in the PPP for tradables. Where differences between real exchange rate deflated with the overall deflator and real exchange rate deflated with the tradable goods deflator are significant (Italy and Canada) we may expect the second part of equation 2 to play an important role in the determination of the real exchange rates.

Evidence against price differentials being quickly arbitrated away among industrial countries is not surprising. We abandon the assumption of PPP for tradables, departing from the literature that focuses exclusively on the non-tradable goods component. The next step is to find out the source of failure in the PPP for tradable goods.

3.1.1 Savings and Investment

The first term in expression 2, the relative price of traded goods, is a key determinant of the current account. At the same time, the current account is driven by the determinants of national savings and investment. Thus, the PPP for tradable goods depends on Savings and Investment determinants. This reasoning is common to all theoretical models. From this point, different models diverge.

Since we are interested in understanding the dynamics of the real exchange rate in industrial countries from the eighties onwards, *portfolio balance models* seem to offer the right framework. In these models (e.g. Mussa 1984) capital movements and monetary

⁴This does not always correspond to the overall deflator since some sectors were not included because of the lack of data.

economy play an important part. We can decompose the current account of any country CA_t into the trade balance XN_t and the interest payments on the stock of net foreign assets.

$$CA_t = XN_t + i_t NFA_t \quad (3)$$

where i_t is the average yield on the stock on net foreign assets. In countries that are relatively small in the world asset markets but that enjoy high capital mobility (e.g. France, Italy) i_t will be predetermined. In countries with a more relevant role in the world asset markets (e.g. United States, Japan) real exchange rate, net foreign assets and i_t will be simultaneously determined. Simultaneous determination of these three variables offers a very realistic framework, but hardly an operational one. We need to relax it while imposing some theory-based restrictions that simplify the analysis. We are going to assume (as several models do) that the real exchange rate has no relevant effect on the stock of net foreign assets, this is $\delta NFA/\delta q_t = 0$.

Real exchange rate depreciations will improve the trade balance as far as the Marshall-Lerner condition holds⁵, thus $\delta CA_t/\delta q_t < 0$. In these models the long-run is defined as a point at which any interest earnings on net foreign assets are offset by a corresponding trade imbalance⁶ and subsequently, $CA_t = 0$. Thus, once in equilibrium, increases in the stock of net foreign assets should appreciate the long run real exchange rate.

Alternatively, we could think of e-rate dynamics as the mechanism through which shocks to the desired stock of net foreign assets are equilibrated. Increases in the desired stock

⁵This condition states that the price elasticity of demand for tradables should be sufficiently high that a real depreciation leads to an increase in the trade balance. Most country estimates satisfy this condition in the long run.

⁶In equilibrium, a country with negative net foreign assets must have a trade surplus to finance the stream of interest and dividend payments. The trade surplus will be induced through a real exchange rate depreciation.

of net foreign assets will generate a real exchange rate appreciation in the long run, but a possible real exchange rate depreciation in the short run. In these portfolio models, the time scope is therefore key.

National and private savings also play an important role in real exchange rate determination. Private net savings are usually assumed to be constant over time. Nevertheless, secular determinants of savings across countries (such as demographic variables or age structure) do affect net foreign assets positions. Controlling for private net savings is thus a way of isolating these country-effects on the real exchange rate.

Finally, both public and private savings can be interpreted as a proxy for national demand. Movements in internal savings will affect real exchange rates both through international trade flows and assets markets. We have decided to differentiate between national savings and private savings and allow different impacts on the real exchange rate. In principle, it is not obvious whether public savings and private savings should affect real exchange rates in a different way. If we consider the possibility that government demand and private demand displays different pressure on national products and imported products, then the scenario changes.

An increase in private consumption (decrease in private savings) would put more pressure on tradable goods than on non-tradable goods, causing an increase in $(p_t^T - p_t^{NT})$ and consequently, a real depreciation. On the contrary, a decrease in public savings will put more pressure on national non-tradable goods, causing a real appreciation. The same relation (with opposite sign) would hold between real exchange rate and the public and private savings of the numeraire country.

We are not claiming that all correlations involving real exchange rate, private and public savings should be like the ones described above. This scenario should be understood as a potential benchmark, with significant scope for differences across countries depending on

idiosyncratic features.

3.1.2 Trade patterns and world commodity prices

The relative price of traded goods can be affected if e.g. oil or commodity shocks have different impacts across economies. Production structures differ across countries and make them vulnerable to the same shocks to different degrees. This effect is partly picked up in the terms of trade of a country⁷, where the different trade structures are captured. Nevertheless, it seems sensible to specifically address the fact that for certain key goods (e.g. oil and non-fuel commodities), only being a net-importer or a net-exporter will make the real exchange rate react in an opposite way to the same shock.

Our sample starts in the first quarter of 1980 so that we do not need to model the oil shocks of the seventies and especially the renovation in the production structure attached to it. The experience made it clear though that e.g. for net oil importers, an increase in the world price of oil causes their real exchange rate to depreciate. Since we are both considering net oil exporters (Canada) and importers (Germany) in our data set, we have decided to capture both oil shocks and non-fuel commodity shocks in real terms.

A final issue relates to the proper deflator. Oil prices are expressed in US\$ while the non-fuel commodity prices is a composite series. Ideally, we would need to construct a specific deflator for each country, but this would also imply using nominal exchange rates. We opt for deflating with US GDP deflator and consider the US real supply a good proxy for other OECD countries.

3.2 The traded-non traded price ratio

Assuming $\alpha = \alpha^*$, the second component in equation 2 becomes $(p_t^{T*} - p_t^{NT*}) - (p_t^T - p_t^{NT})$. There are different theories that try to explain what factors may drive the relative price

⁷Price of exports divided price of imports

of non-traded to traded goods, but all of them can be grouped into supply and demand factors.

3.2.1 Supply Factors: Balassa-Samuelson

This is the best known theory in the literature on real exchange rate determination. Authors applying it tend to assume that PPP for tradables holds and thus, the real exchange rate is driven by the second term in equation 2. It basically states that productivity advances are concentrated in the traded goods sector, and as a consequence, countries growing more should experience real exchange rate appreciation. Goods markets as well as labour markets are supposed to be competitive. There is also labour mobility across sectors (nominal wage equalizes). Relative prices are then related to nominal wages and nominal wages to productivity differentials. Real exchange rates defined for overall price indices should appreciate for fast growing countries.

Within the Balassa-Samuelson model, productivity increases are always assumed to be absorbed by the tradable sector. But if the rise in productivity affects the allocation of resources across sectors in a different way or the differentiation between tradables and non-tradables is not proper, we could expect increases in productivity causing real exchange rate depreciation.

From an empirical point of view, applying the Balassa-Samuelson hypothesis is not straightforward, with the main difficulty being the availability of good data sets containing productivity for tradable and non-tradable goods and especially, focusing on what we understand as tradable. Common practice considers the services sector as non-tradable and agriculture, fishing and manufacturing-related sectors as tradable. When such data are not available, different variables can be used to capture productivity (labour productivity of the whole economy, total factor productivity, marginal or average labour productivity of the manufacturing sector, etc). Each measure has its own drawbacks, but in this context

and since the theory focuses on the tradable sector, we will use the productivity of the manufacturing sector. The relevant variable will be the productivity differential of the manufacturing sector between the home country and the numeraire (the United States).

According to our results in Figures 1 to 6, we would expect the productivity differential to play a relevant role in the determination of the CAN\$/US\$ and the ITL/US\$, while being rather negligible when explaining the JPY/US\$.

3.2.2 Demand factors

Even if productivity growth is not biased towards the tradable goods sector, as far as the income elasticity of demand for non-tradable goods is greater than unity, the relative price of non-traded goods will rise as income rises. This argument was firstly proposed by Genberg (1978). When income rises, demand for services tends to increase more than proportionally to income. The effect is reinforced if the share of government expenditure devoted to non-traded goods is greater than the share of private expenditure, and if income is distributed by the government over time.

In Section 3.1.1. we introduced two proxies for demand shocks: public and private savings. These are computed as the proportion of income not consumed by the private sector or the public sector respectively. Demand shocks are expected to have a positive effect on both public and private consumption, but the consecutive effect on the real exchange rate will be of a different sign.

As explained above, The Balassa-Samuelson theory is based on the double assumption of competitive labour and goods markets. Manufacturing industries in the countries considered have different degrees of market power (mark-ups). Labour market institutions also differ significantly, conditioning the mobility across industries. These factors allow demand shocks to play an important role in the determination of the real exchange rate.

Our discussion up to now could be summarized with the following simple econometric model:

$$ReR = f(NFA_i, NFA_{US}, S1_i, S1_{US}, S2_i, S2_{US}, RPOIL, NFCRP, (PR_i - PR_{US}), TOT_i, TOT_{US}) \quad (4)$$

where the subscript i refers to the country while US refers to the United States.

INTERPRETATION OF THE COEFFICIENTS

Variable	Variable	Expected sign
ReR	Bilateral real exchange rate	Dependent variable
$S1_i$	Private savings of the home country	-
$S1_{US}$	Private savings of the US	+
$S2_i$	Public Savings of the home country	+
$S2_{US}$	Public savings of the US	-
NFA_i	Net Foreign Assets of the home country	+
NFA_{US}	Net Foreign Assets of the US	-
RPOIL	Real price of oil	?
NFCRP	Non-fuel commodities real price	?
$PR_i - PR_{US}$	Labour productivity differentials	+
TOT_i	Terms of Trade of the home country	+
TOT_{US}	Terms of Trade of the US	-

4 The Econometric model

4.1 The usual framework

As soon as we depart from the PPP hypothesis, the equilibrium real exchange rate becomes a time-varying concept. Therefore, standard econometrics, textbook knowledge would suggest, can no longer be applied. Times series of real exchange rates are normally found to be $I(1)$, as well as most of the macroeconomic variables that are assumed to be their fundamental determinants. With a specific set of $I(1)$ variables, cointegration techniques are then applied. We first revise the concept of cointegration.

A set of variables x is said to be cointegrated of order d, b , denoted as $x_t \sim C(d, b)$ if i) x_t is integrated of order d , denoted as $I(d)$, and ii) There exists a non-zero vector α such that $\alpha'x_t \sim I(d - b), d \geq b > 0$. The vector α is called the cointegrating vector.

Almost all models on real exchange rate determination are performed in a cointegration framework. Since cointegration is just a statistical property of the data, an economic model is needed in order to identify the cointegrating vector with the notion of equilibrium⁸. The concept of an equilibrium or fundamentals determined exchange rate is fuzzy. Depending on the theoretical model a host of fundamentals are explicitly considered. Thus there is a wide range of equilibrium exchange rate paths or long run equilibriums, each one with a different theoretical focus.

It is not the scope of this paper to revise all feasible models and establish some comparative analysis with our approach. Nevertheless, we may point out that both NATREX and FEER models are closely related to ours. From an econometric point of view, when

⁸The difference between the current exchange rate and its equilibrium level is then regarded as the “equilibrium deviation”. Different versions of error correction terms are used to capture the short run dynamics.

testing for cointegration, only the zero frequency of $I(1)$ cointegrated time series is usually considered. In general though, a much richer class of cointegrated systems may exist with integration of higher orders occurring over a range of frequencies. As stated by Haldrup and Salmon (1998):

In these more general cointegrated systems the left nullspace may often most easily be described in terms of a *polynomial* space such that the cointegrating vectors which span the space are polynomials in the lag operator rather than vectors.

In this context, the Smith-Mc. Millan decomposition of a rational polynomial matrix (see Yoo, 1986 and Salmon 1988 among others) offers a tool for considering interactions among variables of different orders of integration within a system. Once the cointegrating vectors have been parceled out, the vector time series is reduced to $I(0)$ and we can contemporaneously consider $I(1)$ and $I(0)$ variables.

4.2 Cointegrating with standard econometrics

Since we cannot perform a Johansen VAR approach in order to test for the cointegrating rank, we need to look for an alternative. The closest methodology would be to estimate a system with Seemingly Unrelated Equations (SURE): we could interpret the adjusted equation as the long run equilibrium as far as the residuals are stationary. With $I(0)$ residuals, the estimated coefficients would be the equivalent of a cointegrating vector, without the need for the same order of integration for the variables involved. Estimating a system by SURE in which both $I(1)$ and $I(0)$ variables are considered as explicative would be a crude way of cointegration in a polynomial space. SURE will also prove to be a convenient estimation procedure for the reason discussed below.

5 The cross-currency consistency issue

When dealing with bilateral exchange rates equations, cross-currency exchange rates can always be constructed from the modeled bilateral ones. Bilateral exchange rates are referred to a specific numeraire (normally the US\$ or the German DM). The problem arises when, instead of constructing the cross-rate exchange rates, we estimate them directly and both values differ (the estimated one and the implied one from the estimated bilateral exchange rates); or alternatively, we change the numeraire and get a different implied cross-exchange rate. This is a simple example of potential *cross-currency inconsistency*.

The theoretical problem is closely related to one of model specification since we are also comparing two models: the one involving bilateral exchange rates and the one involving cross exchange rates. As far as we are dealing with linear relations and we include the same regressors in all the equations involved, cross currency consistency problems will not arise. But this is not a convenient methodology since it may imply an overspecification of the model and yield spurious correlations. To see this point let us assume we are estimating the log of two real bilateral exchange rates, with US\$ as the numeraire: $US\$/FF$ denoted as $y_{US\$/FF}$ and $US\$/DM$ denoted as $y_{US\$/DM}$. Note that the implied cross-currency exchange rate (DM/FF , denoted as $y_{DM/FF}$) will be a linear combination of the other two. Matrix X represents an array of regressors capturing the fundamental determinants of their respective dependent variable (indicated by a subscript). For k parameters to be estimated per equation, the three equations can be expressed as follows:

$$\begin{aligned}
 y_{US\$/FF} &= \alpha_{10} + \beta_{11}X_{DM} + \gamma_{12}X_{FF} + \delta_{13}X_{US} + \epsilon_1 \\
 y_{US\$/DM} &= \alpha_{20} + \beta_{21}X_{DM} + \gamma_{22}X_{FF} + \delta_{23}X_{US} + \epsilon_2 \\
 y_{DM/FF} &= \alpha_{30} + \beta_{31}X_{DM} + \gamma_{32}X_{FF} + \delta_{33}X_{US} + \epsilon_3
 \end{aligned}
 \tag{5}$$

If we estimate each equation by OLS, we can show that there will be k linear relationships involving the three equations. For X denoting the regressors matrix and β^{ols} the

vector of estimated coefficients:

$$\beta_{DM/FF}^{ols} = [X'X]^{-1}X'y_{DM/FF} = [X'X]^{-1}X'(y_{US\$/FF} - y_{US\$/DM}) = \beta_{US\$/FF}^{ols} - \beta_{US\$/DM}^{ols}$$

Cross-currency consistency will be fully achieved in this case and the estimated value of the DM/FF will be equal to the one derived from the estimated $US\$/DM$ and $US\$/FF$, this is:

$$\hat{y}_{DM/FF} = (\hat{y}_{US\$/DM})^{-1} - \hat{y}_{US\$/FF} \quad (6)$$

We have dealt here with two bilateral exchange rates and its implied cross exchange rate. In general though, for n bilateral exchange rates there will $n(n - 1)/2$ cross exchange rates and therefore $n(n - 1)/2$ sets of fundamentals that should be included as regressors in the relevant equations (e.g if we are working with the G7 countries, US\$ numeraire, and consider the fundamentals of each exchange rate to be properly captured with 6 regressors, we should add 90 regressors to each OLS equation). This is clearly very costly in terms of the loss in the degrees of freedom but overall it stimulates spurious relationships.

Let us estimate now a different version of (5), namely we estimate the following set of equations by OLS:

$$\begin{aligned} y_{US\$/FF} &= \alpha_{10} + \beta_{11}X_{FF} + \delta_{12}X_{US} + \epsilon_1 \\ y_{US\$/DM} &= \alpha_{20} + \beta_{21}X_{DM} + \delta_{22}X_{US} + \epsilon_2 \\ y_{DM/FF} &= \alpha_{30} + \beta_{31}X_{DM} + \gamma_{32}X_{FF} + \epsilon_3 \end{aligned} \quad (7)$$

In this case, the estimated value of the DM/FF will be different to the one derived from the estimated $US\$/DM$ and $US\$/FF$ because the set of regressors is not the same. The difference will depend on the explanatory power of the absent regressors. Since there

is no link across equations (no restrictions are imposed and each equation is estimated separately) cross-currency consistency will be violated.

We could overcome this problem by estimating $y_{US\$/FF}$ and $y_{US\$/DM}$ jointly by Weighted Least Squares (WLS), while imposing the set of linear restrictions derived from (6). These are a combination of exclusion restrictions as well as cross-equation restrictions of the form:

$$\begin{aligned}\beta_{31} &= 0 - \beta_{21} & (8) \\ \gamma_{32} &= \beta_{11} \\ 0 &= \gamma_{12} - \gamma_{22}\end{aligned}$$

Unfortunately, this approach becomes non-viable as soon as we increase the number of dependent variables. In the previous example we would need to impose 90 restrictions per equation: we would have to deal with an overidentified model. We could specify a full range of models and, depending on the set of regressors and the estimated method, different *degrees* of cross-currency inconsistency will arise.

The relevant question turns out to be what is the proper degree of inconsistency that should be allowed. We have tackled the problem from two complementary approaches. At a theoretical level, we have tried to estimate the bilateral exchange rates with a methodology which allows to extract the maximum information from the joint relationship across currencies (a lighter version of the cross-equation restrictions). This has been done by estimating a SURE system (see Appendix A for a summary on SURE). From a statistical point of view, we have also tested whether our implied degree of inconsistency is statistically significant (at 5%), finding out that this is not the case⁹. This makes us confident that no cross-currency inconsistency is going to invalidate our analysis.

⁹This was tested with the same set of equations used in our example $Y_{DM/FF}, Y_{US\$/DM}$ and $Y_{US\$/FF}$, including only two regressors per currency (and country) for simplicity: total savings and productivity of the economy as a whole

By using SURE we allow the equations to be linked through their disturbances. In particular, we estimate the same system as in (7), but allowing for $E[\epsilon_1\epsilon_2\epsilon_3] = V \neq I$. Since the parameters are estimated controlling for this link, the relationship between the dependent variables and the absent regressors, e.g. $E(Y_{US\$/DM}, X_{FF})$ in the first equation, will be proxied through V .

6 Results

We have estimated a system of 7 equations by SURE, each one aiming to capture the fundamental determinants of the corresponding real exchange rate. All exchange rates are bilateral, with the $US\%$ as the numeraire. Data are of quarterly frequency and cover the period 1980 Q1 – 1999 Q1. This is a convenient sample period since we do not need to control specifically for the oil crisis. An extensive explanation of the data used can be found in Appendix C.

We first regress each dependent variable on the whole set of regressors presented in equation 2 by simple OLS. We also control for the collinearity among the predetermined variables. This is done in order to avoid unstable specifications and fragile models: The higher the correlation between the regressors, the less precise the estimates will be and thus small changes in the data can produce wide swings in the parameter estimates. We want to avoid this situation, specially undesirable for forecasting purposes. Basically, once the correlation matrix is considered, we proceed to eliminate those variables that may be problematic (correlations over 0.85 fell into that category) in such a way that the remaining regressors constitute a stable model¹⁰. We also eliminate variables with poor explicative power (t statistic below 1). Note that a high correlation across regressors in different equations is also detrimental to the SURE estimation, since it diminishes the gain in efficiency:

¹⁰There are several ways of dealing with multicollinearity, probably dropping regressors is the crudest one. Since we are more concerned with a meaningful specification than with the maximum adjustment, this seems to be a sensible practice to follow.

Variables attached to the United States fundamentals and supply related variables can be present both in the same equation and across equations. We integrate all the real exchange rates in the SURE system and gradually simplify it until we reach a final specification. To have an overview of the model, Tables B.1 and B.2 in the Appendix present the final specification per currency.

Once the SURE system has been estimated, the first relevant exercise consists of testing whether the residuals are stationary. If we find them to be $I(1)$ we could not carry on with the analysis, and the long run determinants of our real exchange rates should be computed with a different methodology. Table B.3 presents the statistics associated to the Augmented Dicky-Fuller and Phillips Perron tests. Fortunately, the null of a unit root is always rejected and we can consider the estimated parameters combined with the regressors as a cointegrating vector. The residuals from the estimated system have been plotted in Figures R.1 to R.7, where their stationarity can be better appreciated.

As stated before, the set of regressors vary across currencies. Some currencies seem to be easily captured through their fundamentals (like the DM/US\$) while other *more problematic* currencies do not seem to respond to the same impulses (specially the Sterling). The estimated parameters very often present the right sign (as stated in Section 3.2.2.). Our suspicion concerning the importance of productivity differentials was right. Figure 2 suggested that the productivity differential was an important determinant of the CAN\$/US\$ exchange rate. Table B.1 shows that the relevant coefficient is positive and highly significant. The Italian productivity differential was also of the right sign and highly significant (as suggested by Figure 4), but was not included in the final specification because of collineality problems. Also as suspected, productivity differentials do not play any role in the modelling of the JPY/US\$ exchange rate.

All terms of trade were of the expected sign (positive for the home country and negative for the US terms of trade), while real price of oil for the sterling (UK being a net exporter of

oil) is also of the expected (positive) sign. Private and public savings of the home country and the US also behave as expected. The same applies to the signs of the estimated coefficients on net foreign assets. Overall only 5 out of the 39 estimated coefficients do not have the expected sign. This can be considered a very satisfactory outcome.

7 Sensitivity Analysis

7.1 Some previous notes

One of the main problems involved in model specification is that of **overspecification**. As an attempt to obtain cross-currency consistency, an approach consists of introducing a wide range of regressors in all the equations. Unfortunately, this can lead to spurious relations affecting the dependent variables. In this context, economic interpretation of the model becomes difficult (if not useless), and forecasting exercises turn fragile. Due to the interrelation among the regressors (partly because of sound economics, partly because of pure correlation), the structure of such model becomes unstable. With an “excessive” number of regressors, a robust final specification becomes highly improbable. It should be noted though that, when the model is overspecified, the in-sample fit is very good. However, this is not a desirable feature of the model unless we believe the real exchange rate stays on its equilibrium path.

Here we have expressed each currency as a function of an array of fundamentals of the country and the numeraire only. All of them are justified from a theoretical point of view. Before starting the specification of the joint model, we control for those regressors that are highly collinear (with correlations above 0.85), to eliminate unstable specifications for statistical reasons.

A related problem to overspecification is the **economic background** of the econometric model. It is certainly a difficult task to set up a model based on any theory, but this

case seems particularly challenging: There is no theoretical integral framework for the determination of more than one bilateral exchange rate in the literature that does not impose PPP for tradables. We have presented here a compendium of theories which focus on different issues, but that can be related to the same statistical model (eq. 2). The structure and the regressors are carefully studied before standard econometric techniques are applied. All the estimators can be interpreted from an economic point of view, and the final model is fully consistent with the theories considered.

Finally, there is the issue of the **pre-filtering of the regressors**. Some authors have used the Hodrick-Prescott filter as a means to capture the trend within the variables. The process involves choosing the right smoothing parameter (an arbitrary lambda). For quarterly data the convention is to set lambda equal to 1600. When using this filter, the outcome becomes very sensitive to the last observations in the sample, and if e.g. estimates instead of actual values are included, the results are overdependent on potentially incorrect data. A final (minor) comment relates to the filter itself: if we filter time series of different degrees of volatility with the same filter, in a way we are forcing the data to look similar and establish relationships linking them.

We have avoided the pre-filtering of the regressors for two main reasons. The first one is not to force any relationship among regressors that may disappear out of sample and therefore yield to false results. The second is not to base the specification of the model on arbitrary information (e.g. the choice of lambda). Nevertheless, post-filtering the predicted value is still an option and we will present some of the results smoothed with a Hodrick-Prescott filter.

7.2 Econometric results

In sample comparisons are of poor informative value and to focus on the *in sample* statistics can be misleading. Since there is no obvious methodology to assess a model, we start by

presenting the different results and then we move to *out of sample* exercises.

The behaviour of the model can be grasped by plotting the predicted nominal exchange rates jointly with the actual one. We have post-filtered the predicted values with a Hodrick-Prescott filter setting lambda to 50 to smooth the series, but we also present the non-filtered series. Figures 7 to 32 in the Appendix present this information, with predicted values going up to 1999 Q4. We first discuss the bilateral US\$ simulated values and then we move to the implied cross-currency exchange rates.

SURE predicts a relatively stable DM/US\$ and a similar evolution for the other intra-EURO currencies. We also present an implied EURO/US\$, derived from the three EURO currencies (DM/US\$, ITL/US\$ and FF/US\$). These three currencies represent more than 73% of Euroland. We have distributed the remaining 27% proportionally in order to compute an EURO expressed in US\$/DM, using the central parities from the EURO. Basically this is the way we have computed it:

$$EURO/US\$ = W_{GR} * [US\$/DM]_{SURE} + W_{FR} * [US\$/FF]_{SURE} * [FF/DM]_{intraEURO} + W_{IT} * [US\$/ITL]_{SURE} * [ITL/DM]_{intraEURO} \quad (9)$$

The simulated values of the EURO currencies were derived from the estimation of the system until 1998 Q4; while the implied EURO/US\$ and the other non-EURO currencies were estimated until the first quarter of 1991 and then projected¹¹. The three euro currencies appear to be slightly undervalued with respect to the US\$, what leads to an undervalued EURO/US\$ that is expected to appreciate until the end of the year¹². Concerning the non-EURO currencies, the equilibrium value of the CAN\$/US\$ is very close to

¹¹Actual values of EURO currencies with respect to the US\$ were obtained through the triangularization of the theoretical EURO from Bloomberg

¹²It should be clear that the synthetic EURO/US\$ exchange rate is just an artificial construction we use for comparative reasons. In its construction we include all currencies in the EURO. Basically we project backwards what the expected forward exchange rate of the ECU/US\$ was at a specific point in time (T),

its actual value. The Sterling exchange rate, undervalued for the last two years, approaches to its fair value which is expected to appreciate during the year. Finally, both the Japan yen and the Swiss Franc appear to be overvalued.

We present one example of cross-currency exchange rate involving two EURO currencies, DM/ITL in Figure 23 and 24. It can be appreciated from the graph how, since the end of 1997, the actual value overlaps with the fair value, suggesting the central parity of the EURO was fairly chosen. We also present the Sterling/DM exchange rate. Recent history suggests the sterling to have been overvalued with respect to the DM. Considering how the fair value of EURO/US\$ has been computed, we would expect the same situation with the Sterling/EURO exchange rate. This can be appreciated in Figures 27 and 28. Both the CAN\$ and the JPY seem to be overvalued with respect to the EURO.

Overall, the model does not present any sign of overspecification since it does not introduce more volatility than that presented in the original series. This phenomenon is also apparent when the cross-currency exchange rates are considered¹³.

One of the best ways to assess a model is to perform *out of sample* exercises. We basically simulate a forecast exercise by estimating up to a specific date and forecast from this date until the last observation, 1999 Q1 (For non EURO currencies) and 1998 Q4 (For EURO currencies). We replicate the exercise for all the real exchange rates and for two different dates: 1994 Q4 and 1996 Q4. Here we have real exchange rates instead of nominal, but since the unwrapping would be done with the same deflators, for comparison purposes they are equivalent. This time the predicted values were not filtered to better appreciate the turning points.

normalized by the ratio of the spot exchange rate of the currency in T and in the period we are computing it. All currencies were weighted by its GDP weight in Euroland.

¹³All the implied cross-currency exchange rates were first derived from the corresponding bilateral exchange rates and then filtered.

We first look at the results when the estimated period ends in 1994 Q4 (Figures 33 to 39). What we are most concerned with is the directional change, not so much the value at a specific point in time. The case of the US\$/CAN\$ is very informative. The model is able to capture the turning point of 1995 Q3 as well as the general trend until the end of 1998. For about three years, SURE also manages to get the right direction for the US\$/JPY exchange rate. An interesting case is the US\$/ITL forecast, where the model correctly predicts almost all turning points for the whole out of sample period. With the US\$/DM exchange rate, SURE makes it to capture the directional change of 1996 and the following overall downward trend. In the case of the Swiss Franc, the model succeeds in capturing the general trend, but at a different level.

One of the most *problematic* currencies to forecast is the sterling. The model fails dramatically in predicting its overall upward trend. Maybe the sterling has been truly driven by ‘non fundamental forces’, or rather by the kind of forces that cannot be captured through economic data. Market expectations in the light of an unprecedented structural change (the EMU) plus herd behaviour could have shaped its evolution.

We have performed the same out of sample exercise when the estimation period ends in 1996 Q4 and found that the results stay essentially the same for all currencies but the Sterling and the Swiss Franc. Thus, for comparative reasons, we only present these two currencies and check whether some learning mechanism can be inferred from the model. This is presented in Figures 40 and 41. Now the model tracks better the evolution of the Swiss Franc. Concerning the Sterling, our result suggests it has been overvalued during the last years (a sensible outcome, which is agreed upon by most FOREX traders).

In summary, we have presented a model with an impressive ability to track down general trends in the currencies involved. A model that performs very successfully when out-of-sample exercises have been studied. This makes it valuable to use as a forecast tool.

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Appendix A - Seemingly Unrelated Regression Model

Let us assume we have to estimate a system of M equations that can be expressed in compact form as:

$$y_i = X_i\beta_i + \epsilon_i, \quad i = 1, \dots, M \quad (10)$$

where

$\epsilon = [\epsilon'_1, \epsilon'_2, \dots, \epsilon'_M]'$, $E[\epsilon] = 0$, $E[\epsilon\epsilon'] = V$; y_i is a set of dependent variables, X_i represents a group of regressors and β_i are the parameters to be estimated.

We use a total of T observations in the estimation of the parameters. Each equation involves K_m parameters to estimate. We believe disturbances are uncorrelated across observations but allow the equations to be linked through their disturbances:

$$E[\epsilon_{it}\epsilon_{js}] = \sigma_{ij} \text{ if } t = s \text{ and } 0 \text{ otherwise}$$

In the estimation of the fundamental determinants of the real exchange rate for the G7 countries, we are including a different set of regressors in each equation. Different restrictions are being placed on different equations, causing the various equations become interrelated through V . Alternatively, we may think that whatever may escape our analysis in one equation might be linked to a similar loss in another equation. Thus, we estimate the system controlling and allowing for such links.

Under these circumstances, an efficient estimator for β is the GLS estimator (Generalized Least Square):

$$\beta^{gls} = [X'V^{-1}X]^{-1}X'V^{-1}y \quad (11)$$

The variance-covariance matrix V is estimated by Feasible Generalized Least Squares¹⁴.

¹⁴See Green (1997)

Appendix B - Tables

SURE ESTIMATION-DEPENDENT VARIABLE REAL EXCHANGE RATES

Regressor (t-Statistics)	GBP/US\$	SwFr/US\$	CAN\$/US\$	ITL/US\$
Constant	-1.51 (-1.85)*	-2.23 (-5.18)*	-1.92 (-3.99)*	-7.16 (-8.42)*
$S1_i$	-2.72 (-7.94)*			-1.96 (-4.63)*
$S1_{US}$	1.92 (3.83)*		0.70 (2.41)*	1.34 (3.05)*
$S2_i$			-5.03 (-14.59)*	4.72 (3.15)*
$S2_{US}$	-5.31 (-3.42)*	-5.75 (-4.00)*		-7.88 (-6.77)*
NFA_i	0.02 (5.06)*		0.01 (3.91)*	
NFA_{US}	-0.04 (-4.13)*	-0.11 (-12.17)*		
RPOIL	0.12 (2.66)*		-0.09 (-4.18)*	
NFCRP		0.18 (2.27)*	-0.07 (-1.23)*	0.35 (4.68)*
$PR_i - PR_{US}$	-0.16 (-3.35)*	-0.05 (-2.27)*		
TOT_i			0.01 (6.72) *	0.01 (13.33)*
TOT_{US}				
R^2	0.66	0.76	0.81	0.87

TABLE B1 Significance at the 5% level is denoted with an asterisk

SURE ESTIMATION-DEPENDENT VARIABLE REAL EXCHANGE RATES

Regressor (t-Statistics)	DM/US\$	FF/US\$	JPY/US\$
Constant	-4.48 (-6.68)*	1.58 (1.63)	-2.27 (-6.28)*
$S1_i$	-0.66 (-3.06)*	0.64 (1.07)	
$S1_{US}$	1.42 (3.45)*	1.82 (3.29)*	
$S2_i$			
$S2_{US}$	-5.79 (-5.49)*	-4.36 (-3.81)*	-6.36 (-5.56)*
NFA_i	-0.01 (-3.66)*		
NFA_{US}			-0.09 (-9.85)*
RPOIL			
NFCRP	0.37 (5.91)*	0.22 (2.59)*	0.18 (3.36)*
$PR_i - PR_{US}$			
TOT_i	0.024 (14.81)*	0.02 (13.07)*	0.008 (8.46)*
TOT_{US}			-0.006 (-3.22)*
R^2	0.88	0.73	0.91

TABLE B2 Significance at the 5% level is denoted with an asterisk

UNIT ROOT TESTS ON THE RESIDUALS

Residual from	ADF Statistic	PP Statistic
United Kingdom	-3.46 (0 lags)	-3.53
Switzerland	-3.37 (0 lags)	-3.42
Canada	-2.32 (1 lags)	-3.04
Germany	-3.67 (4 lags)	-4.80
Italy	-4.02 (4 lags)	-4.89
France	-2.66 (2 lags)	-3.54
Japan	-6.43 (1 lag)	-6.50
CV=1% -2.59 CV=5% -1.94 CV=10% -1.61		

TABLE B3 Significance at the 5% level is denoted with an asterisk. All tests were performed without trend or intercept (they did not turn out to be significant). We use a lag truncation of 3 in the Phillips-Perron tests.

Appendix C - Data Appendix

- **Nominal and real exchange rates.** Nominal exchange rates were obtained from the OECD quarterly accounts. They refer to the end of the period. Real exchange rates were constructed with the GDP deflator (explained in the next subsection.)

UKOCEXCH	US dollar to sterling, spot
SWOCEXCH	US dollar to Swiss Franc, spot
CNOCEXCH	US dollar to Canadian dollar, spot
BDOCEXCH	US dollar to Deutschmark, spot
ITOCEXCH	US dollar to Italian lira, spot
FROCEXCH	US dollar to French Franc, spot
JPOCEXCH	US dollar to Japanese yen, spot

- **Savings and deflators.** Data on Gross Domestic Product, private consumption expenditure and government expenditure were used in the construction of private and public savings. GDP deflators were obtained by dividing GDP current into GDP constant. All data are from the OECD quarterly accounts except for Switzerland. The relevant codes are as follows:

USOCGNPDB	US GDP at annual rates, current
USOCGNPDD	US GDP at annual rates, constant
USOCCONXD	US Consumers' expenditure, constant
USOCGOVXD	US Government expenditure (at annual rates), constant
UKOCGDPDB	US GDP at annual rates, current
UKOCGDPDD	US GDP at annual rates, constant
UKOCCONXD	US Private final consumption expenditure, constant
UKOCGOVXD	US Government current expenditure (at annual rates), constant

CNOCGNPDB	Canada GDP at annual rates, current
CNOCGNPDD	Canada GDP at annual rates, constant
CNOCCONXD	Canada Consumers' expenditure, constant
CNOCGOVXD	Canada Government expenditure (at annual rates), constant
BDOCGNPDB	Germany GDP at annual rates, current
BDOCGNPDD	Germany GDP at annual rates, constant
BDOCCONXD	Germany Consumers' expenditure, constant
BDOCGOVXD	Germany Government expenditure (at annual rates), constant
FROCGDPDB	France GDP at annual rates, current
FROCGDPDD	France GDP at annual rates, constant
FROCCONXD	France Consumers' expenditure, constant
FROCGOVXD	France Government expenditure (at annual rates), constant
ITOCGDPDB	Italy GDP at annual rates, current
ITOCGDPDD	Italy GDP at annual rates, constant
ITOCCONXD	Italy Consumers' expenditure, constant
ITOCGOVXD	Italy Government expenditure (at annual rates), constant
JPOCGNPDB	Japan GDP at annual rates, current
JPOCGNPDD	Japan GDP at annual rates, constant
JPOCCONXD	Japan Consumers' expenditure, constant
JPOCGOVXD	Japan Government expenditure (at annual rates), constant

- **Productivity in the tradable sector** The relevant variable was constructed as the productivity differential in the manufacturing sector between the country and the United States when available. Productivity data were calculated as the annual average in the rate of change of employment to output ratio in the manufacturing sectors. Some series were obtained as indeces, some other were computed from employment and output data. Non seasonally adjusted series were filtered with the x11.

USOPHDURE	US Output per hour of all persons, durable sector SA
UKYEHW..	UK Employee jobs, manufacturing
UK output	UK manufacturing output from ESA 95
CN980634	Canada, Employment, manufacturing.
CNGDPMAND	GDP, total manufacturing
BDPRODMHE	Germany, output per man hour in industry NSA
ITFL1578F	Italy, Employees, industry, NSA
ITCT1462D	Italy, Gross value added, industry
FRISACMNF	France, hours worked, manufacturing sector
FRISIPMGD	France production, manufacturing goods
JPPRDVTMF	Japan labour productivity index, manufacturing NSA

- **NFA** All series on net foreign assets were normalized by the GDP of the country. The data were obtained from the International Financial Statistics of the IMF. Codes are as follows:

USI31n...A	US Net foreign assets
UKI31n...A	UK Net foreign assets
CNI31n...A	Canada Net foreign assets
BDI31n...A	Germany Net foreign assets
III31n...A	Italy Net foreign assets
FRI31n...A	France Net foreign assets
JPI31n...A	Japan Net Foreign assets

- **Supply: Prices and Terms of trade** Prices on oil and non-fuel commodities were obtained from the IMF. The real supply was constructed by deflating with the US deflator. Data on terms of trade were obtained from the National Accounts and forecasted by simple ARIMA models. We distinguish three trade areas (where correlation among countries is high) each one forecasted independently:

A) United States and United Kingdom. United States terms of trade are modelled as an ARIMA (2,1,1). The forecasted data are then used to project the United Kingdom series.

B) Germany, France and Italy. German terms of trade are modelled as an ARIMA (1,1,0). The forecasted data are also used to project the series for France and Italy.

C) Canada and Japan. Canadian terms of trade are modelled as an ARIMA (2,0,1) with a seasonal MA component in the tenth quarter. As before, forecasted data of Canadian terms of trade are used to project the Japanese ones.

UKI76AAZA	UK market petroleum, spot (US\$/Barrel) UK Brent
WDI76AXDF	IMF all non-fuel commodity prices index
USTERMSTF	Terms of trade 1975=100
UKTERMSTF	UK Terms of trade 1990=100
CNTERMSTE	Canada Terms of trade 1992=100
BDTERMSTF	Germany Terms of trade 1991=100
ITTERMSTF	Italy terms of trade 1980=100
FRTERMSTF	France Terms of trade 1980=100
JPTERMSTF	Japan Terms of trade 1980=100

Figure R.1

Residuals from DM/US\$ equation

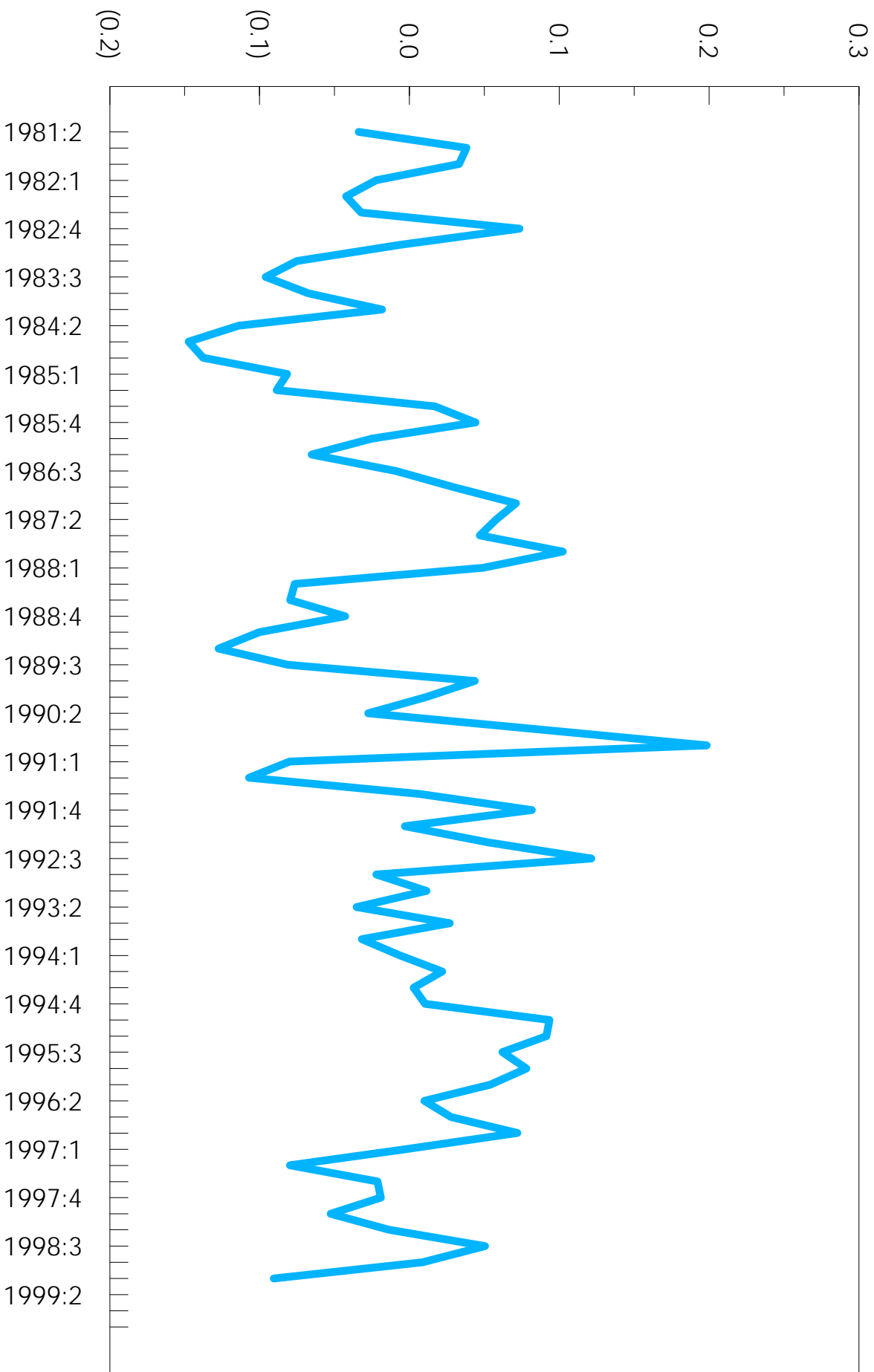


Figure R.2

Residuals from SwFr/US\$ equation

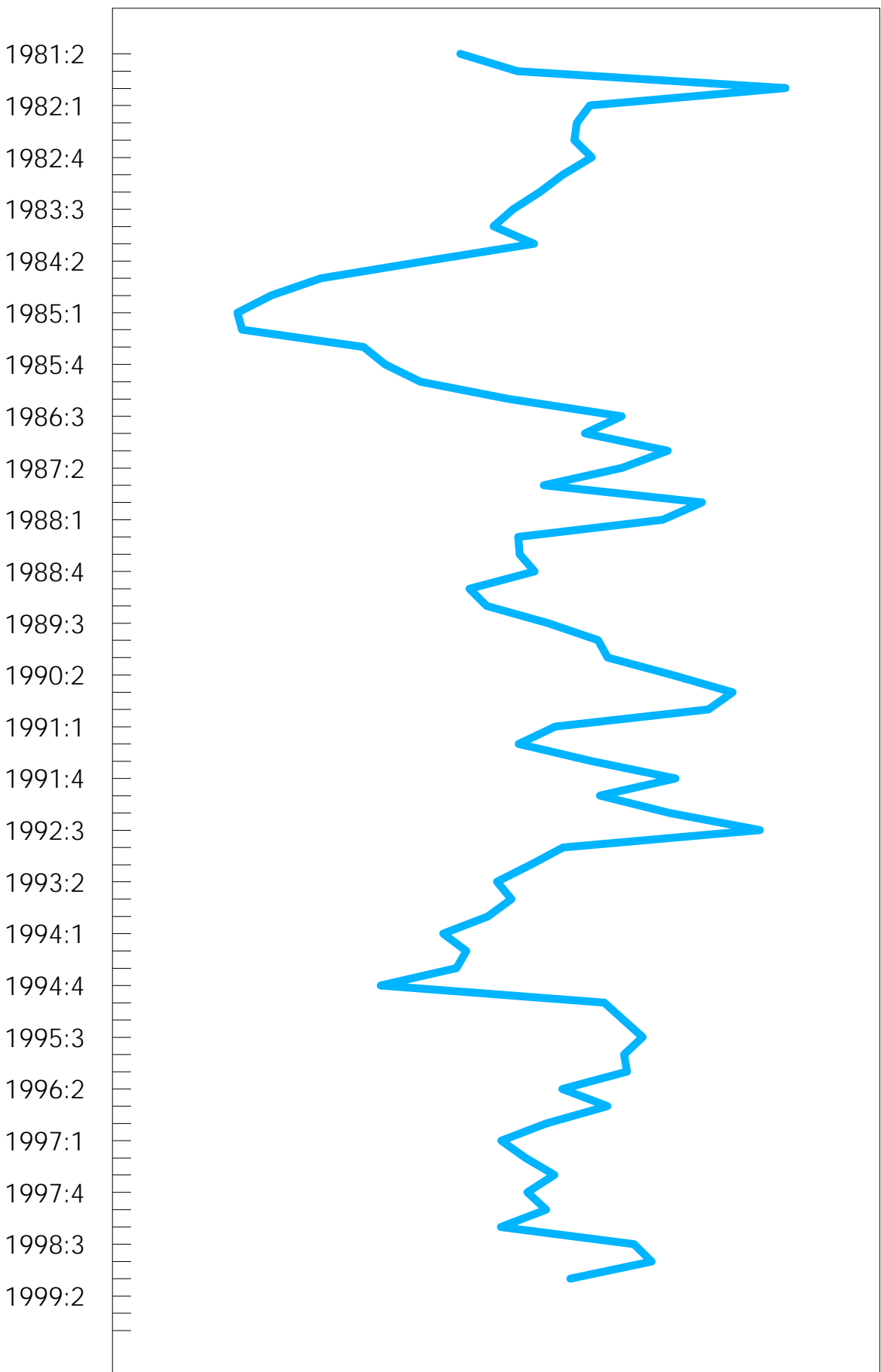


Figure R.3

Residuals from FF/US\$ equation

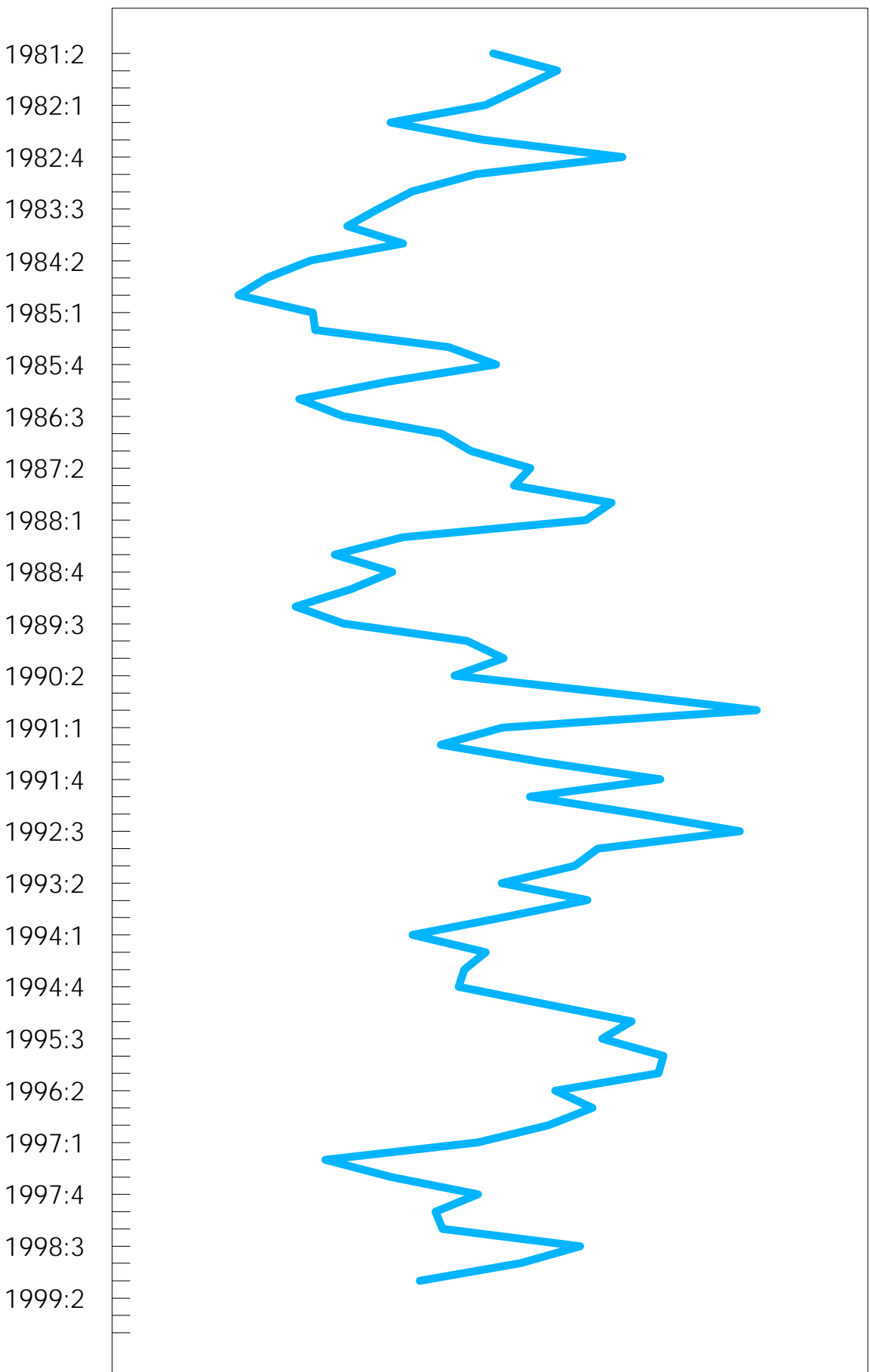


Figure R.4

Residuals from ITL/US\$ equation

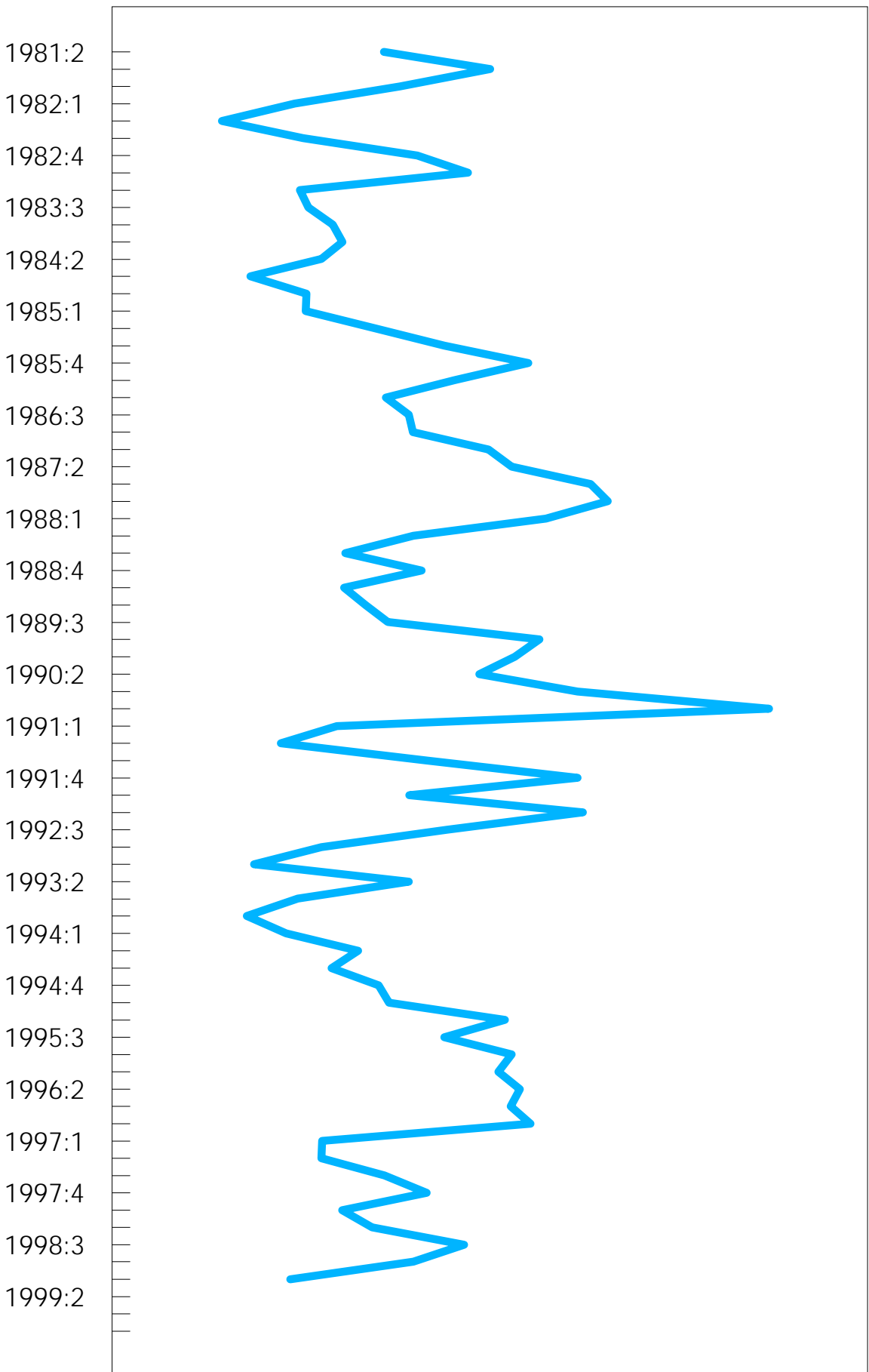


Figure R.5

Residuals from CAN\$/US\$ equation

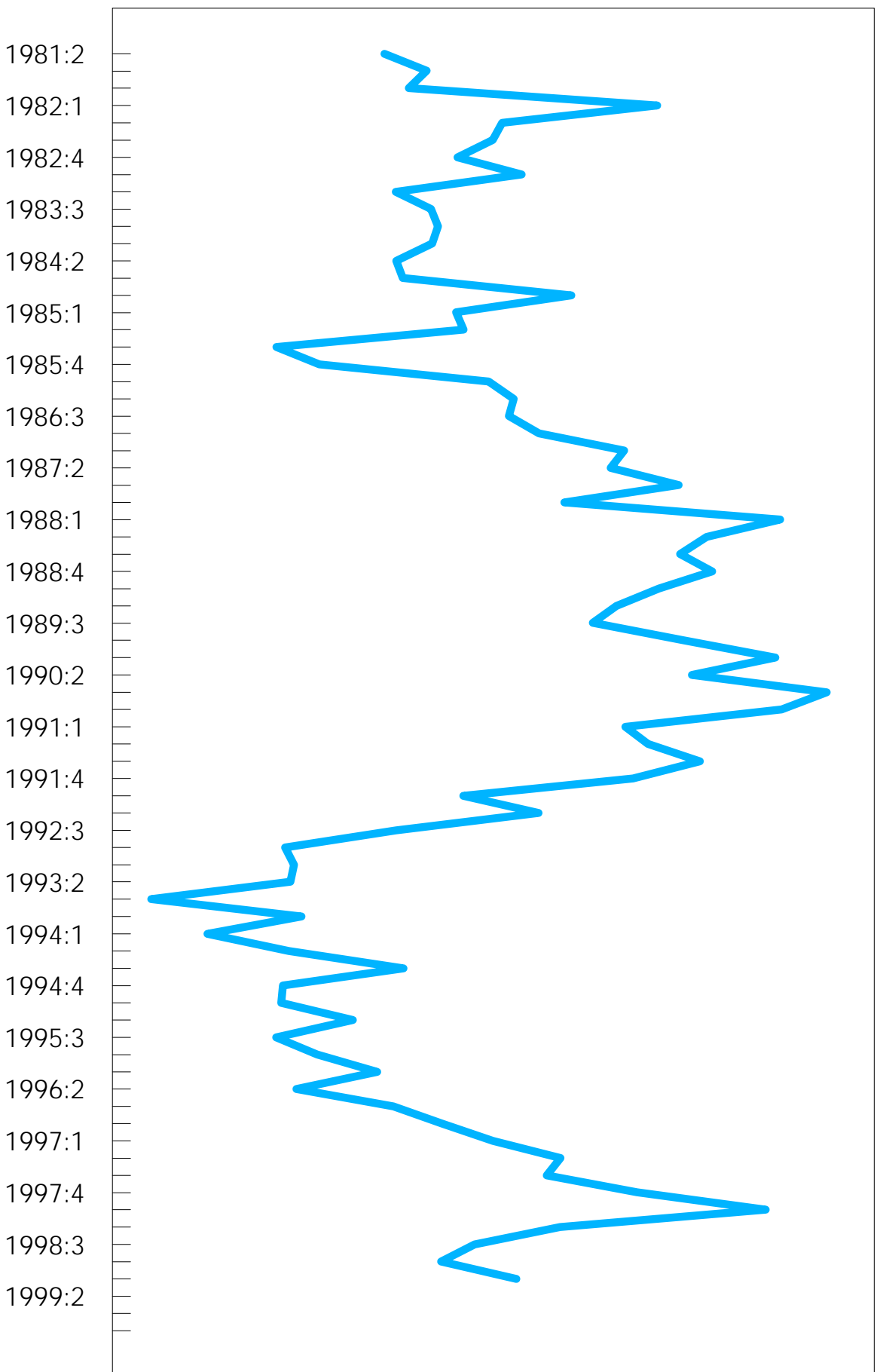


Figure R.6

Residuals from £/US\$ equation

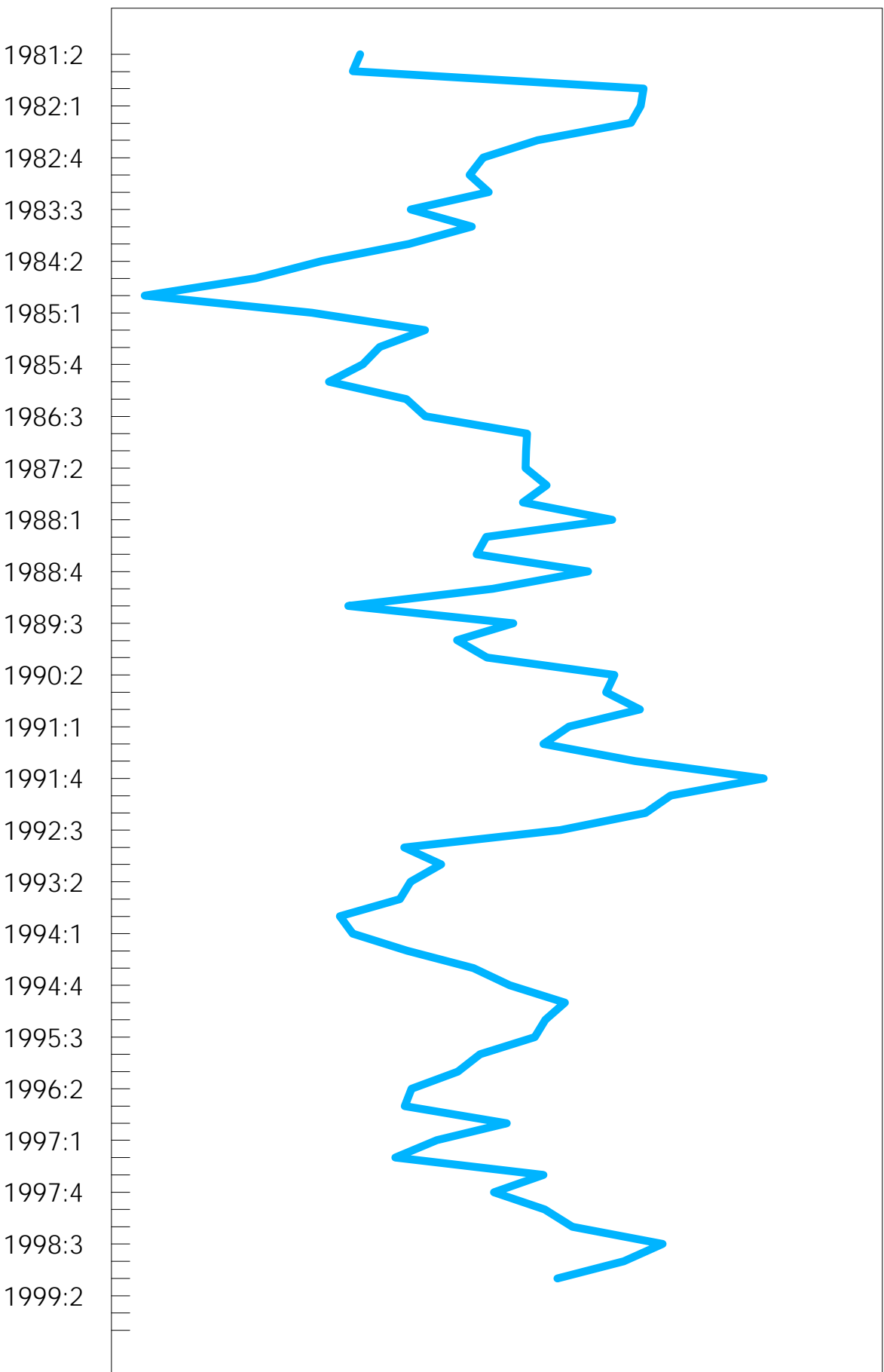


Figure R.7

Residuals from JPY/US\$ equation

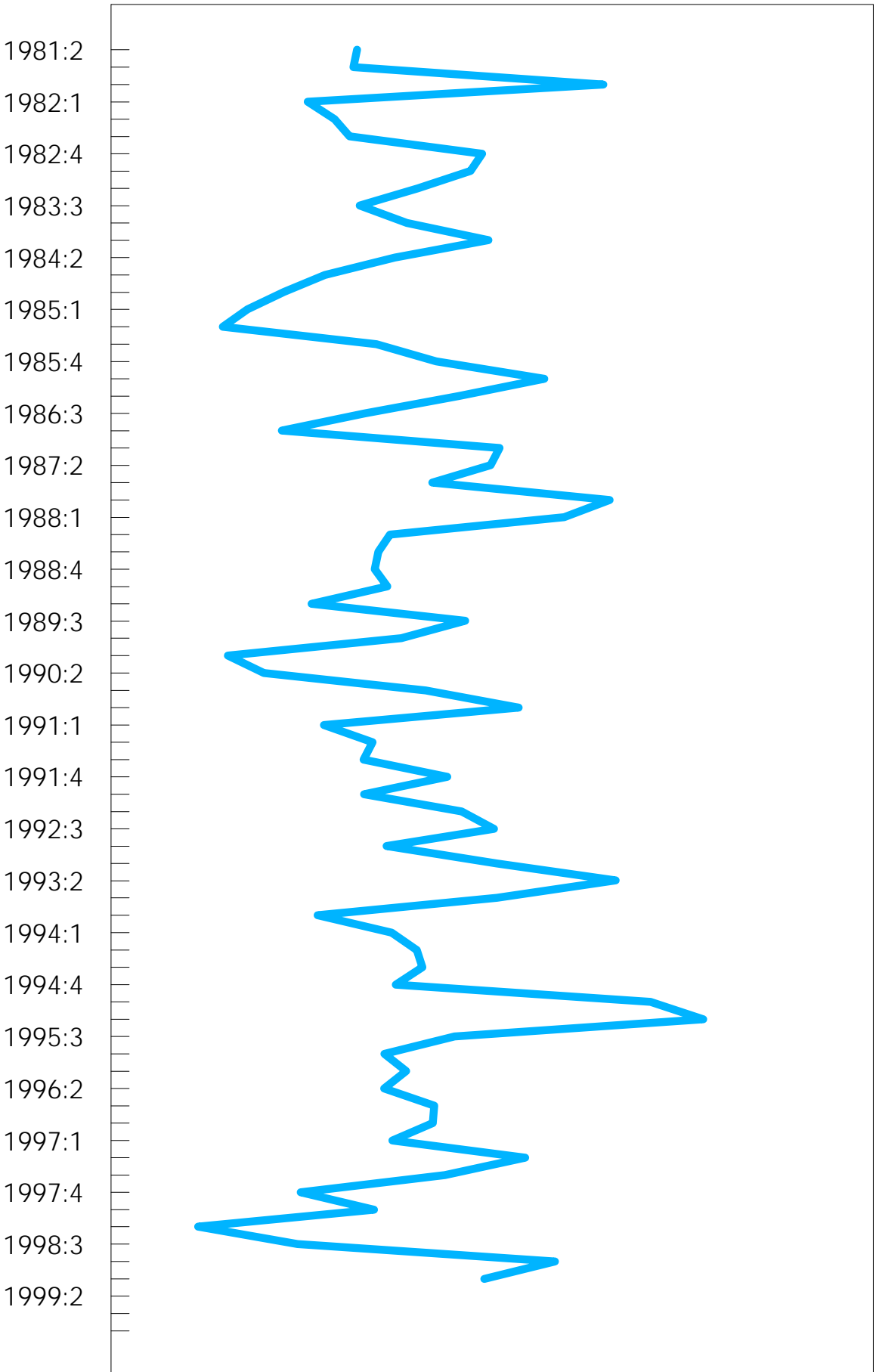
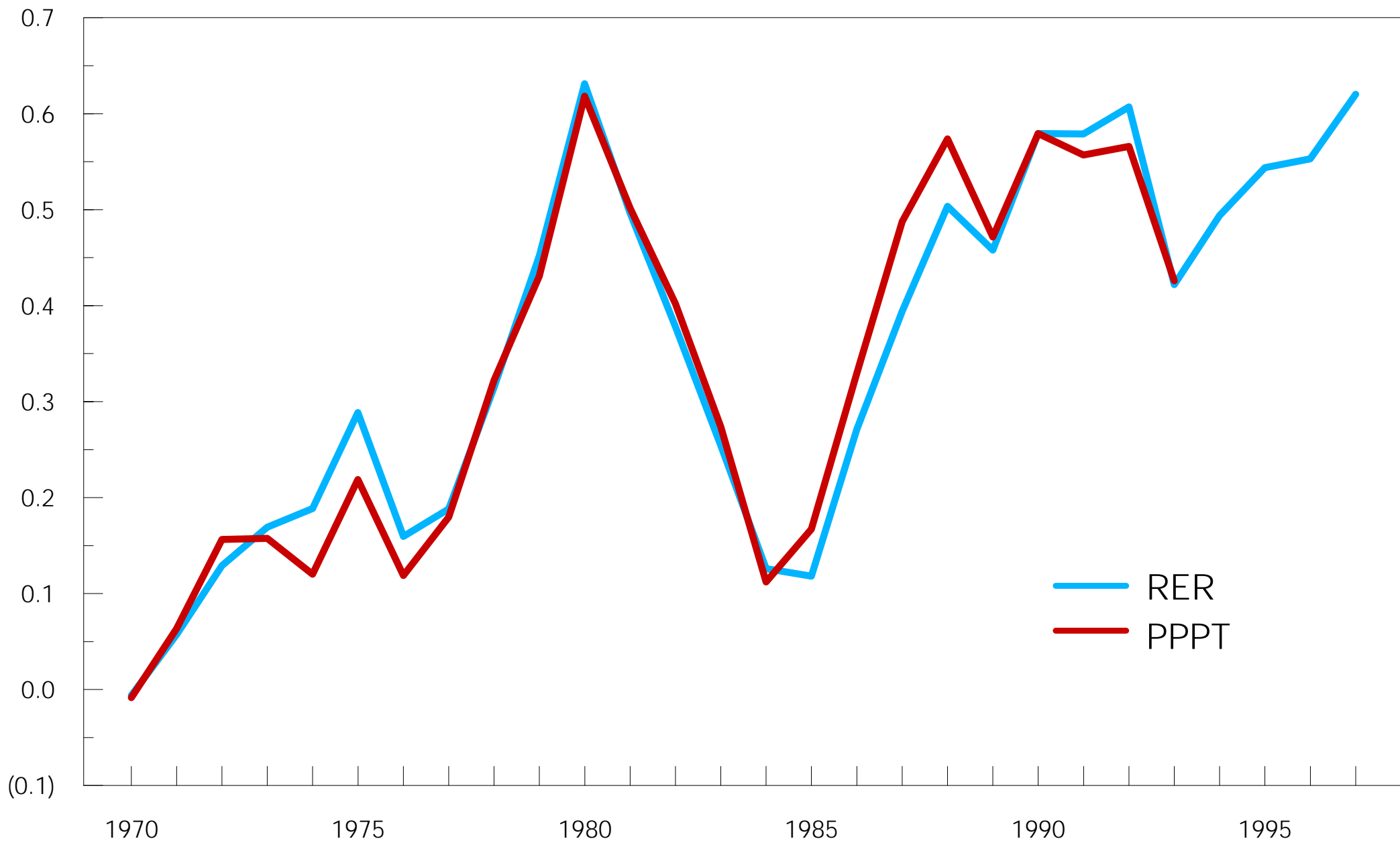


Figure 1

UK

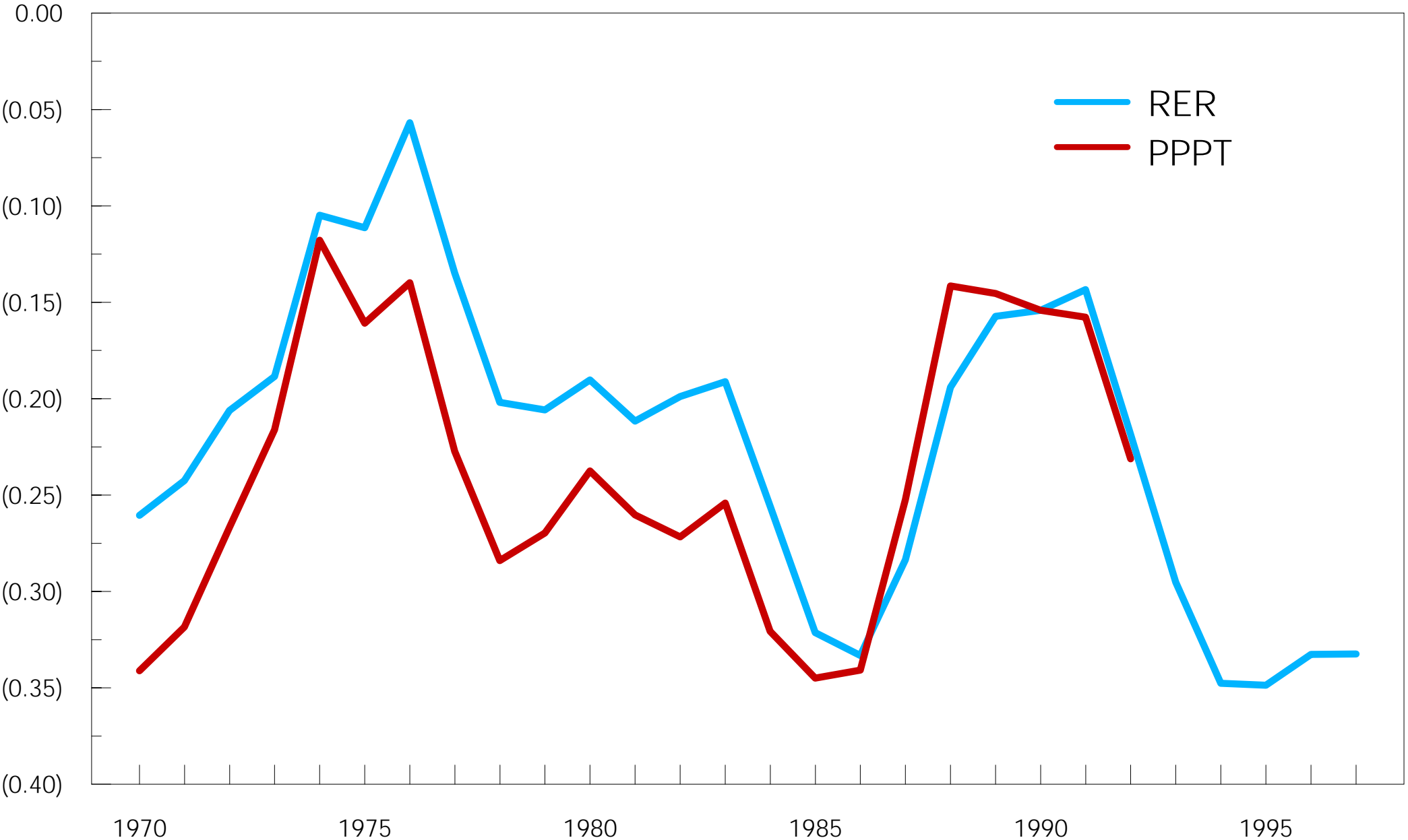


N.B. RER means real exchange rate deflated with total deflator

PPPT means real exchange rate deflated with tradable goods deflator

Figure 2

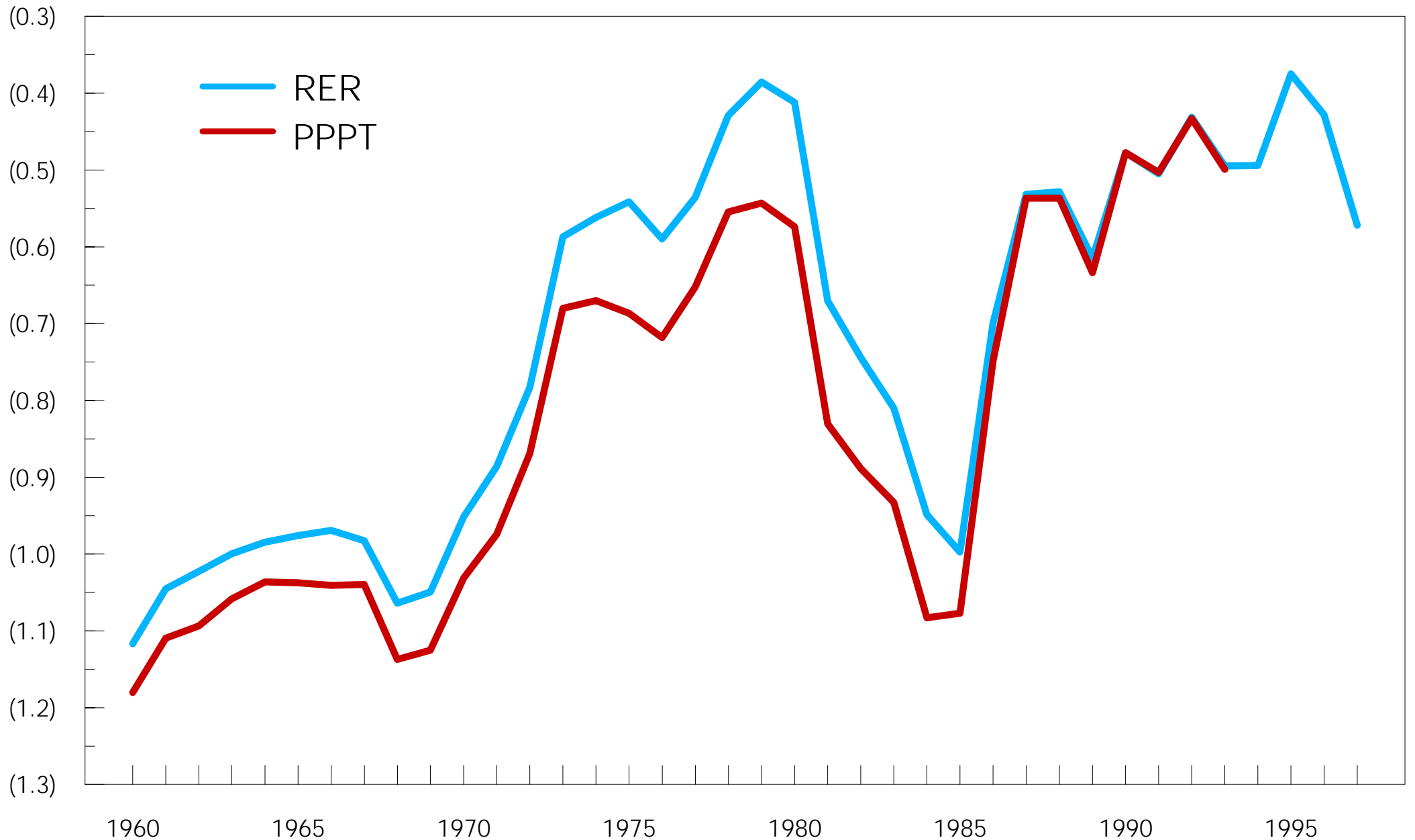
Canada



N.B. RER means real exchange rate deflated with total deflator
PPPT means real exchange rate deflated with tradable goods deflator

Figure 3

Germany

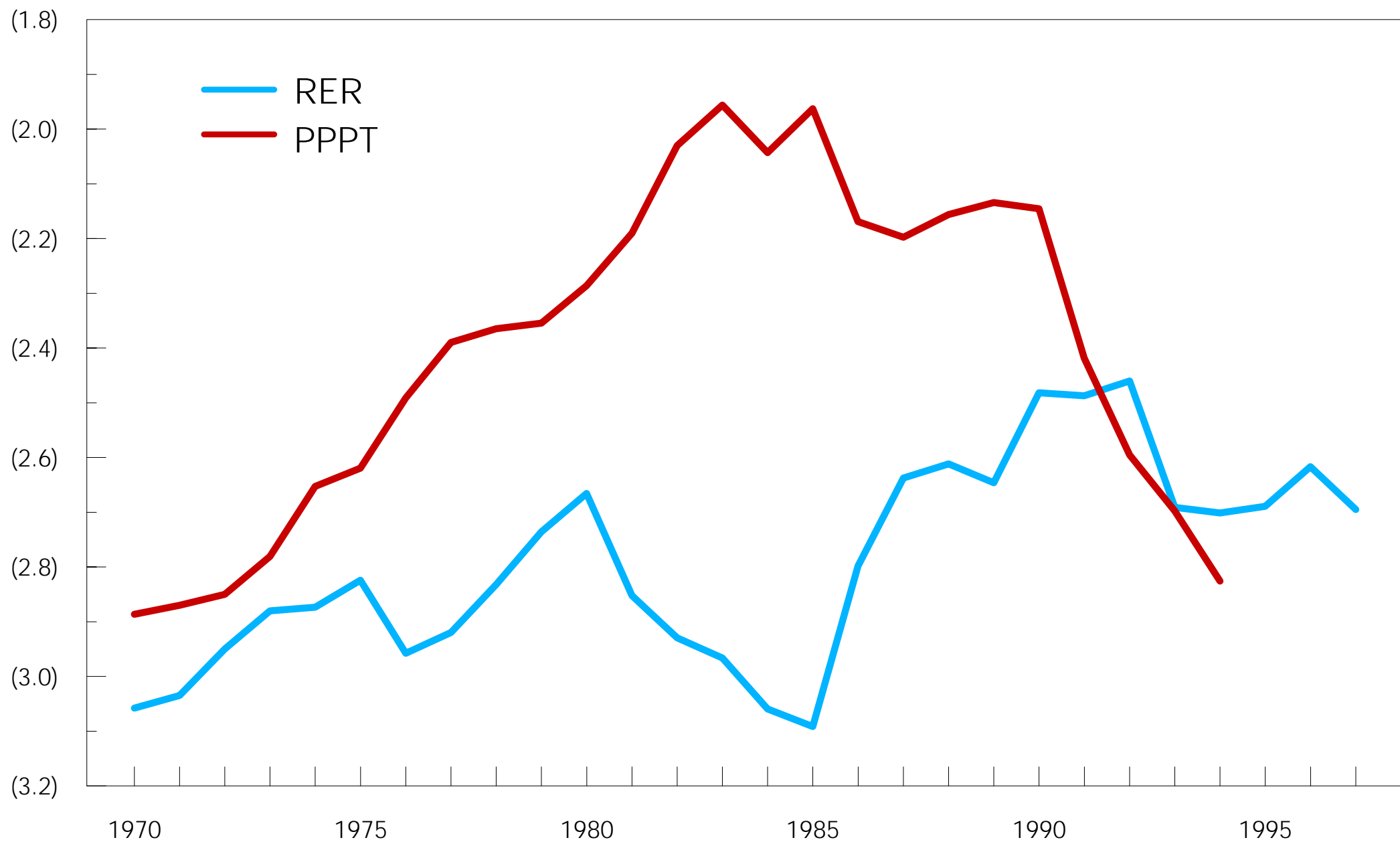


N.B. RER means real exchange rate deflated with total deflator

PPPT means real exchange rate deflated with tradable goods deflator

Figure 4

Italy

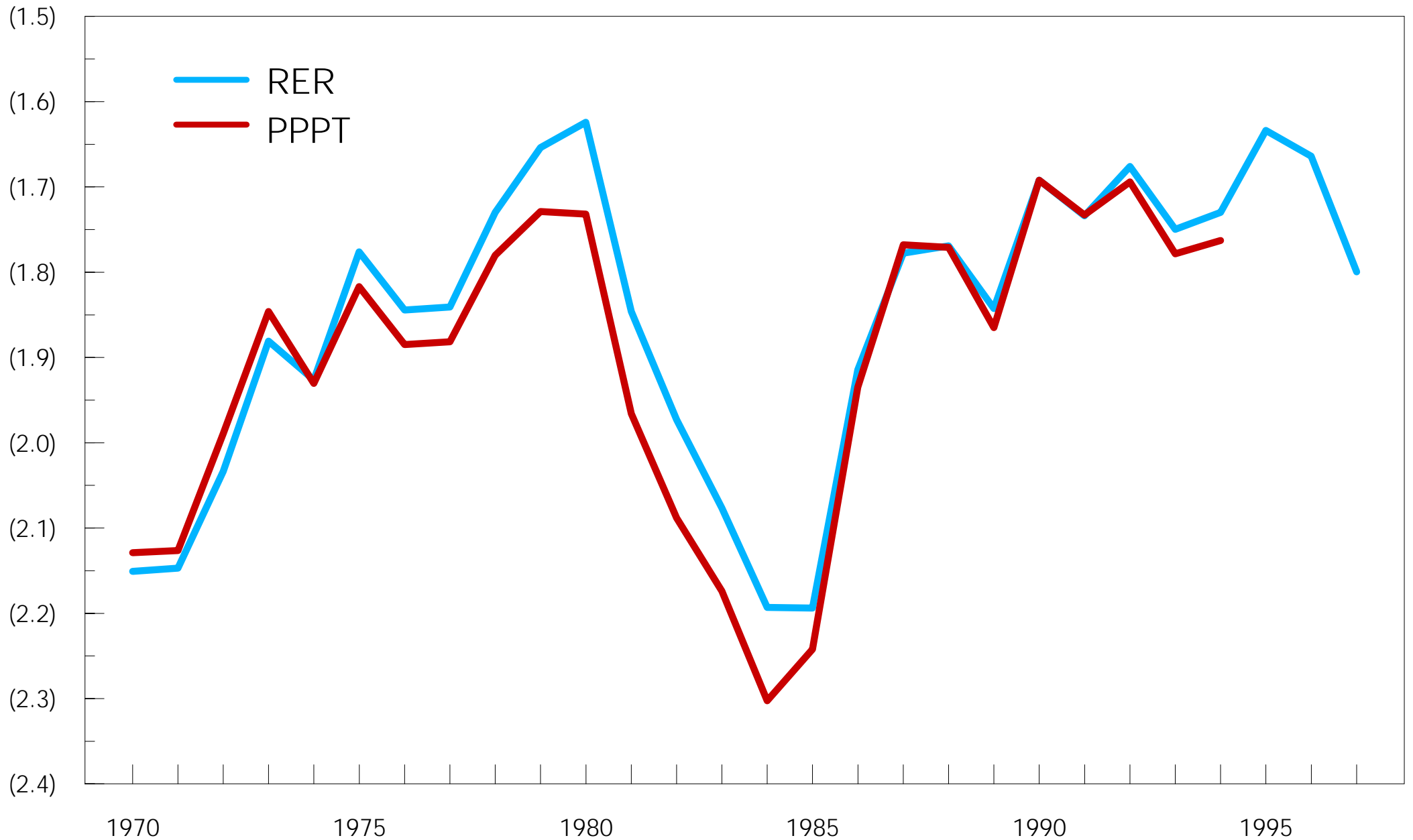


N.B. RER means real exchange rate deflated with total deflator

PPPT means real exchange rate deflated with tradable goods deflator

Figure 5

France

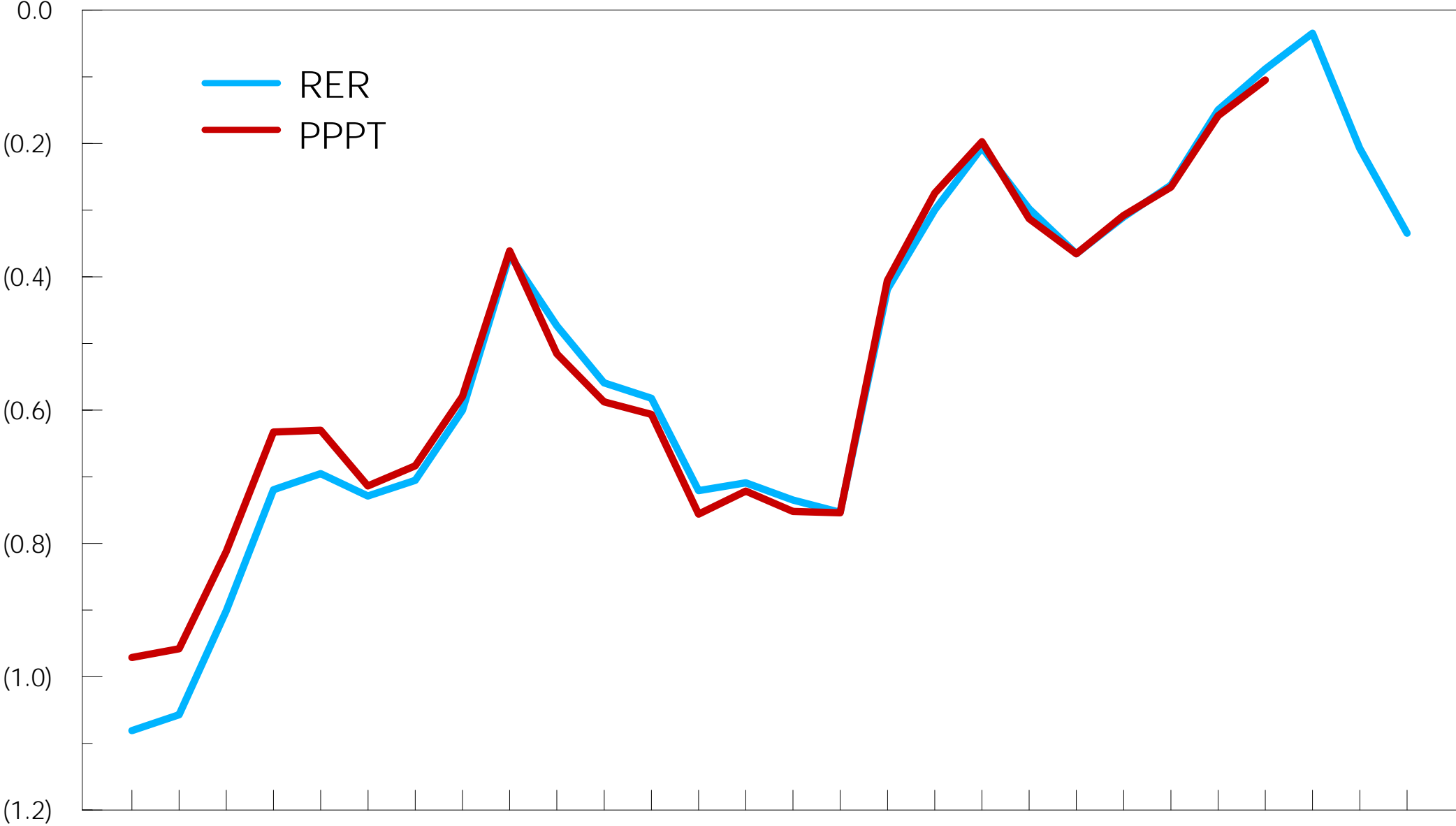


N.B. RER means real exchange rate deflated with total deflator

PPPT means real exchange rate deflated with tradable goods deflator

Figure 6

Japan



N.B. RER means real exchange rate deflated with total deflator
PPPT means real exchange rate deflated with tradable goods deflator

Figure 7

US\$/DM - Actual and Non-smoothed

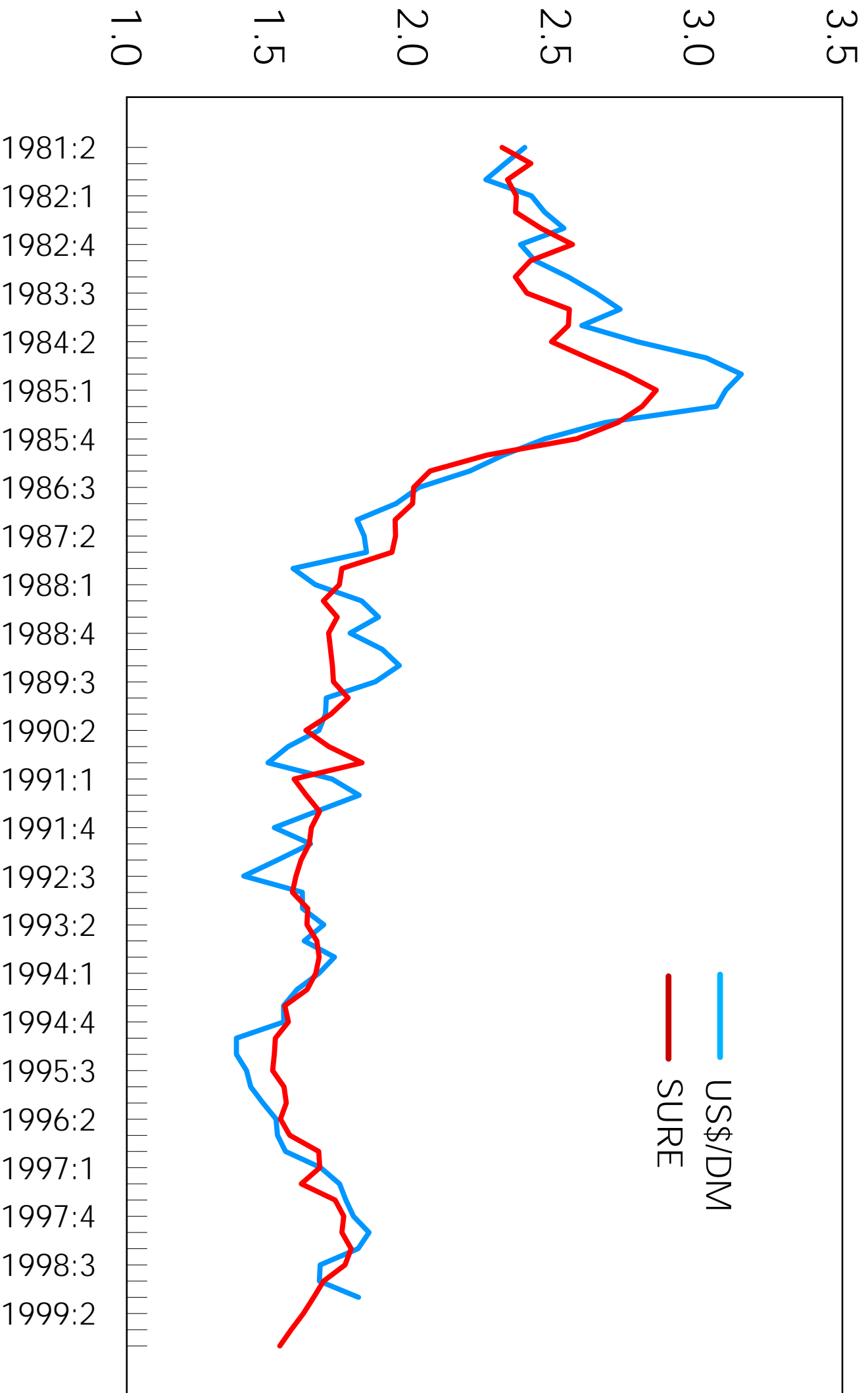


Figure 8

US\$/DM - Actual and Smoothed

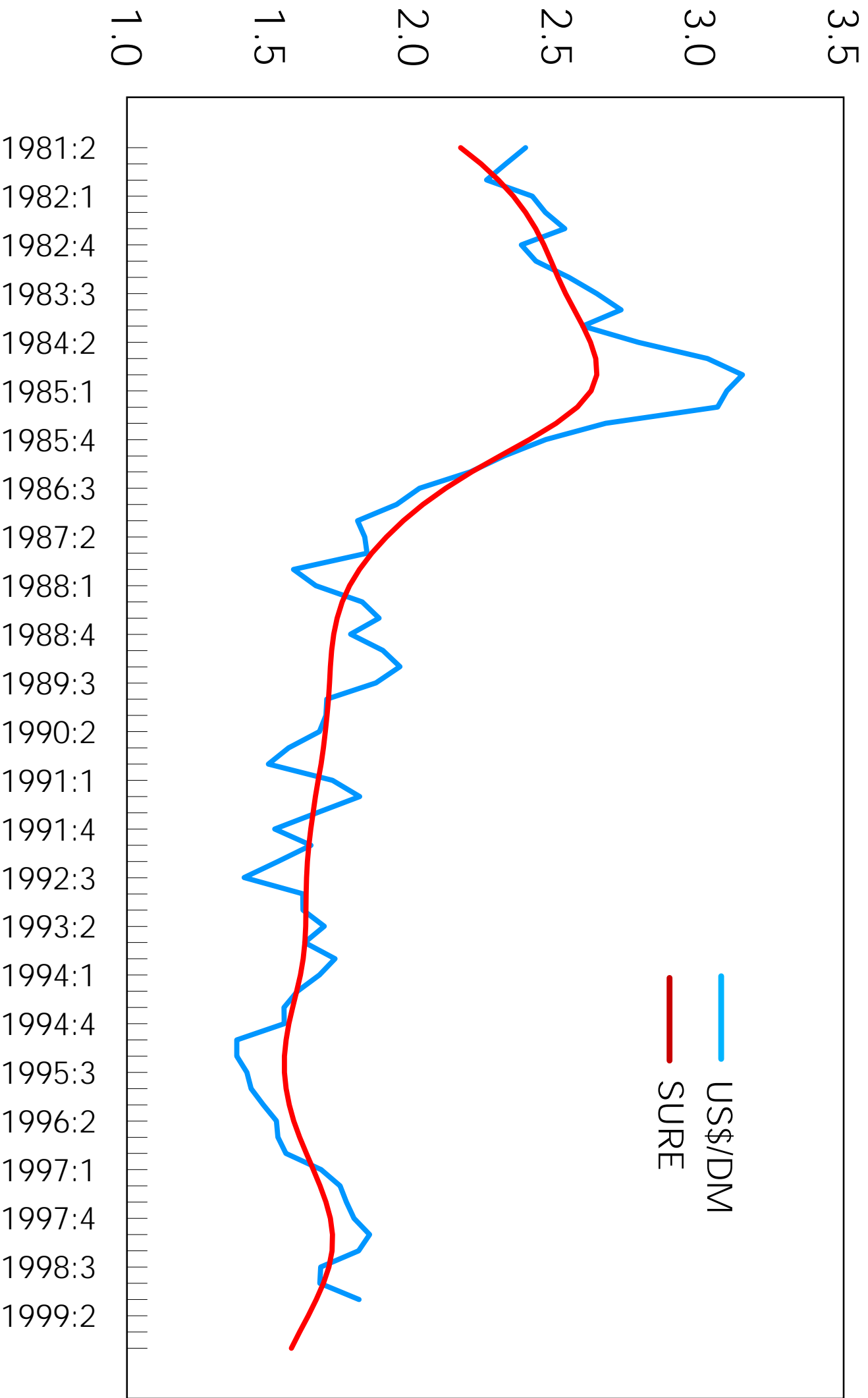


Figure 9

US\$/ITL - Actual and Non-smoothed

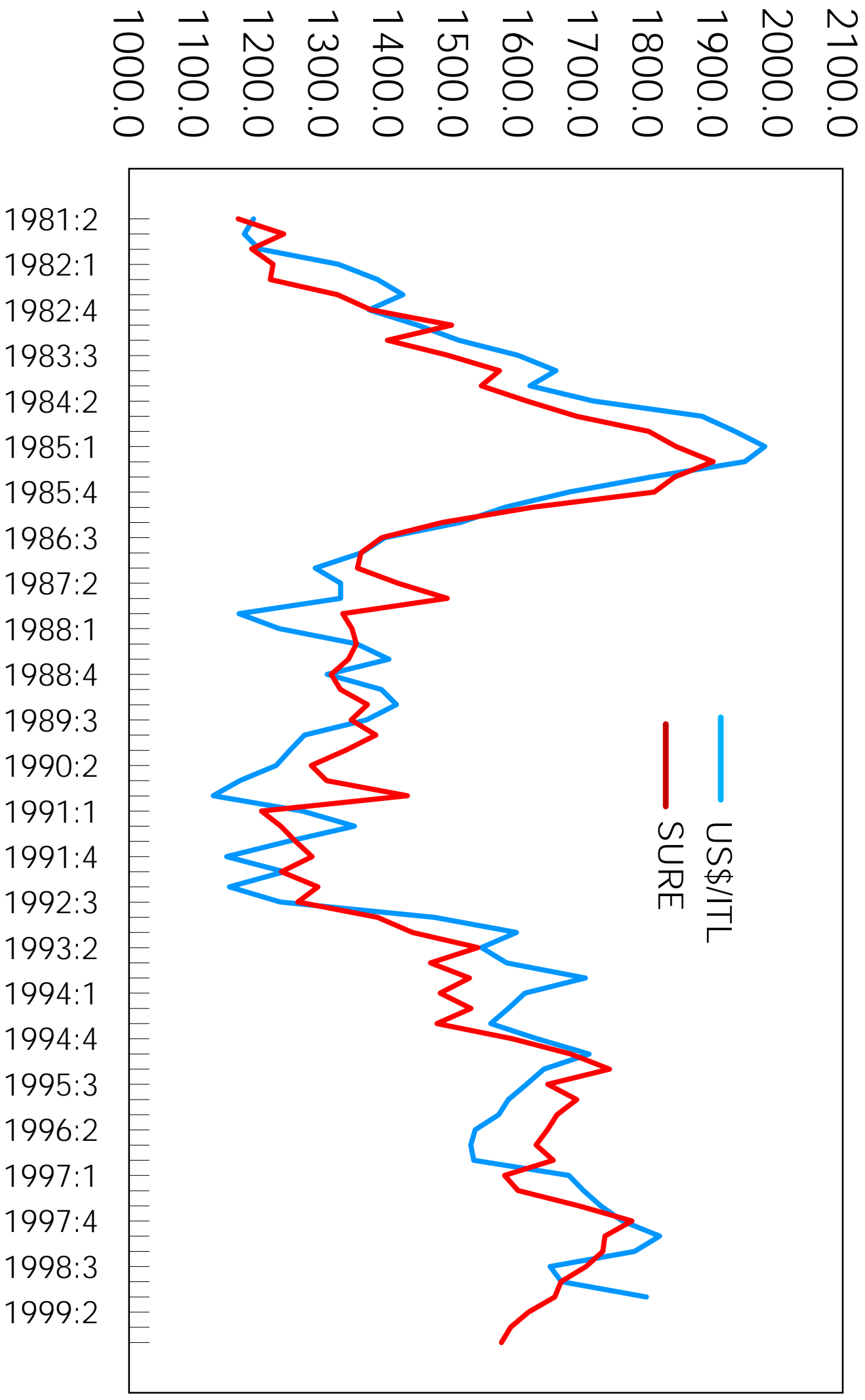


Figure 10

US\$/ITL - Actual and Non-smoothed

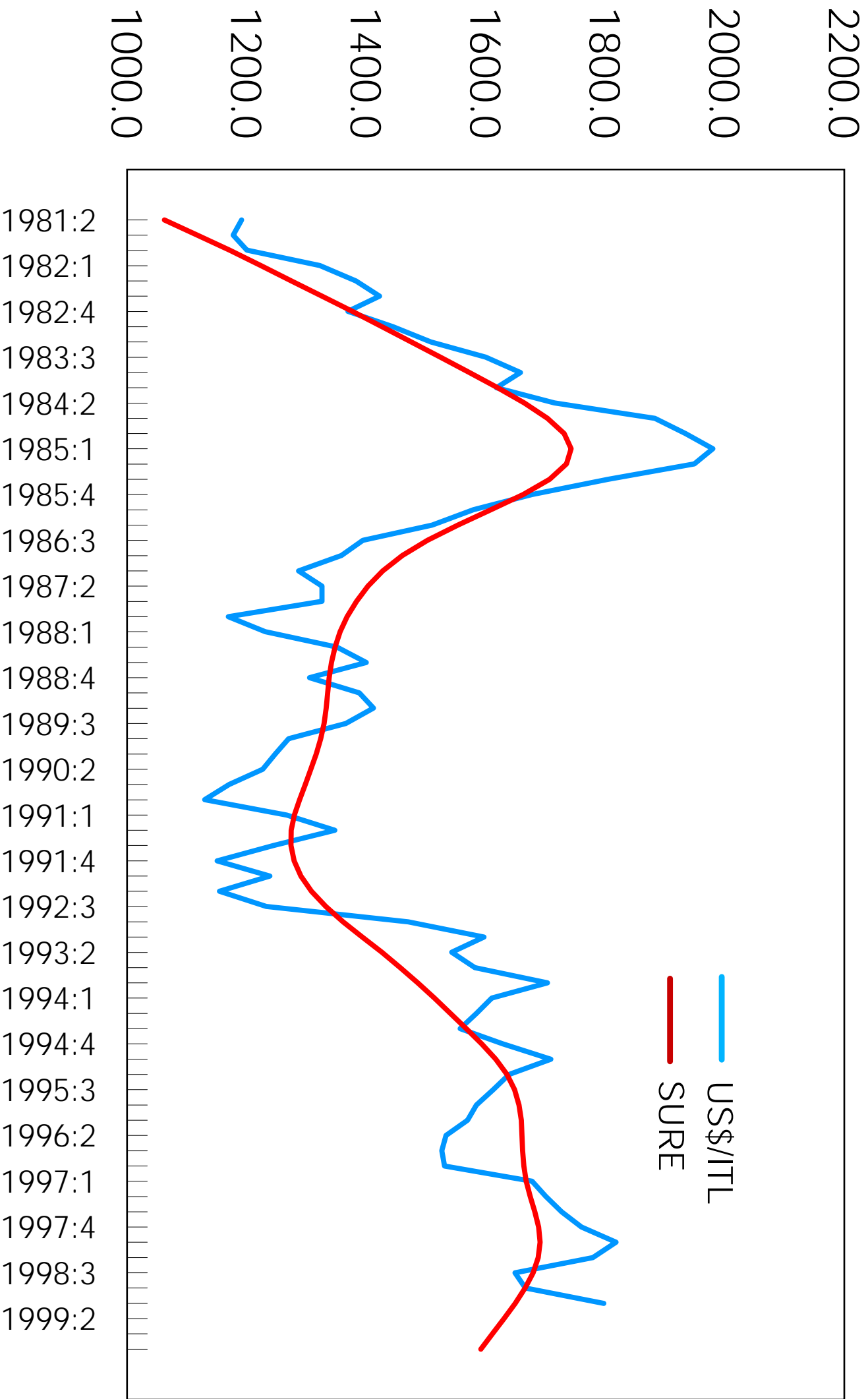


Figure 11

US\$/FF - Actual and Non-smoothed

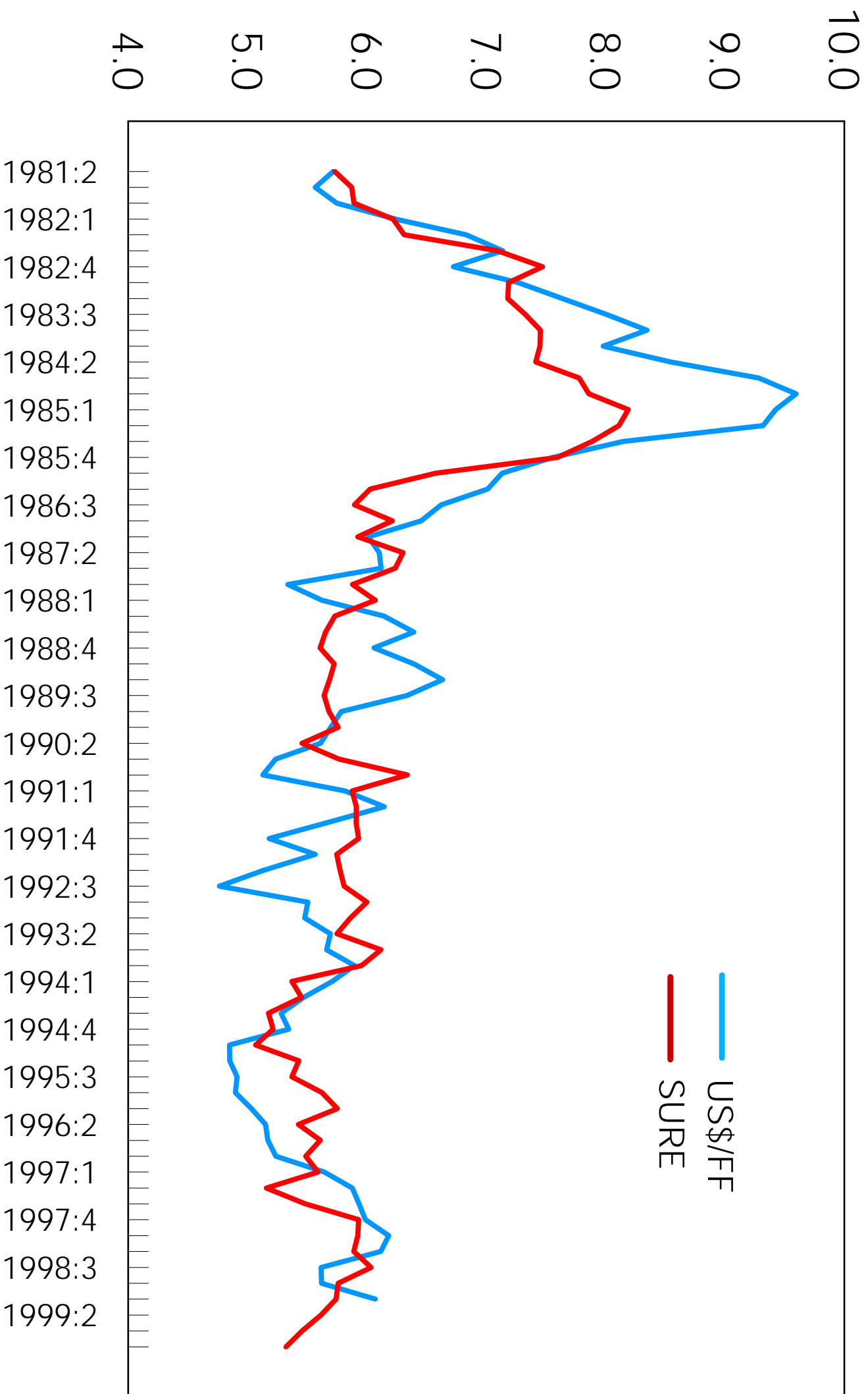


Figure 12

US\$/FF - Actual and Smoothed

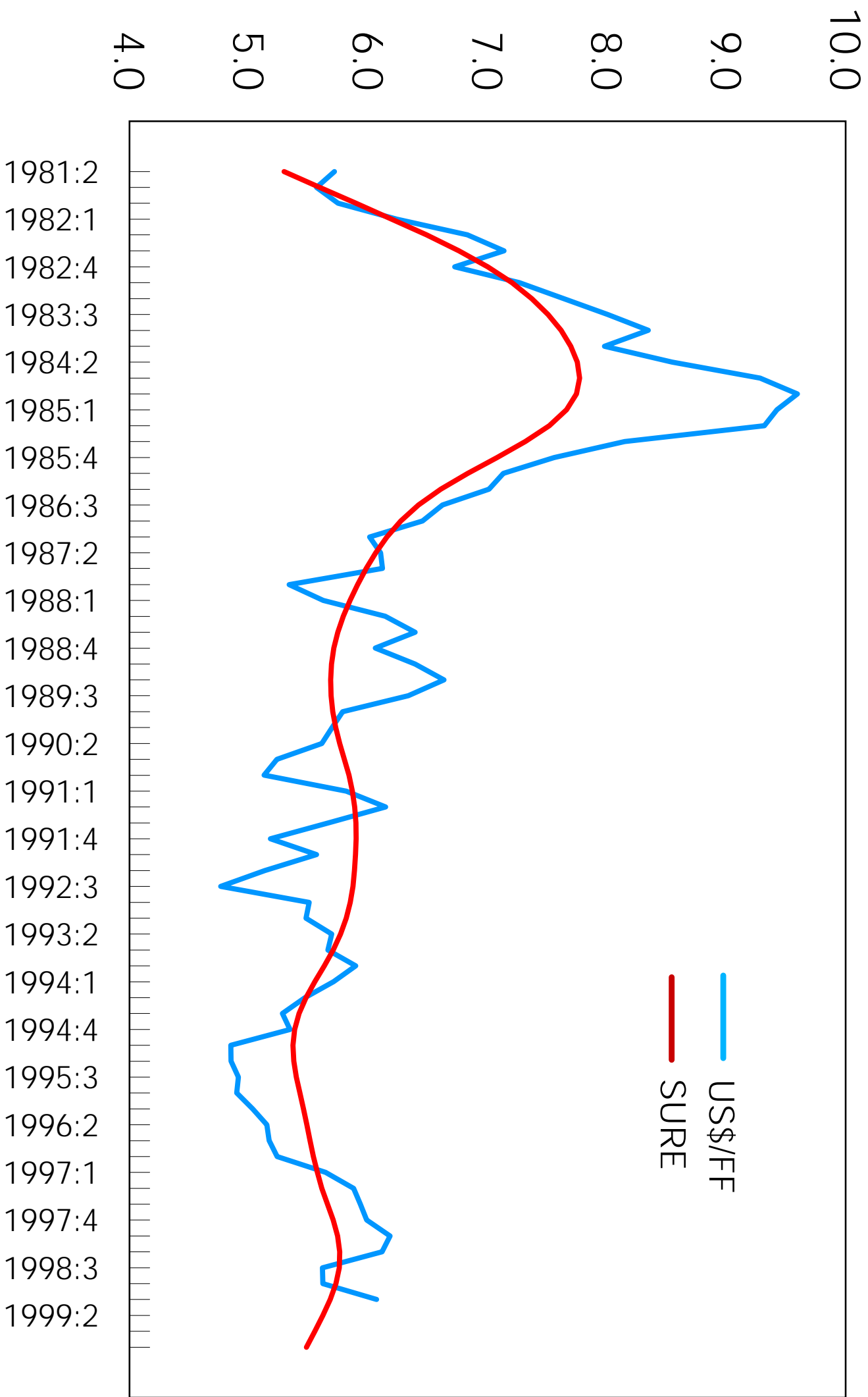


Figure 13

EURO-US\$ - Actual and Non-Smoothed

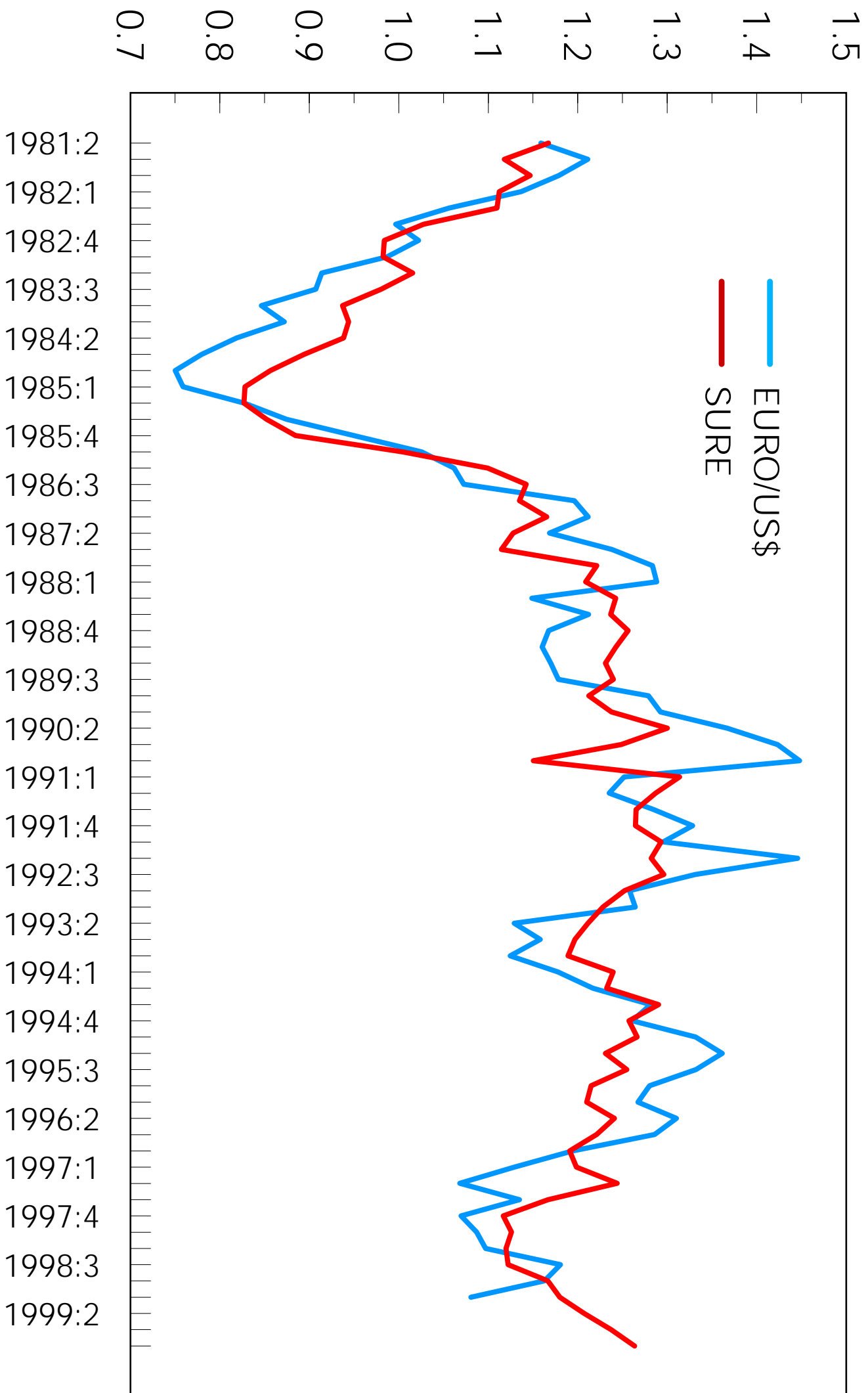


Figure 14

EURO-US\$ - Actual and Smoothed

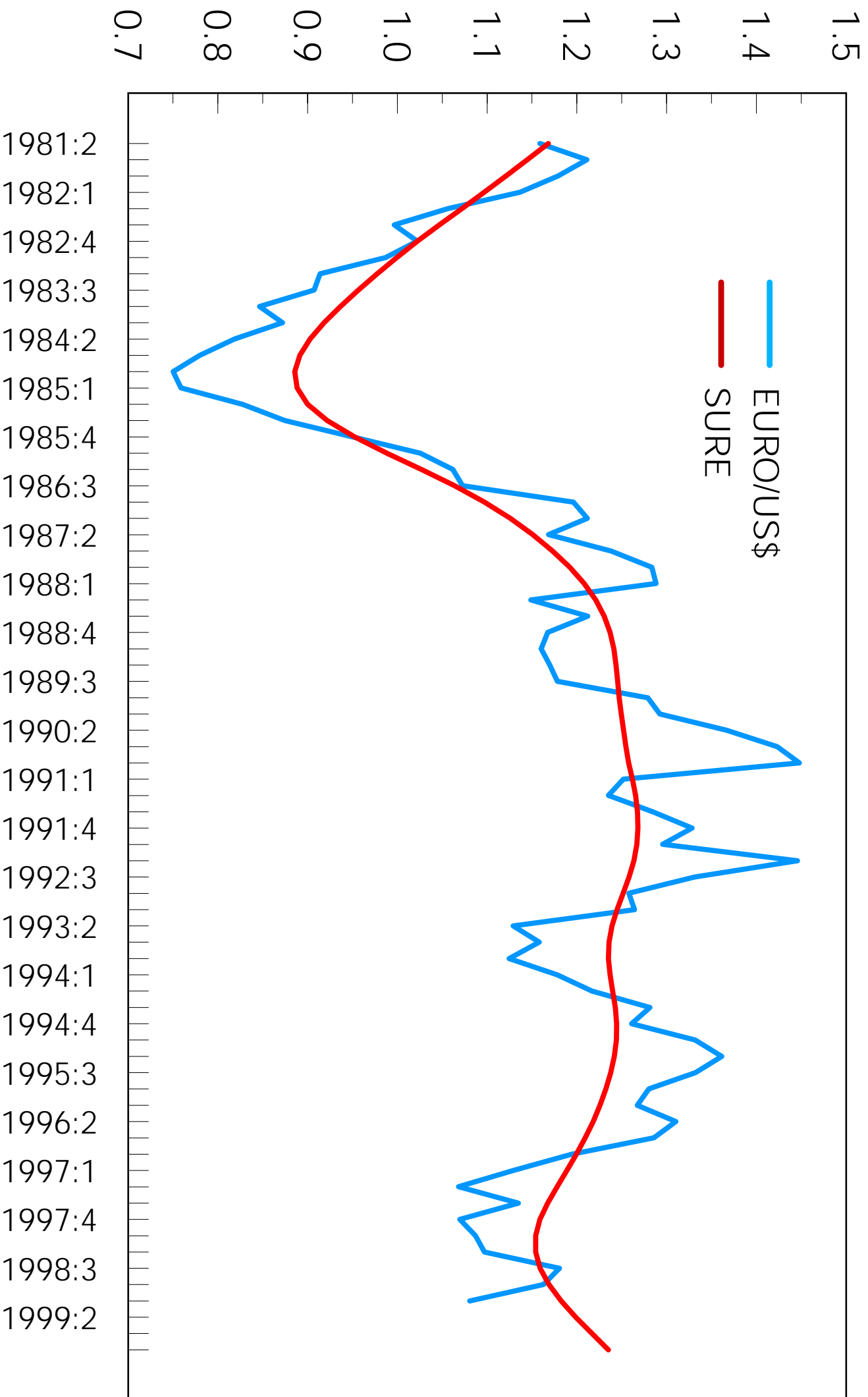


Figure 15

US\$/CAN\$ - Actual and Non-smoothed

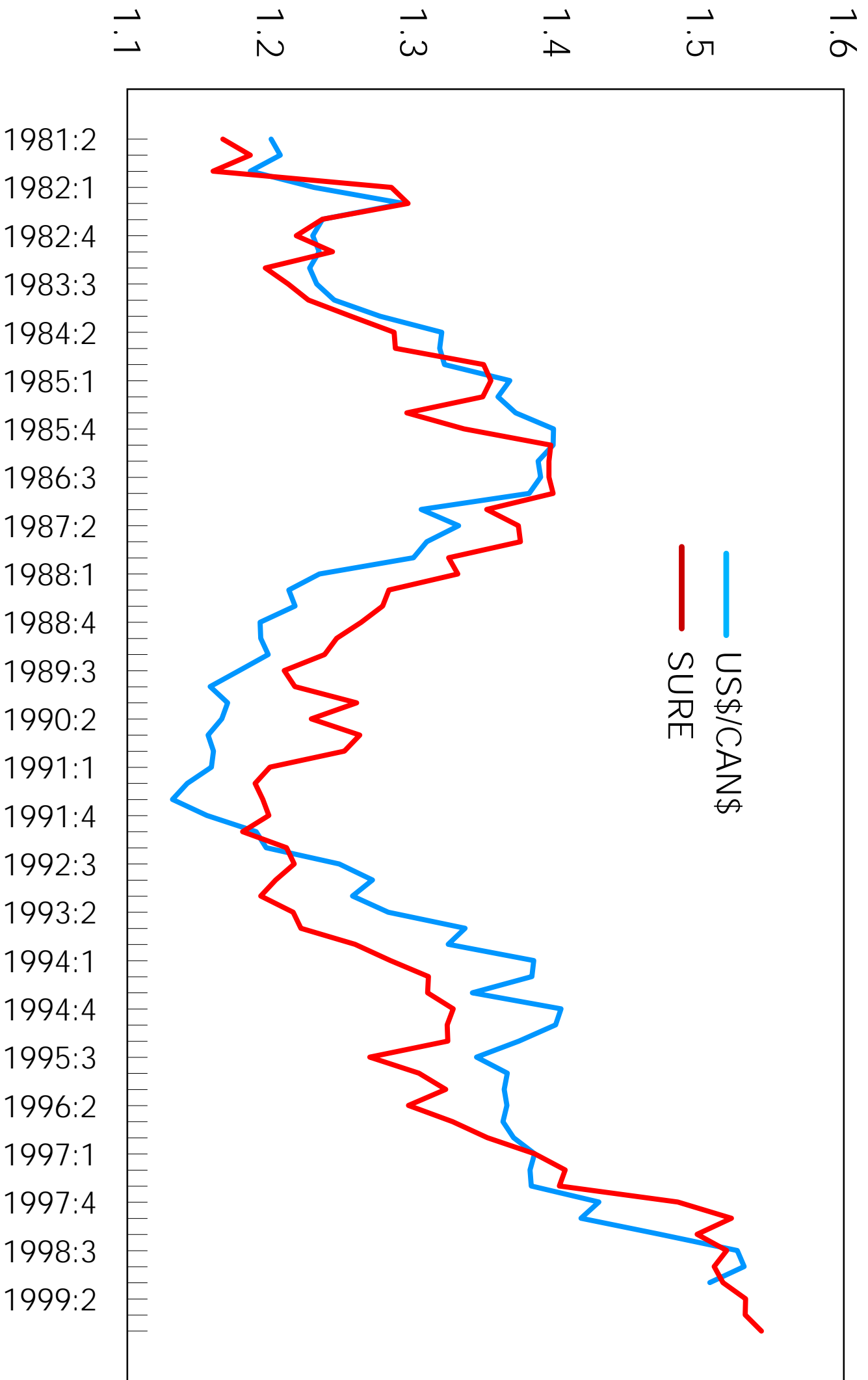


Figure 16

US\$/CAN\$ - Actual and Smoothed

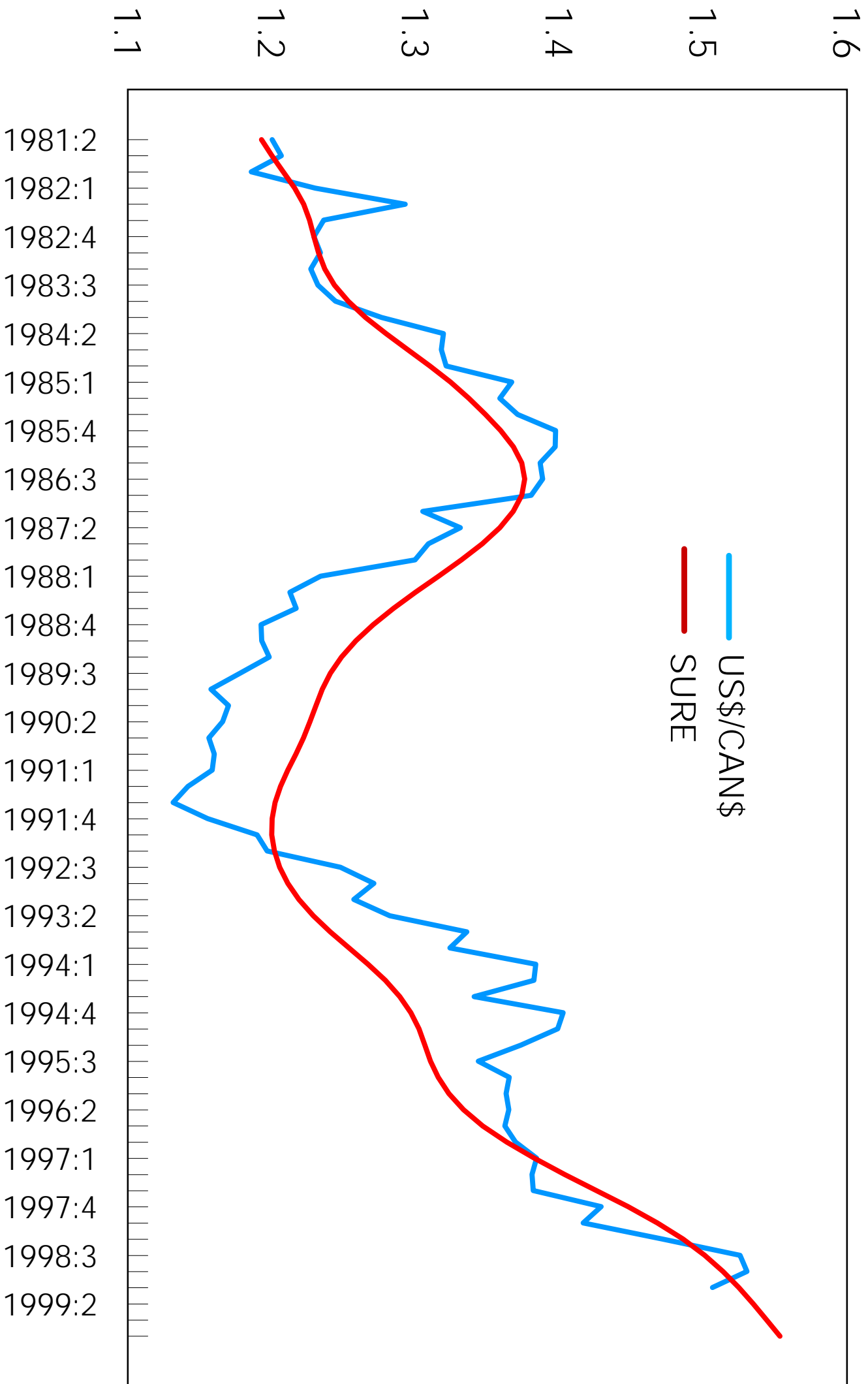


Figure 17

£/US\$ - Actual and Non-smoothed

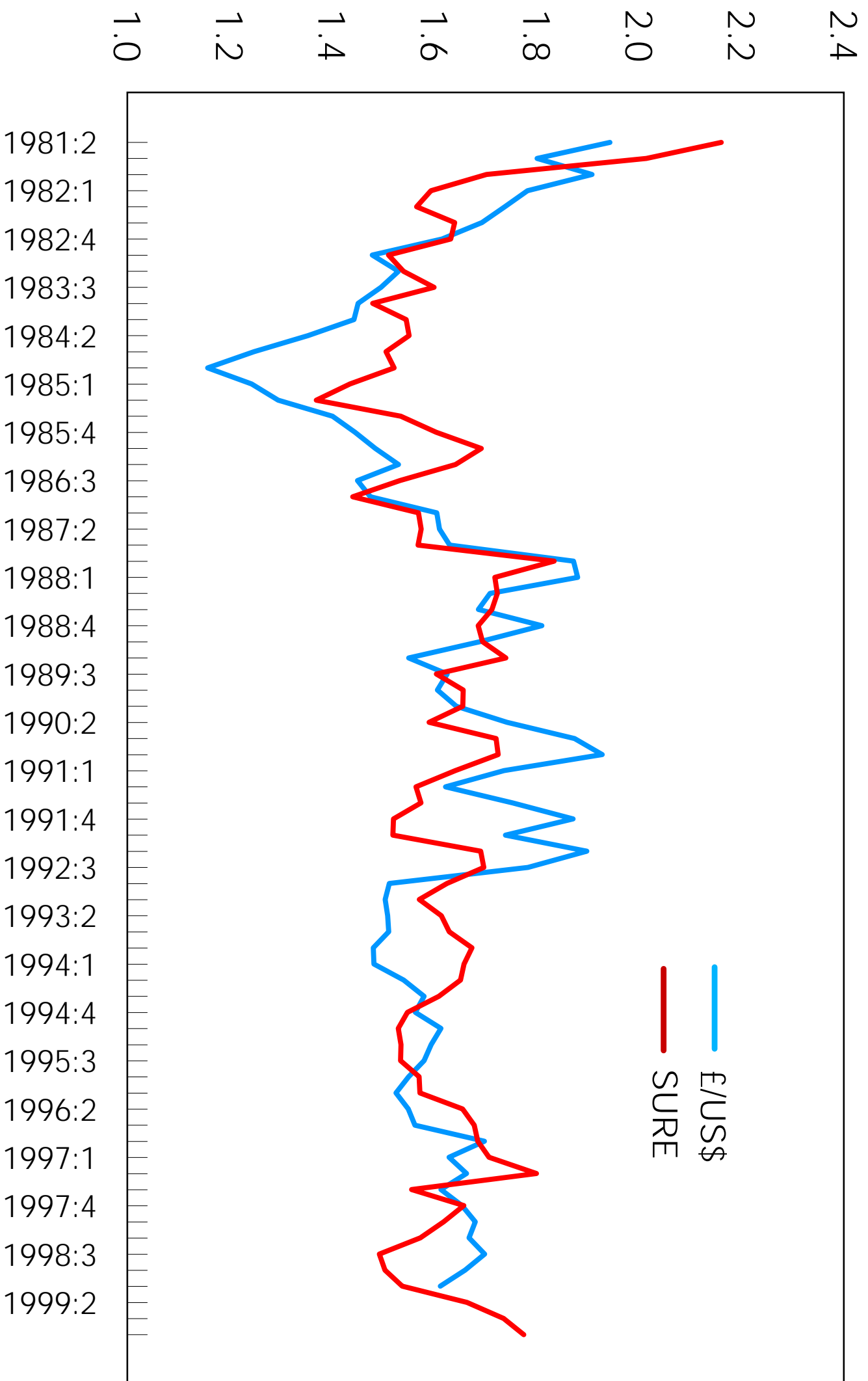


Figure 18

£/US\$ - Actual and Smoothed

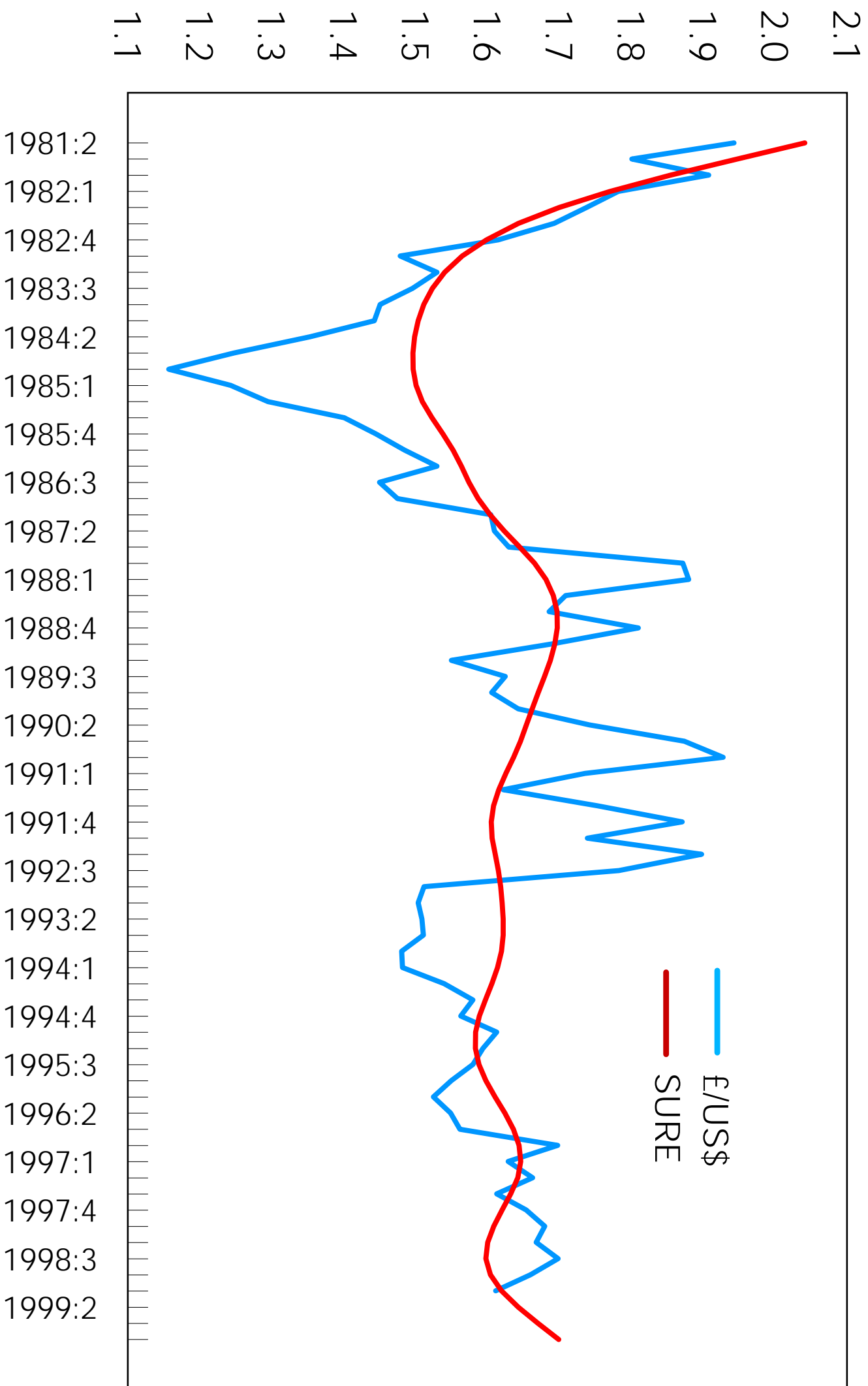


Figure 19

US\$/JPY - Actual and Non-smoothed

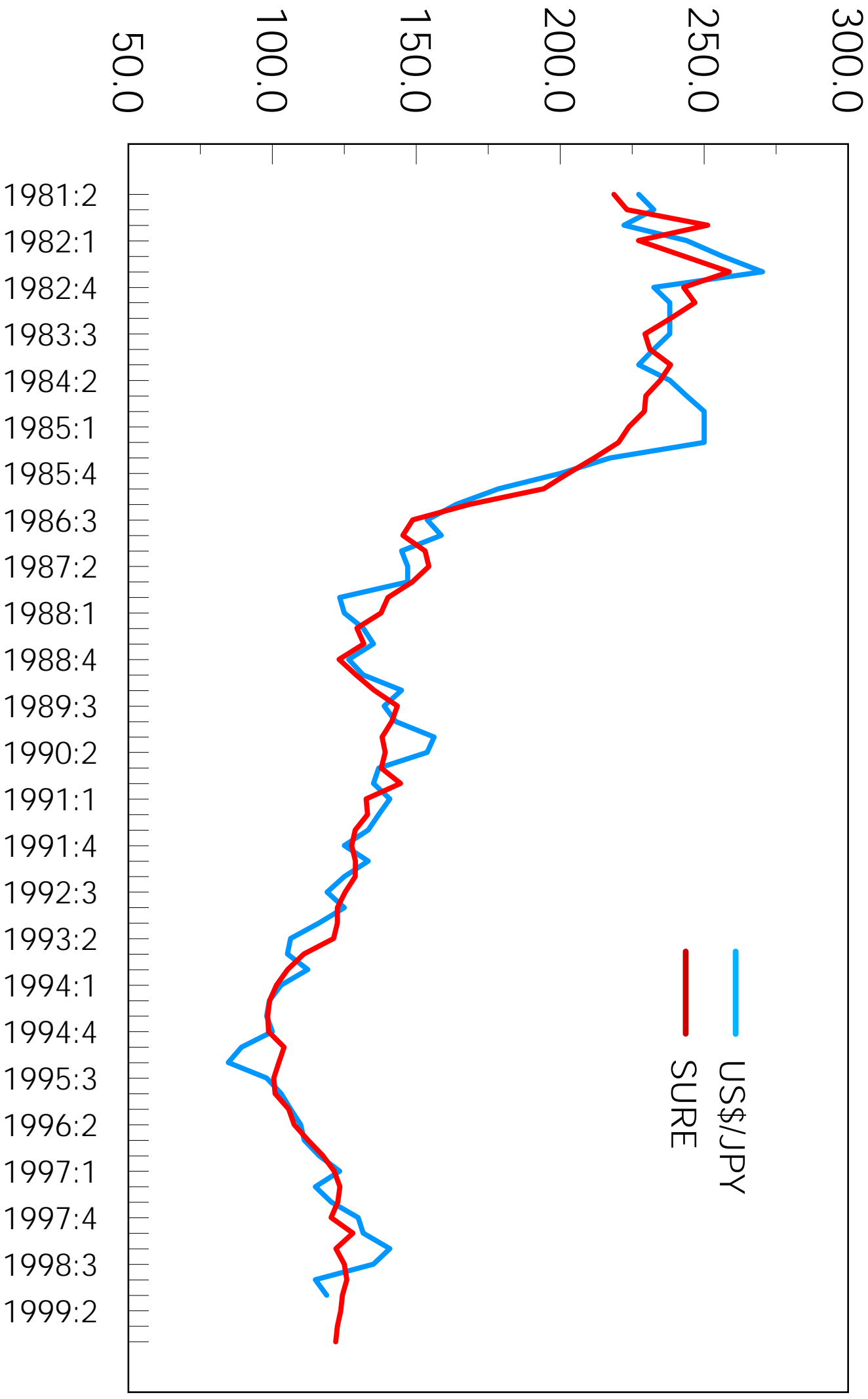


Figure 20

US\$/JPY - Actual and Smoothed

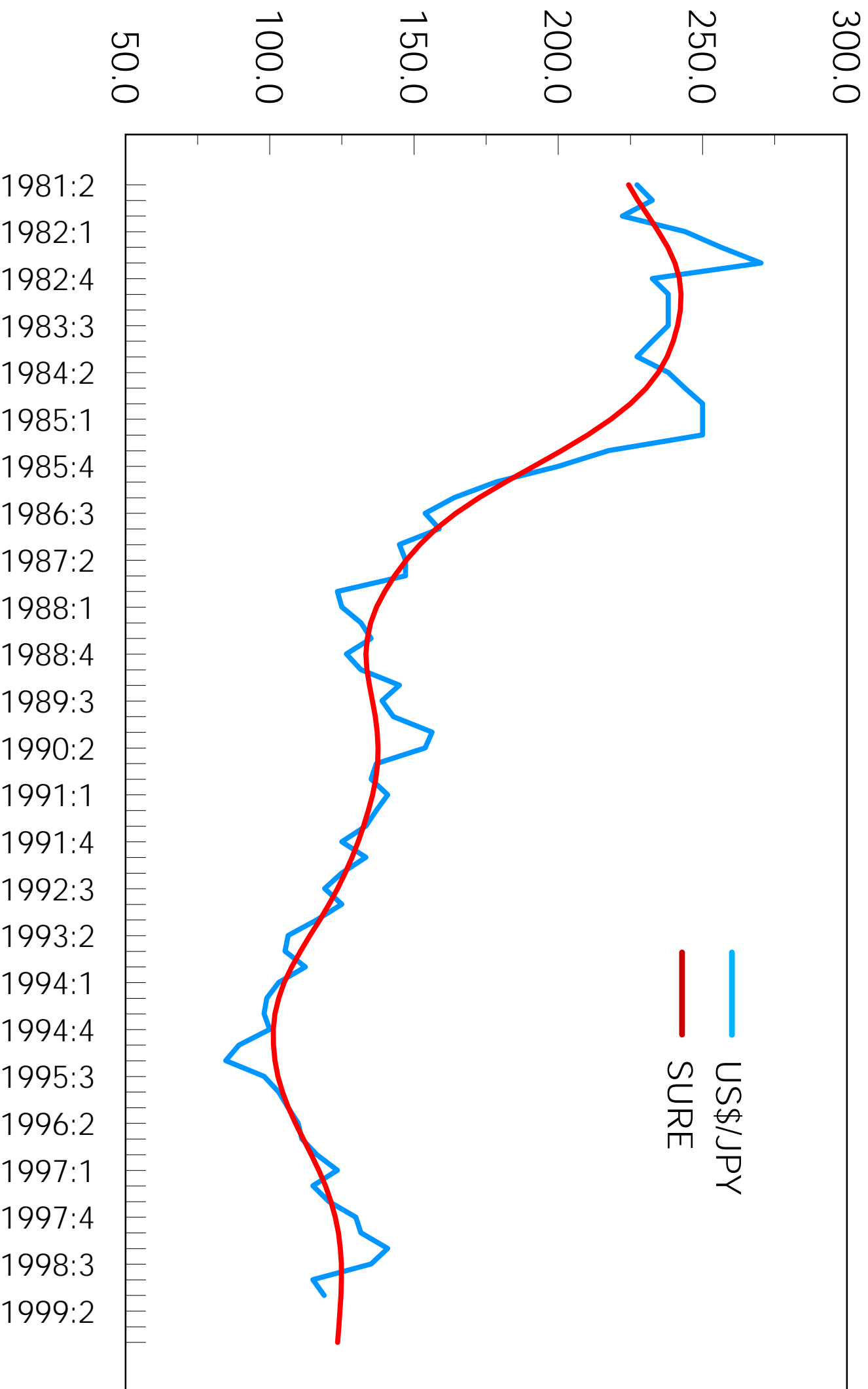


Figure 21

US\$/SwFr - Actual and Non-smoothed

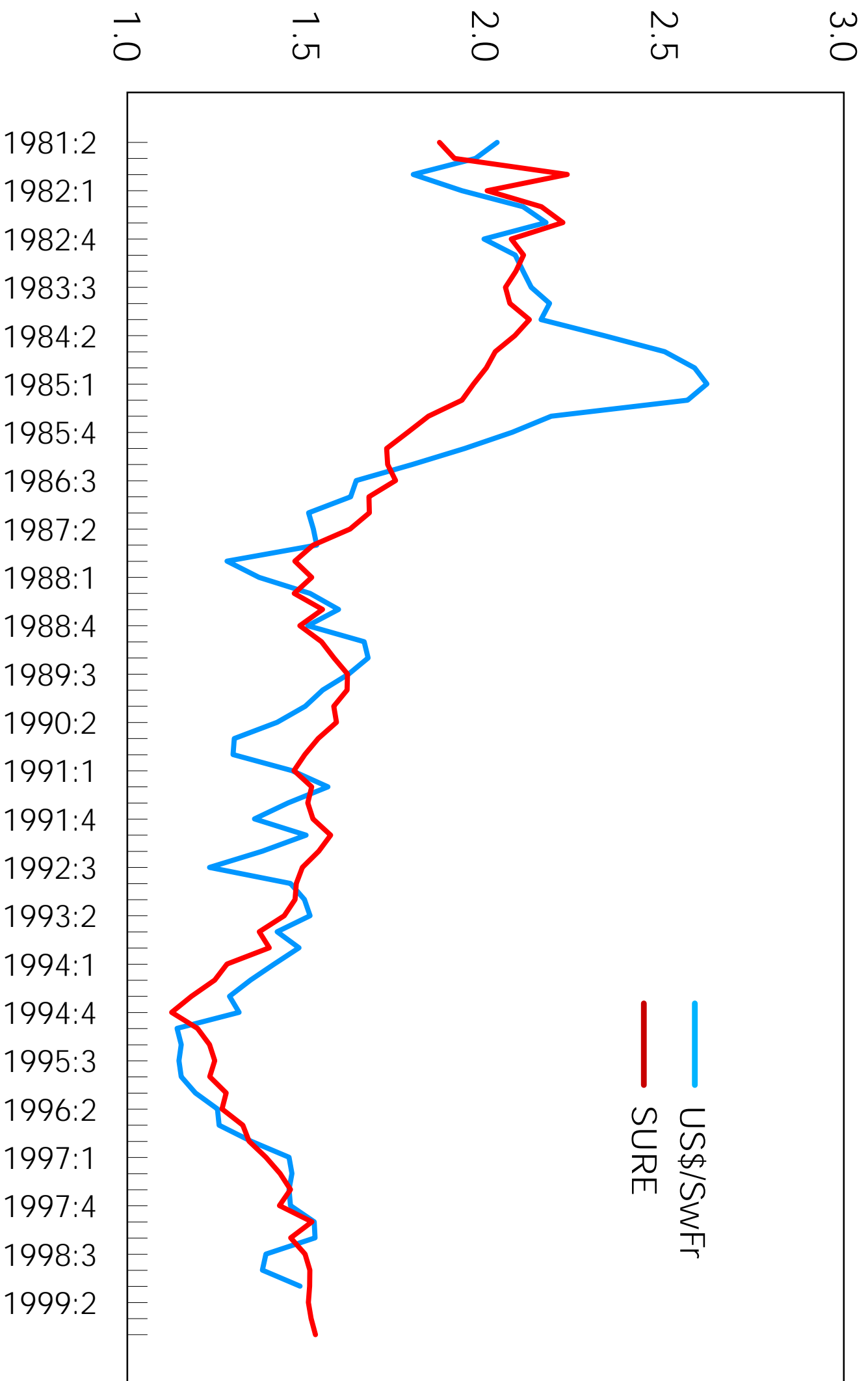


Figure 22

US\$/SwFr - Actual and Smoothed

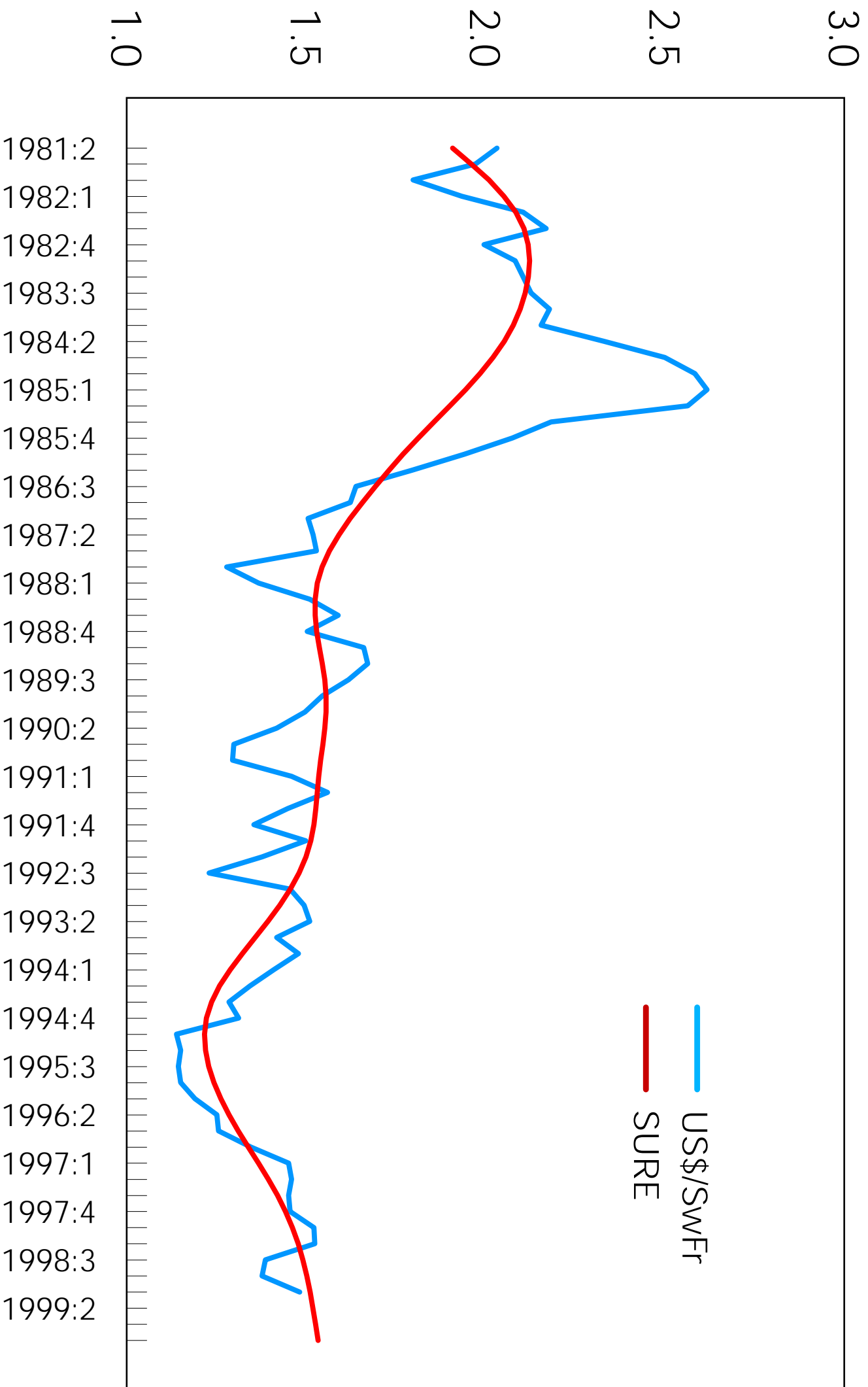


Figure 23

DM/ITL - Actual and Non-smoothed

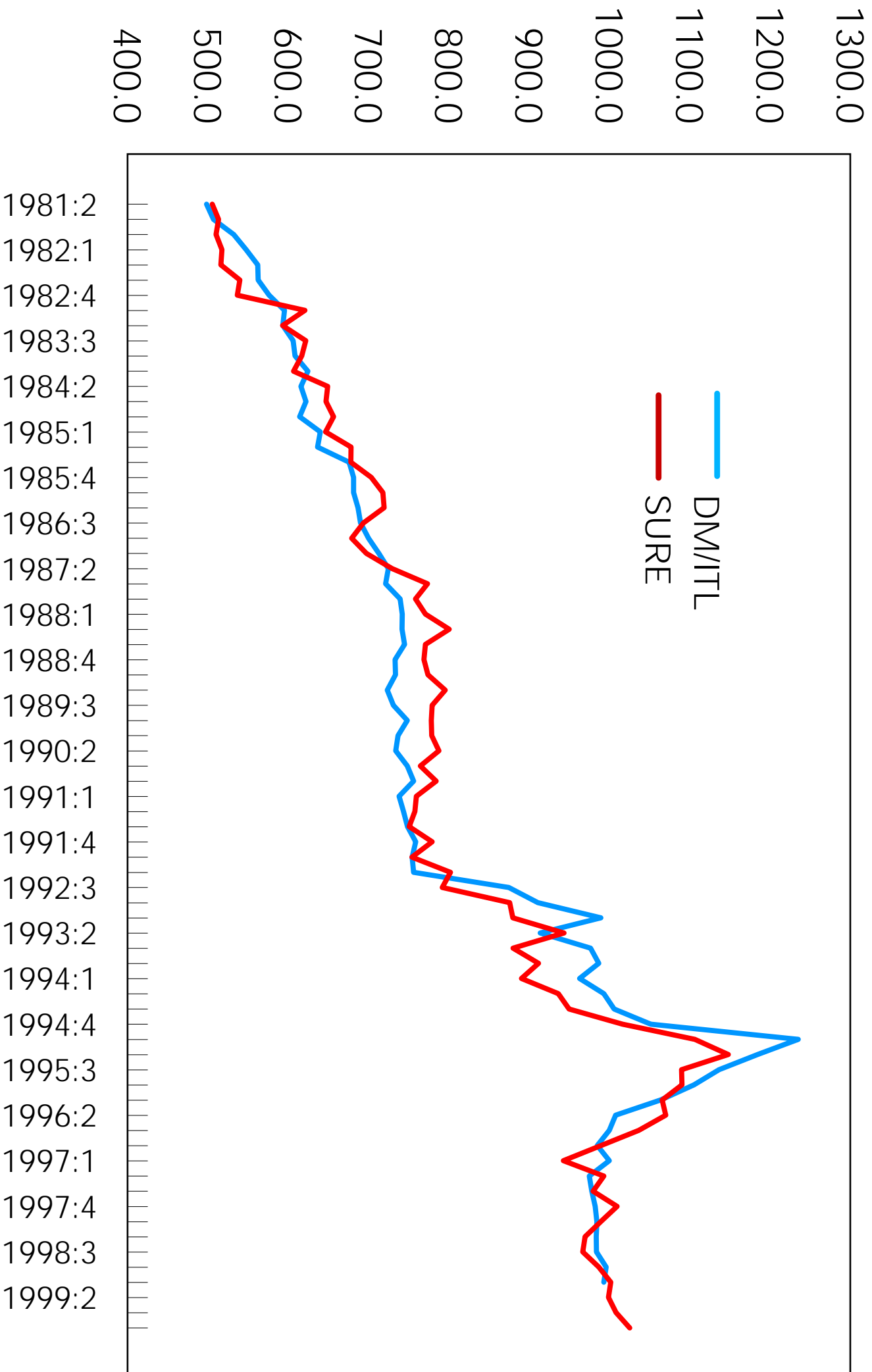


Figure 24

DM/ITL - Actual and Smoothed

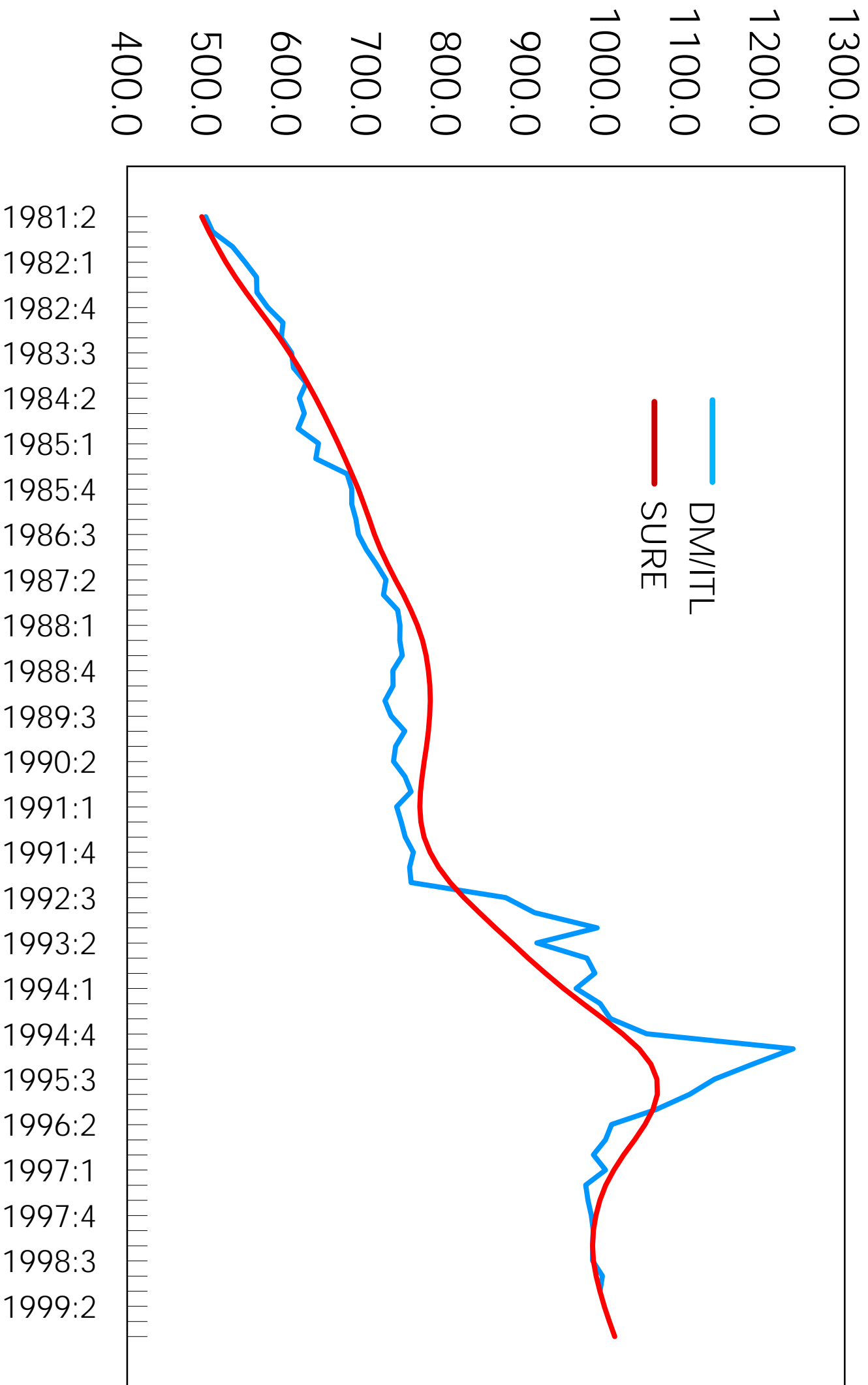


Figure 25

F/DM - Actual and Non-smoothed

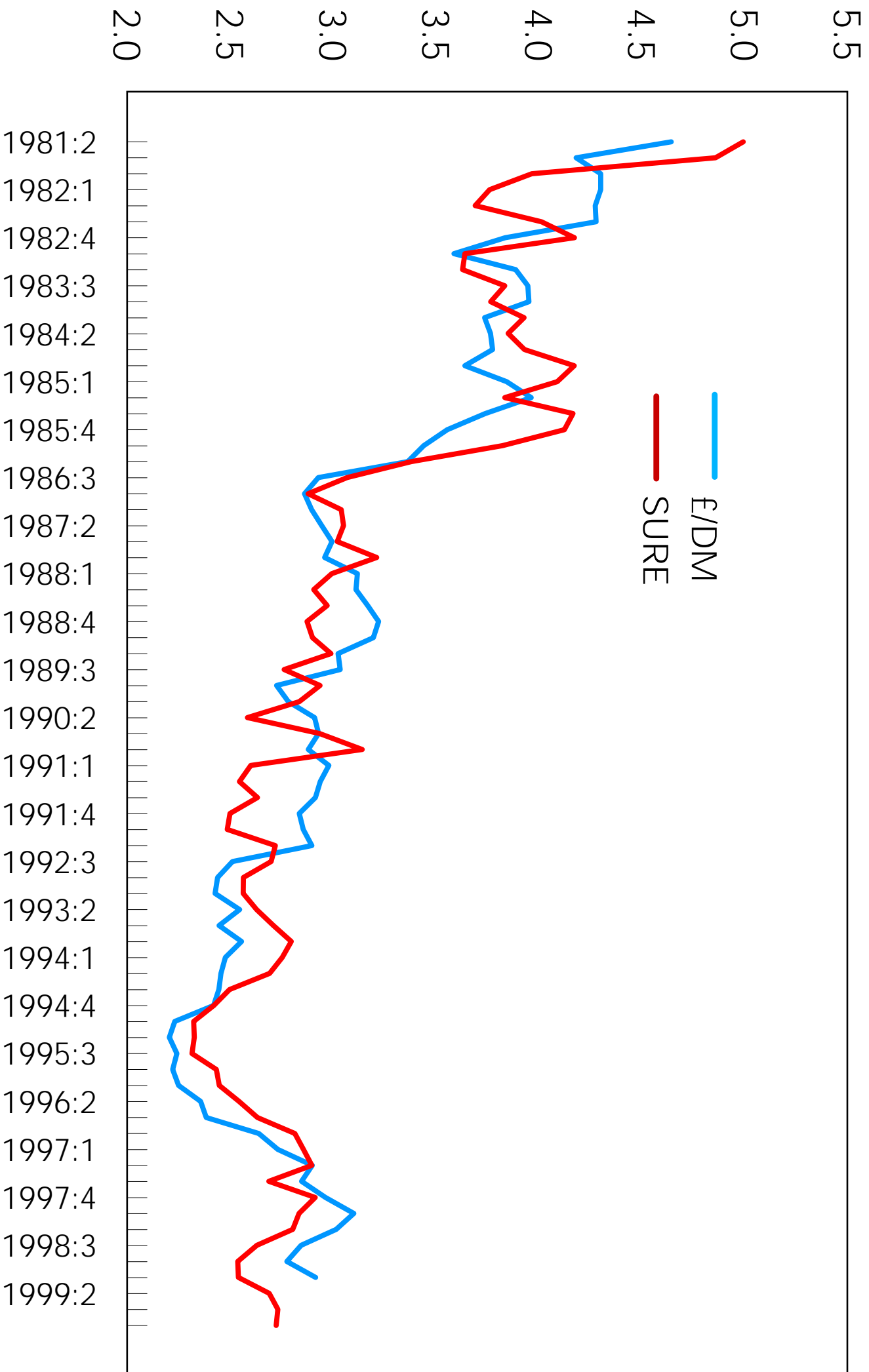


Figure 26

E/DM - Actual and Non-smoothed

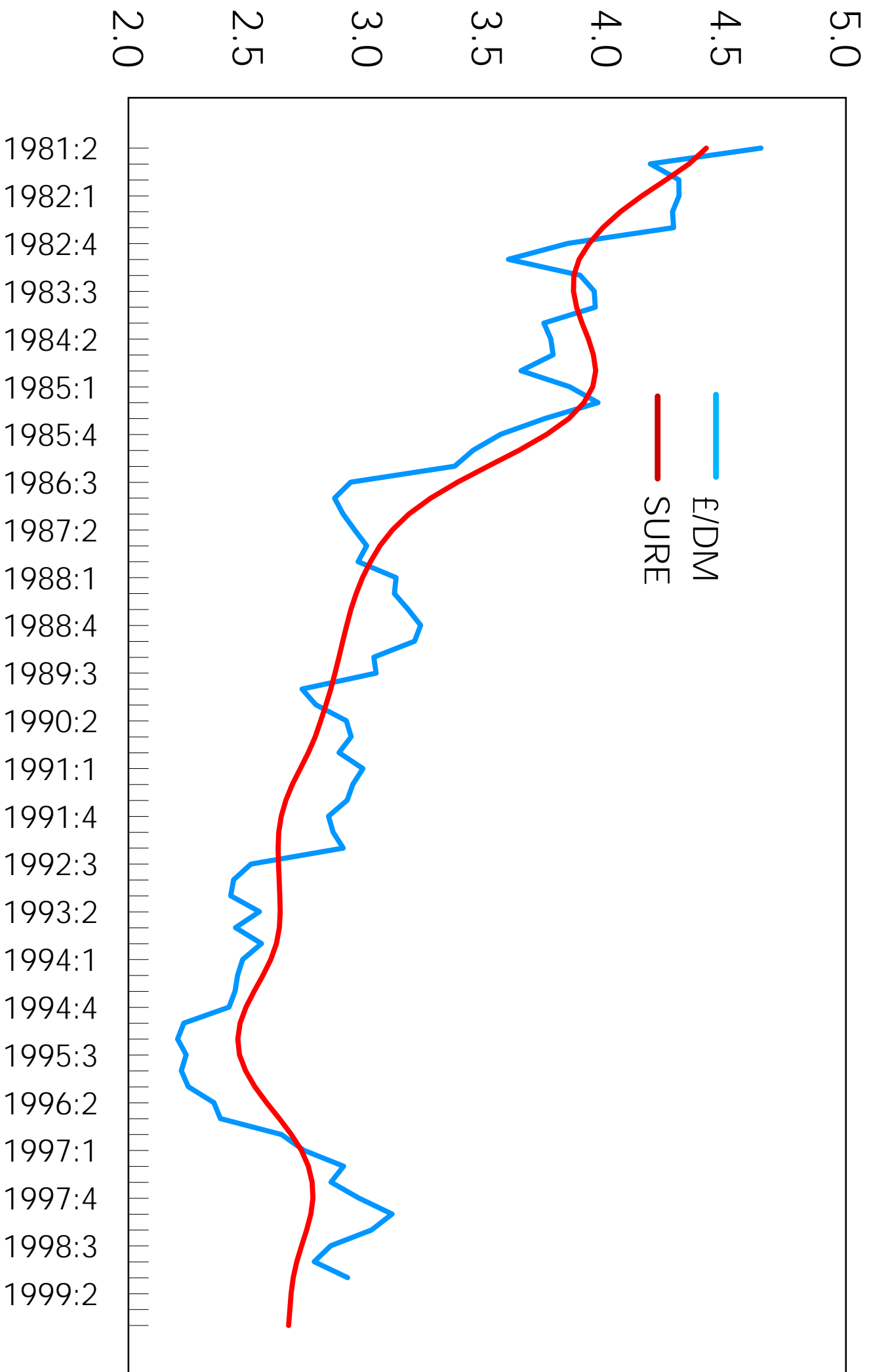


Figure 27

$F/EURO$ - Actual and Non-smoothed

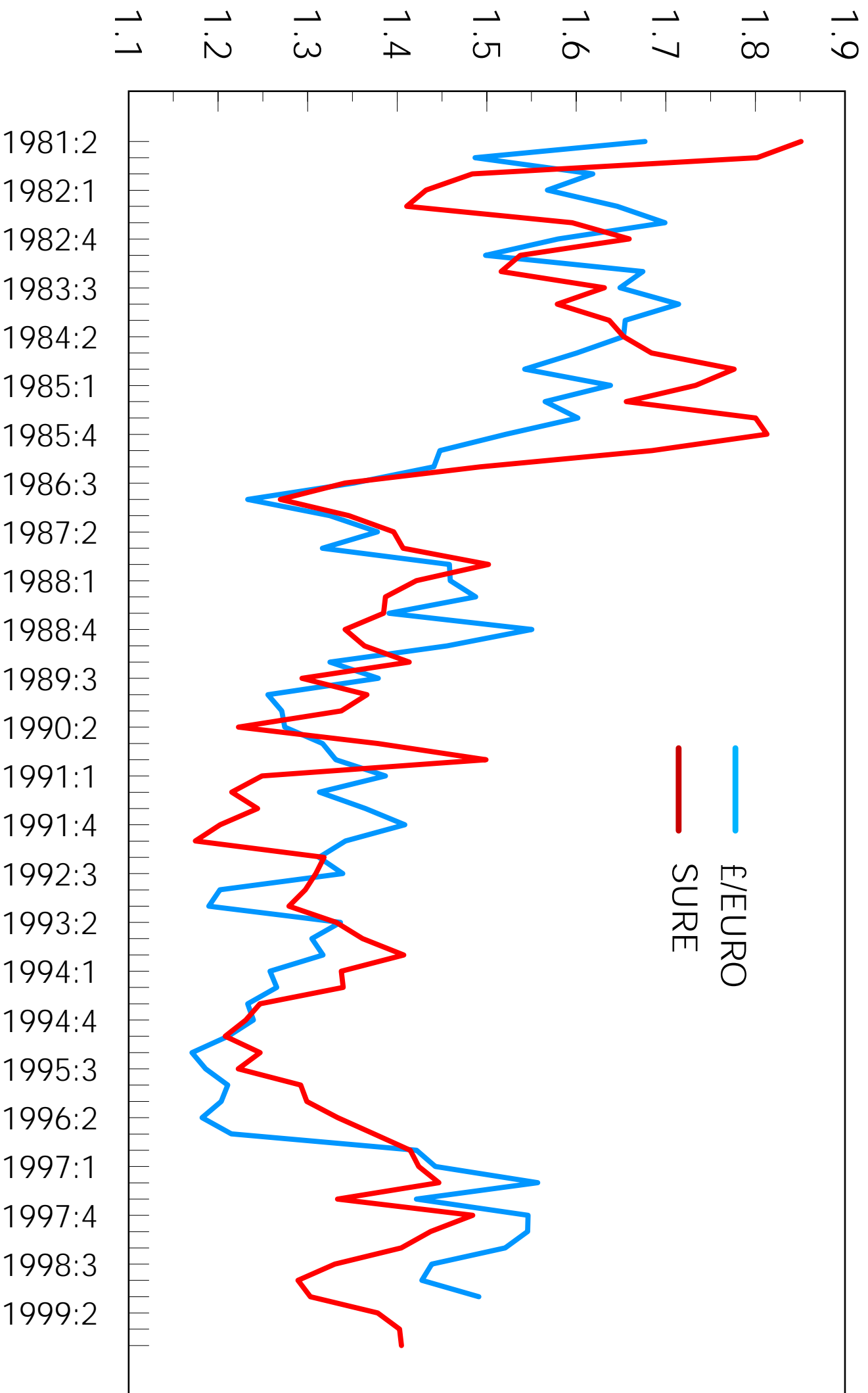


Figure 28

£/EURO - Actual and Smoothed

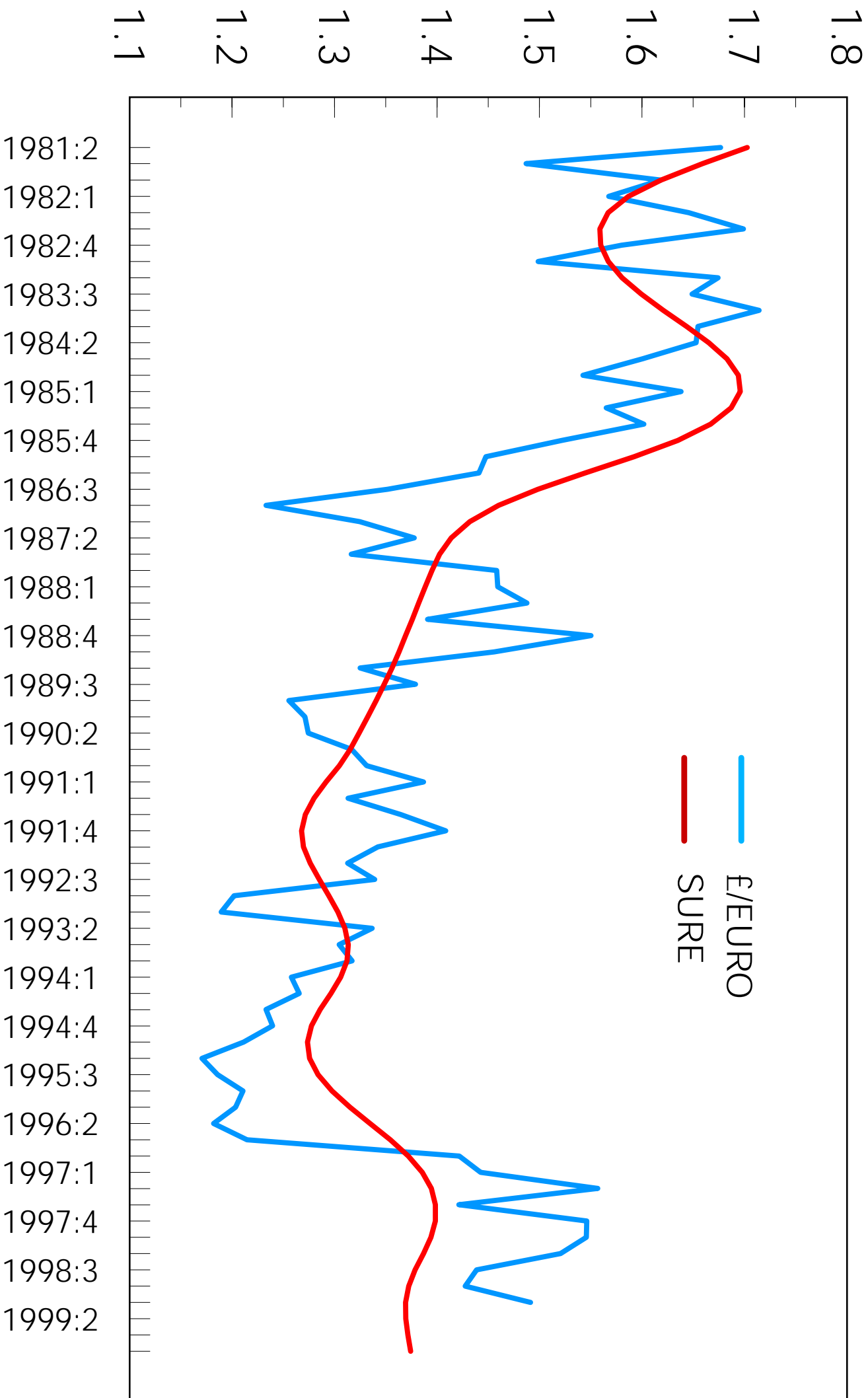


Figure 29

EURO/JPY - Actual and Non-smoothed

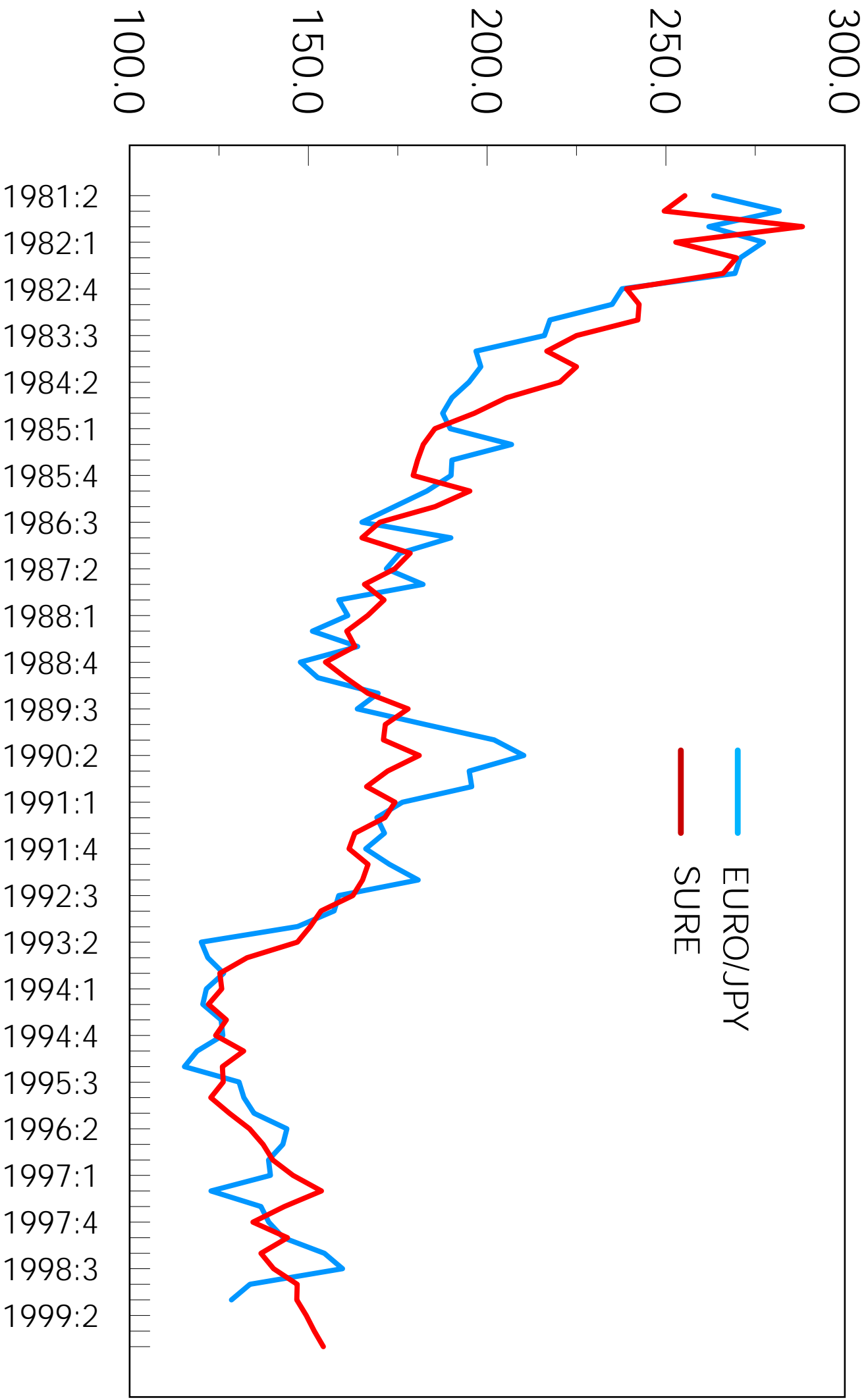


Figure 30

EURO/JPY - Actual and Smoothed

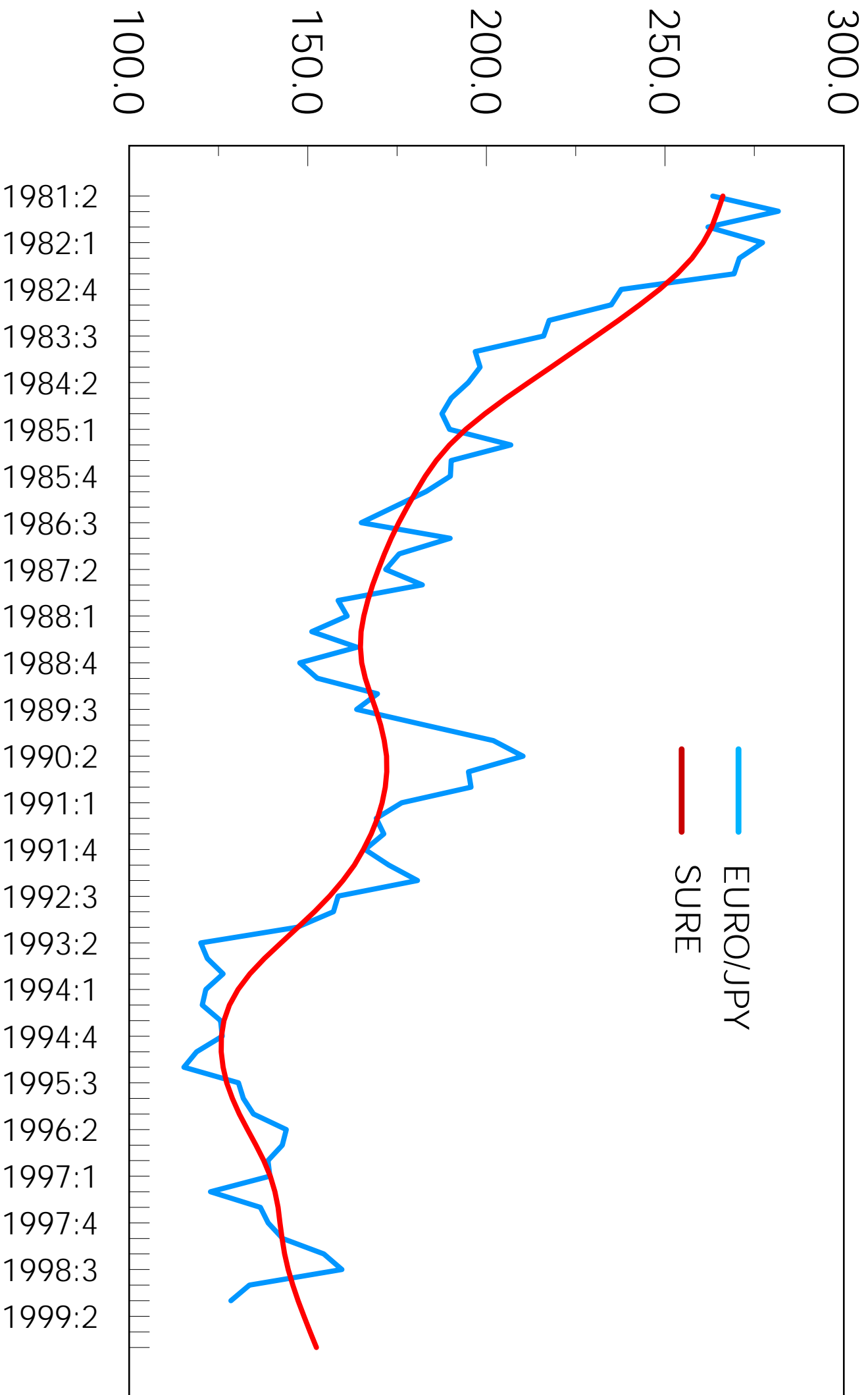


Figure 31

EURO/CAN\$ - Actual and Non-smoothed

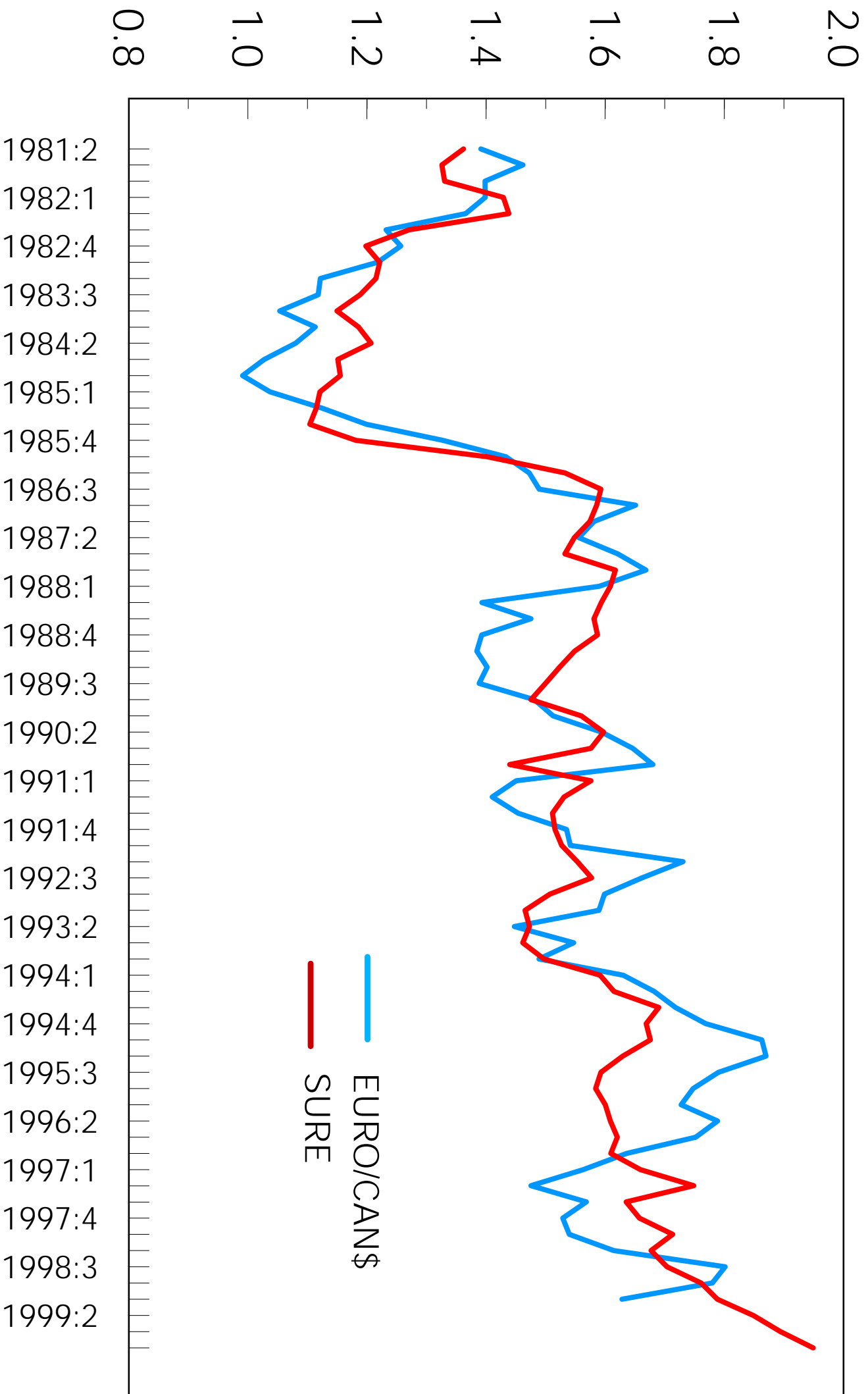


Figure 32

EURO/CAN\$ - Actual and Non-smoothed

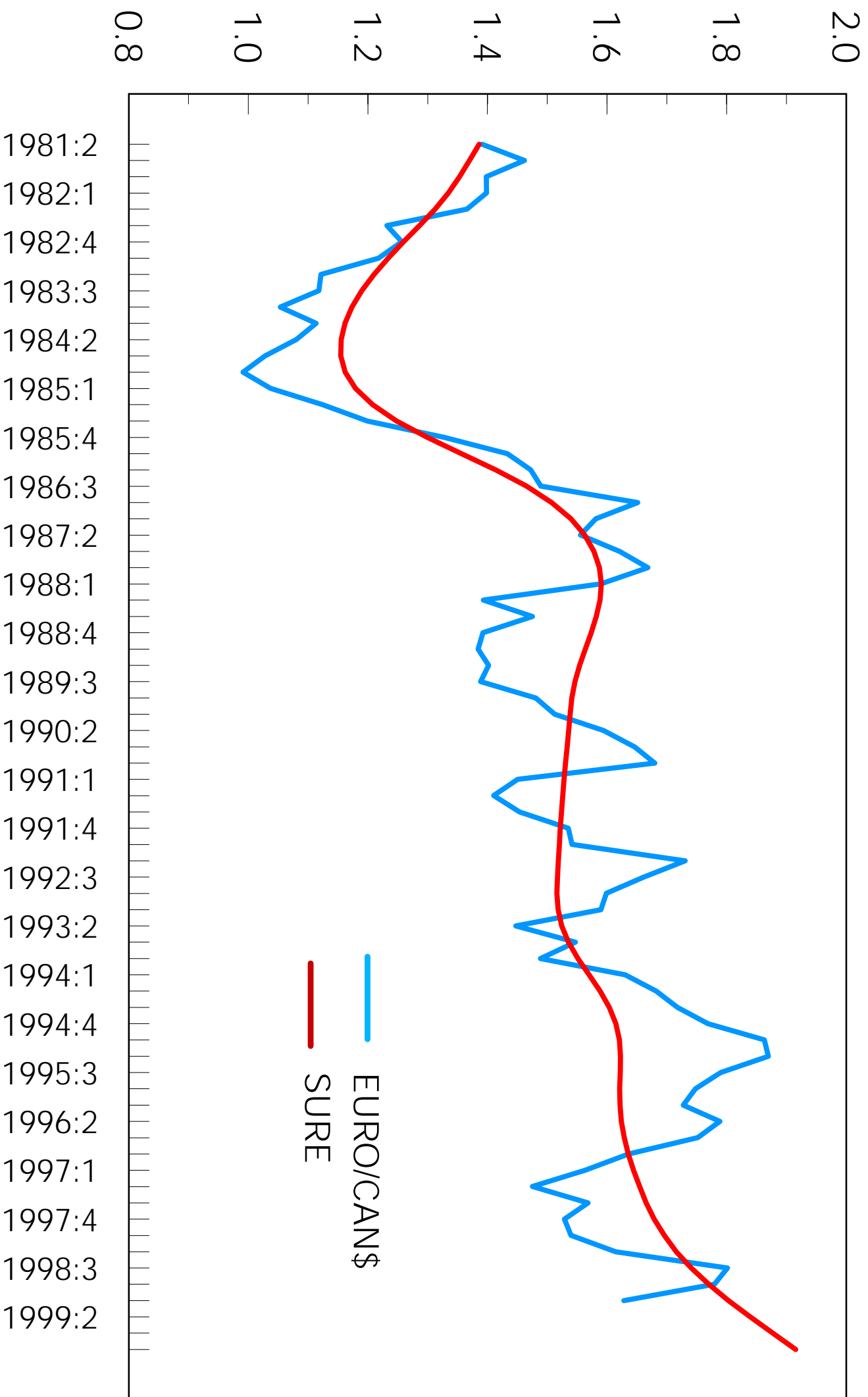


Figure 33

Real exchange rates: US\$/DEM

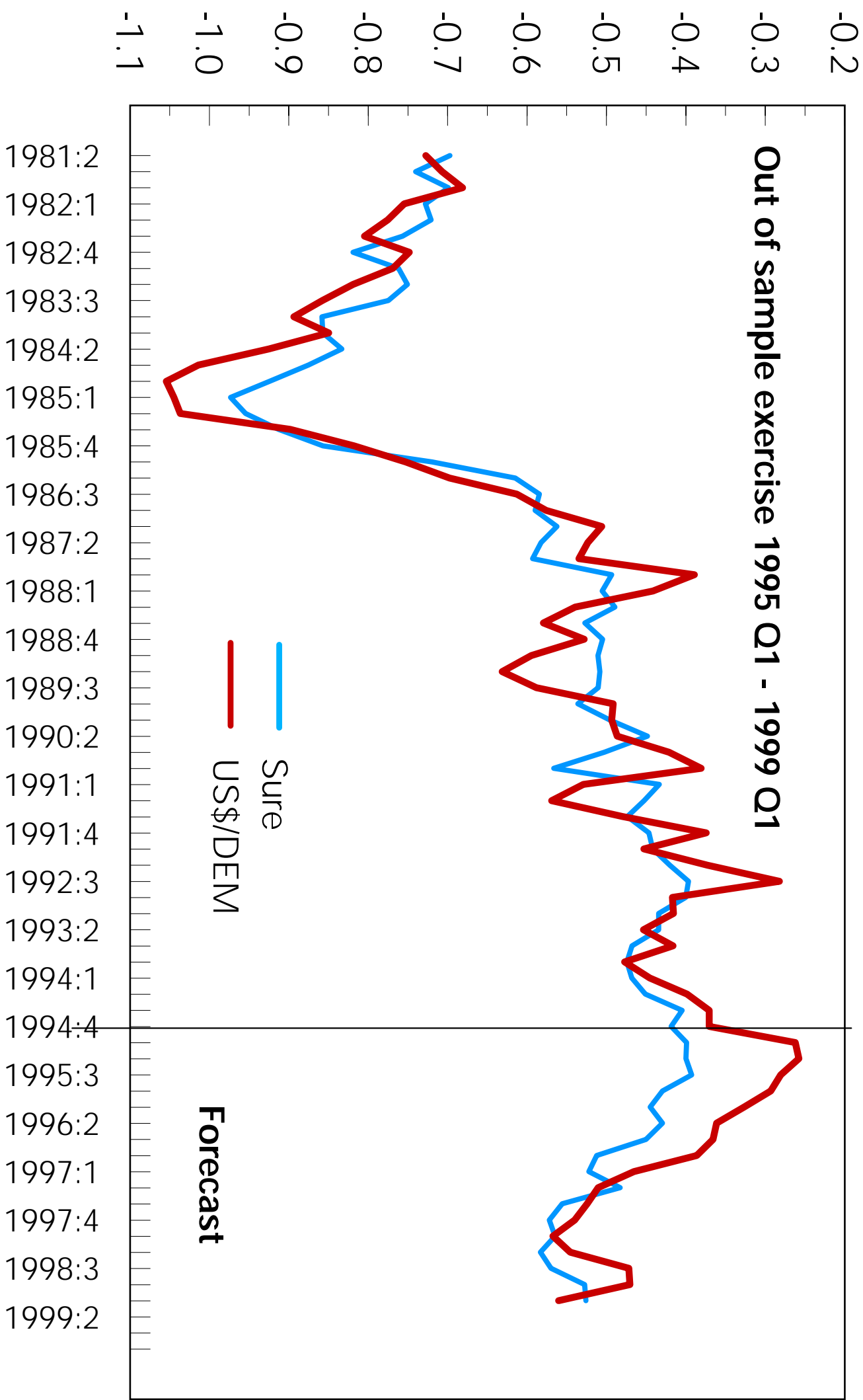


Figure 34

Real exchange rates: US\$/ITL

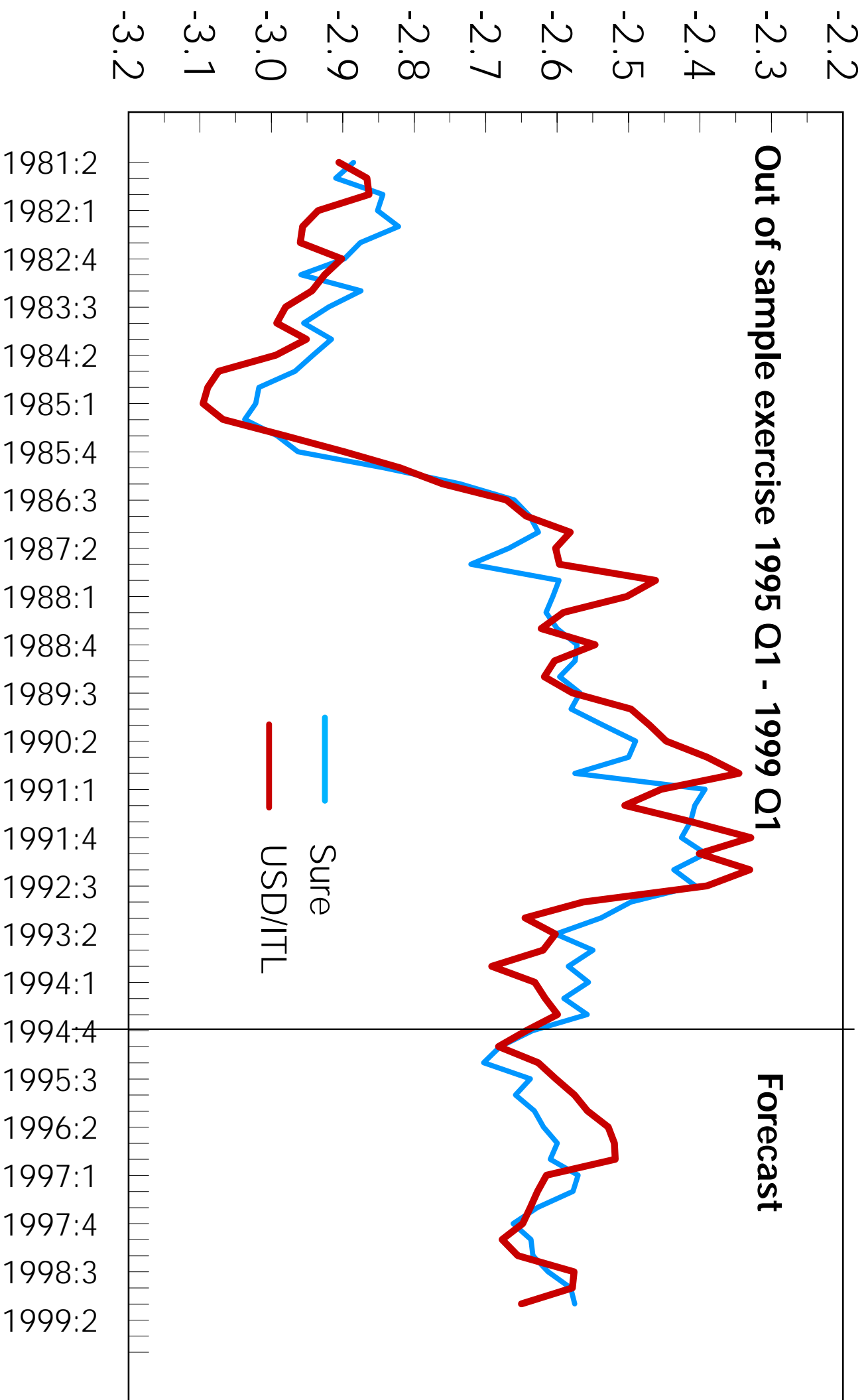


Figure 35

Real Exchange rates: US\$/FRF

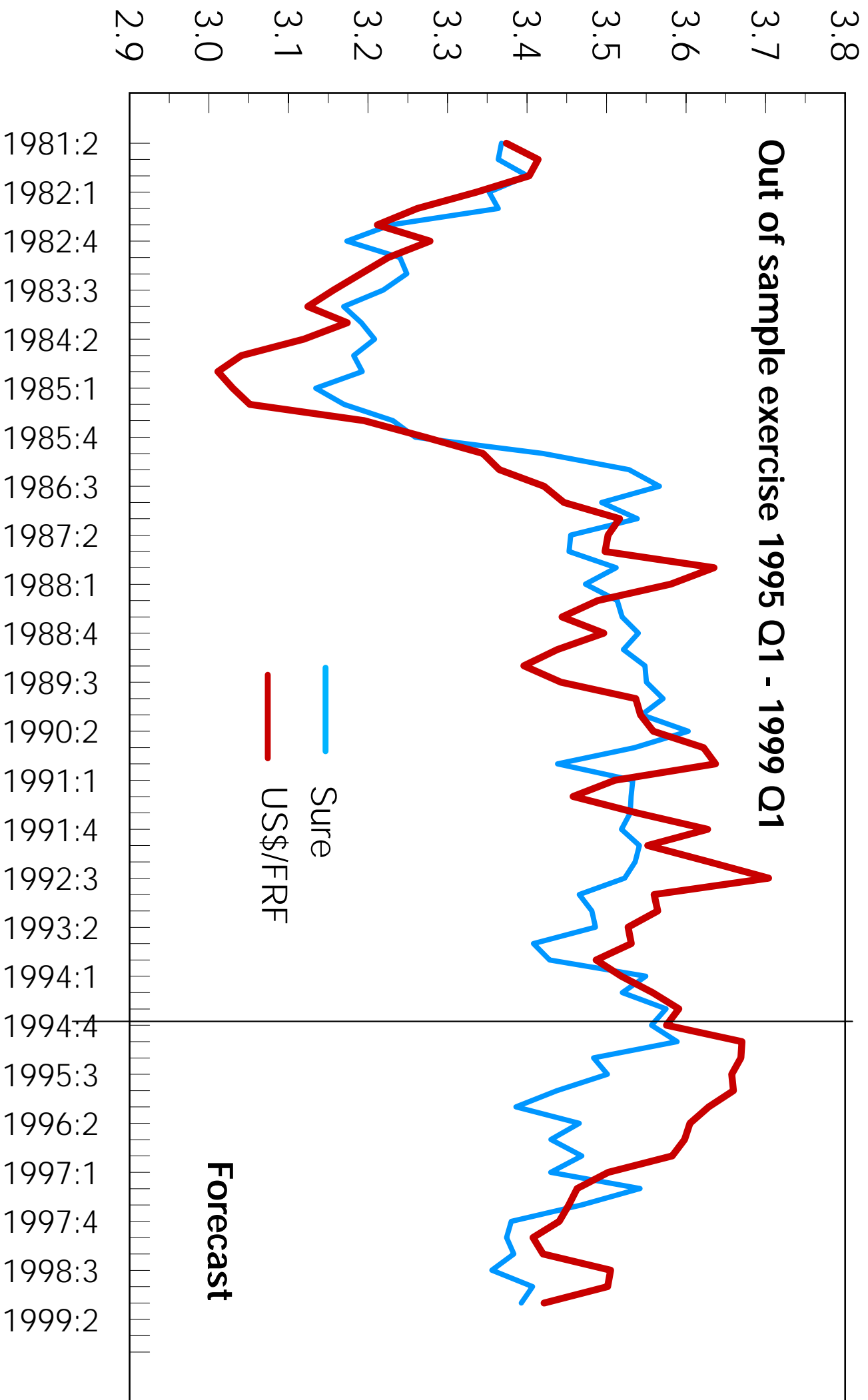


Figure 36

Real exchange rates: US\$/CAD

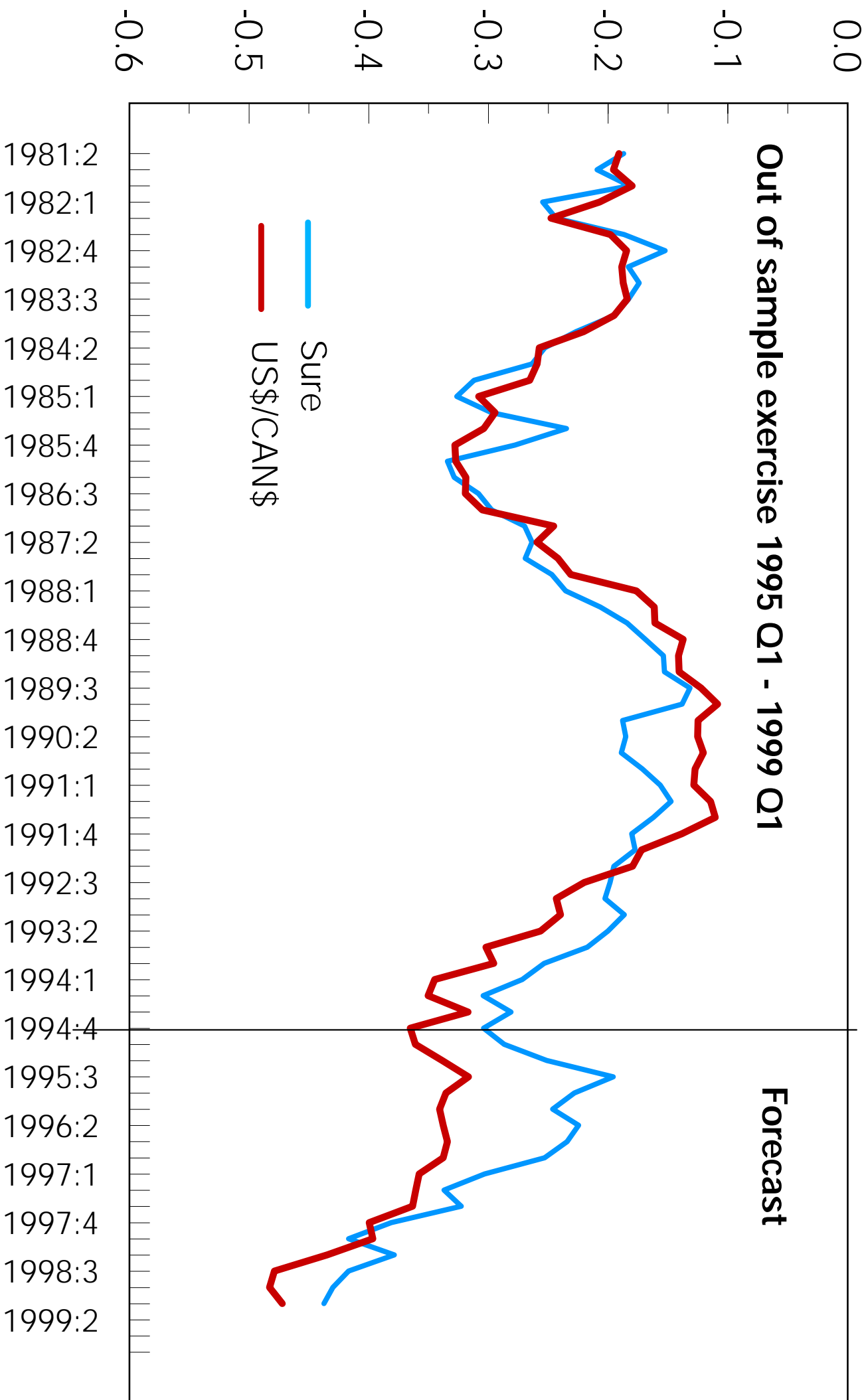


Figure 37

Real exchange rates: F/USD

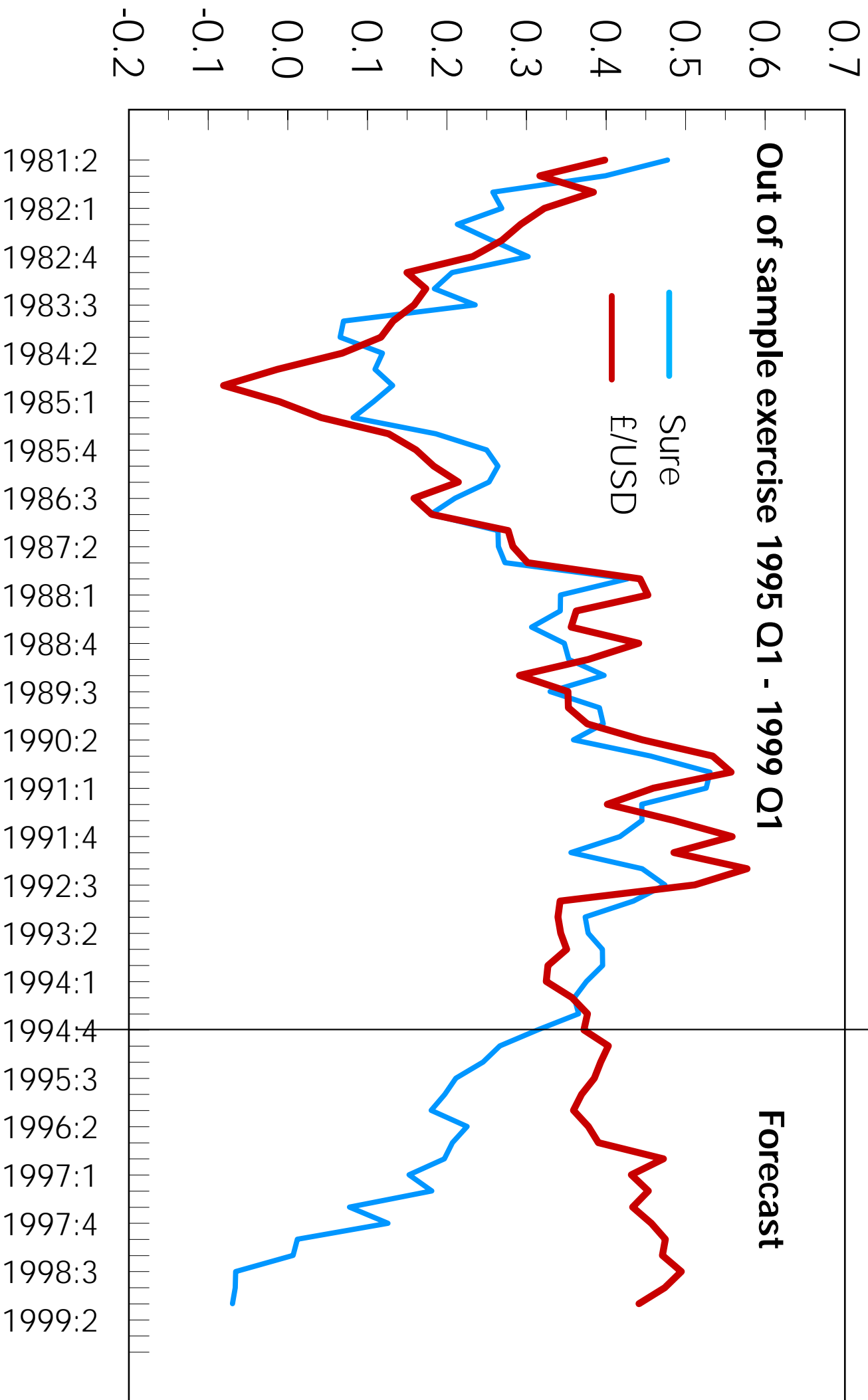


Figure 38

Real exchange rates: US\$/JPY

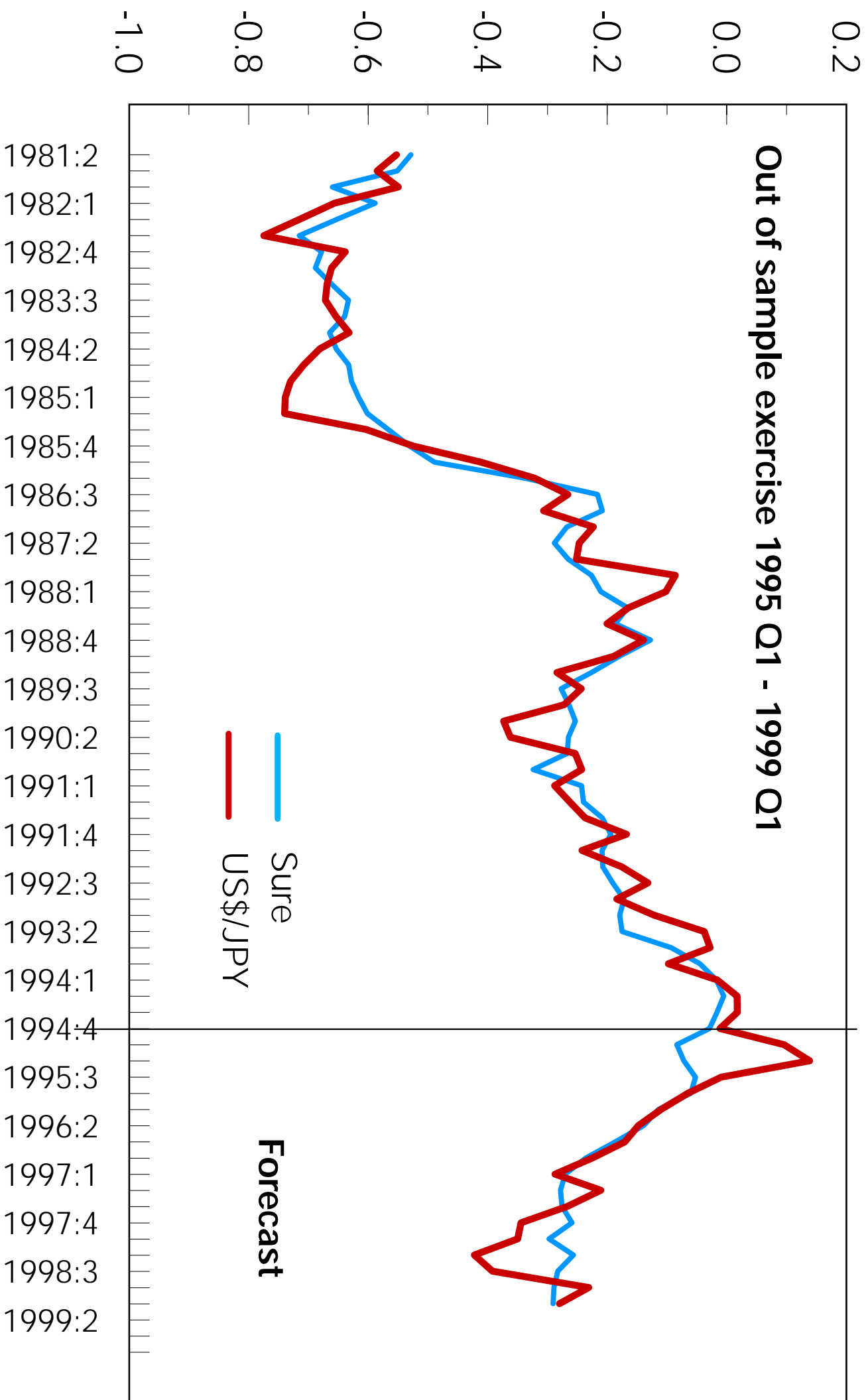


Figure 39

Real exchange rates: US\$/CHF

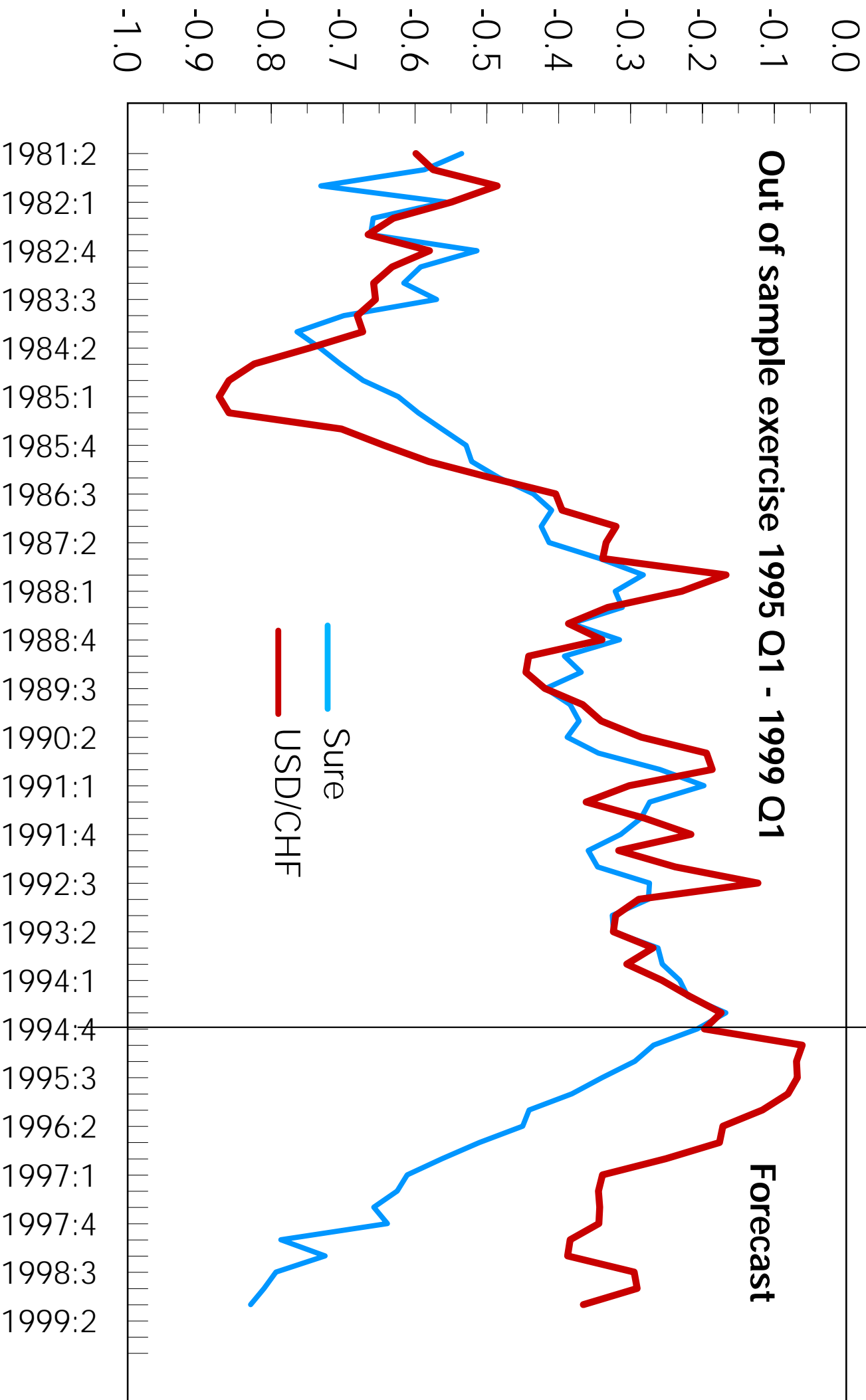


Figure 40

Real exchange rates: £/US\$

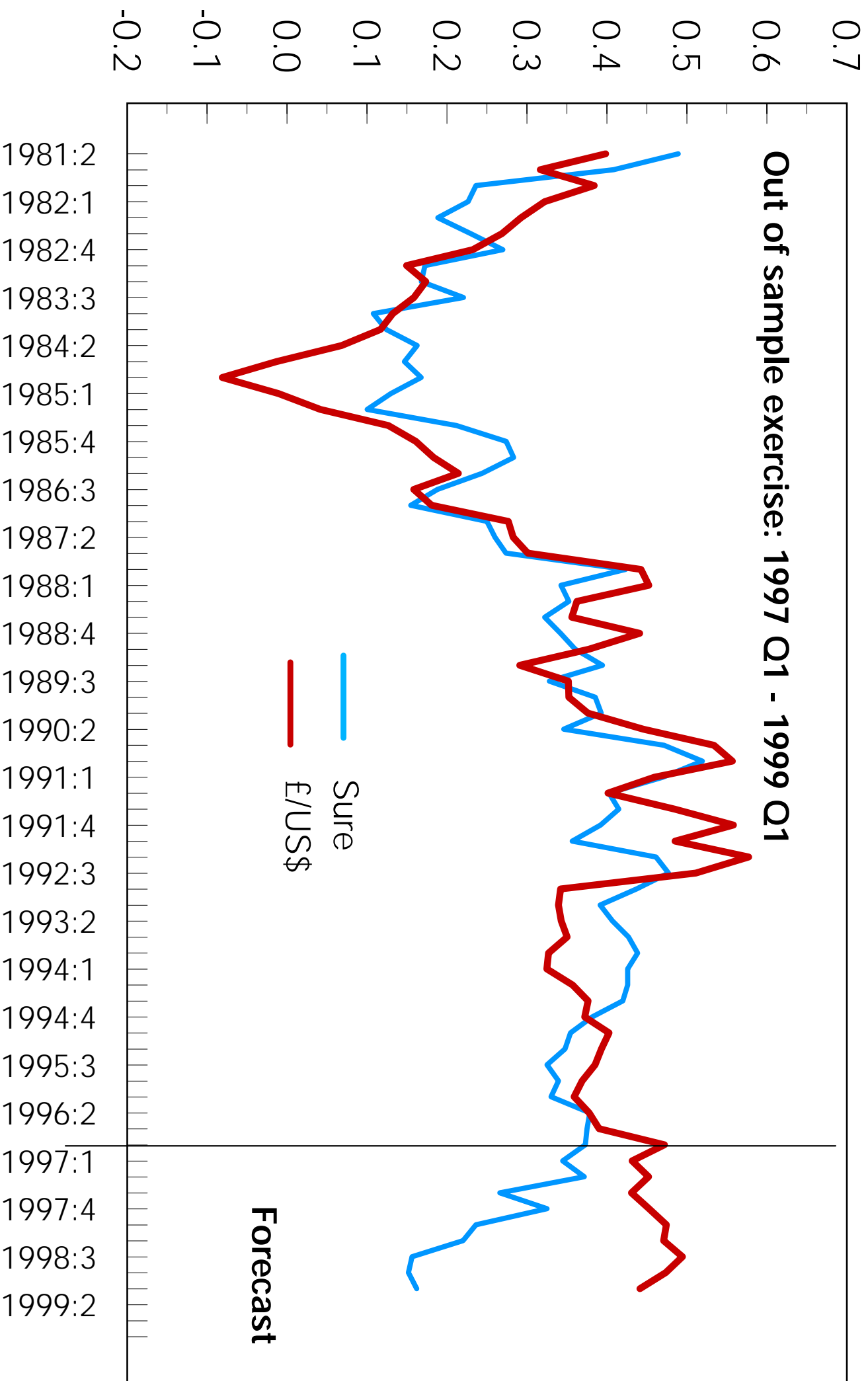
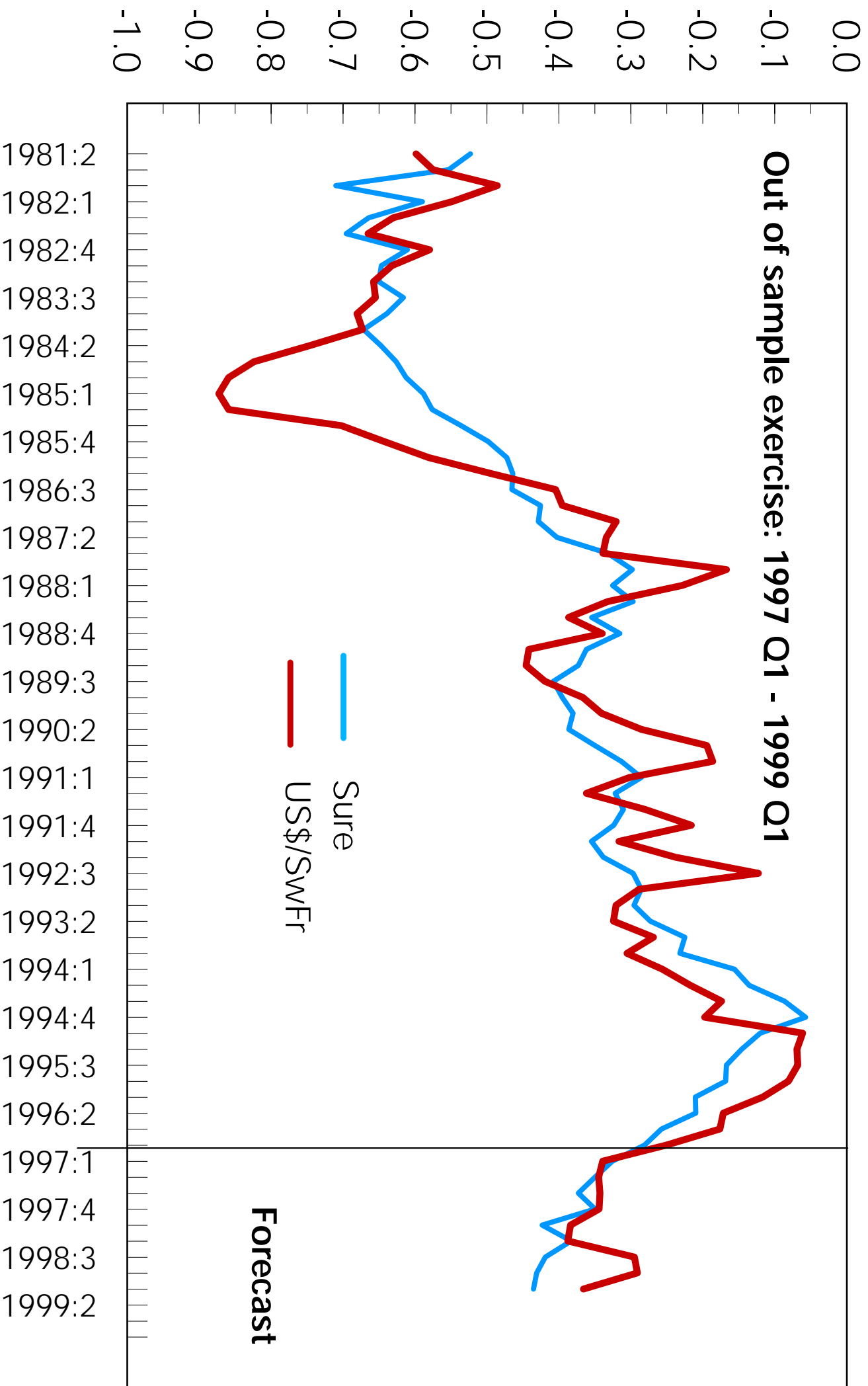


Figure 41

Real exchange rates: US\$/SwFr



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