CENTRUM VOOR ECONOMISCHE STUDIEN

DISCUSSION PAPER

MEASURING CONVERGENCE SPEED OF ASSET PRICES TOWARD A PRE-ANNOUNCED TARGET

by

Hans DEWACHTER
Dirk VEESTRAETEN

International Economics (IERP nr. 140)

Center for Economic Studies
Discussion Paper Series DPS 99.02

Katholieke Universiteit Leuven
Departement Economie
Naamsestraat 69
B-3000 Leuven

Measuring Convergence Speed of Asset Prices toward a Pre-Announced Target

Hans Dewachter* and Dirk Veestraeten

C.E.S.
Catholic University of Leuven
Naamsestraat 69
3000 Leuven
Belgium

January 18, 1999

Abstract

In this paper we examine asset price dynamics (i.e. the convergence speed) in the event of pre-announced conversion values and dates. The theoretical framework for these dynamics has been developed in De Grauwe *et al.* (1999). We examine two instances of conversion, notably the 1879-Resumption of Specie Payments in the USA and the conversion of European currencies into the Euro on January 1, 1999. In our econometric model we treat the underlying fundamentals as unobservable and estimate their evolution via a Kalman filtering technique. Estimation results reveal values for the rate or speed of convergence that are in line with intuition and amount to levels well below (implicit) estimates listed in literature.

JEL classification: F31, F33.
Keywords: Stochastic process switching, asset pricing, EMU, conversion, Kalman filter.

*Corresponding author. Address for correspondence: C.E.S., Naamsestraat 69, 3000 Leuven, Belgium. Phone: (+)32(0)16/326859, fax: (+)32(0)16/326796, e-mail: Hans.Dewachter@econ.KULeuven.ac.be. We are indebted to Stephanie Devisscher for providing us with the data.

1 Introduction

Econometric analysis of asset pricing models is hampered by the intricate problem of identification of expectations. As such, econometric analysis is most often an analysis of a joined hypothesis of assumptions concerning expectations and some model driving the fundamentals. Real-life asset conversion experiments, however, offer a neat solution to the problem of expectation identification and thus allow us to test asset pricing relations separately for the behavioral assumptions with respect to expectations formation. The goal of this paper is to take the opportunity created by two such conversion experiments to test the canonical asset-pricing approach.

The basic asset pricing model, discussed in for instance Klein and Lewis (1993), starts from the assumption that the price of an asset is to be seen as a function of (unobservable) fundamentals and its own expected change. De Grauwe *et al.* (1999) extend this simple framework to assets for which conversion with take place at a fixed terminal price and at a pre-specified point in time. Such a finite-horizon set-up has a strong appeal as the conversion value acts as a coordination device in the formation of expectations. Hence, markets have but a single focal point which, under the assumption of credibility of the conversion modalities, precludes the emergence of diverging expectations or sun spots. This particular feature has strong implications for the ability to empirically test the underlying asset price model. In contrast to the infinite-horizon model, expectations in the event of conversion can easily be identified. As such, the model will evolve around only one unknown parameter which can subsequently be estimated. This parameter is the subjective discount rate or the speed of convergence.[1]

The advantages of the theoretical and empirical approach to be undertaken are twofold. First, direct testing of one of the most widespread and accepted pricing frameworks is straightforward as argued above. Second, the paper presents an alternative estimation framework for the crucial theoretical parameter, namely the rate or speed of convergence. Previous research used two approaches to empirically identify the latter parameter. First, in exchange rate economics the basic asset pricing approach was given content via the monetary model of exchange rate determination. The sensitivity of the exchange rate to its expected change then can be interpreted as the interest rate semi-elasticity of money demand, α. Estimates of

[1] The concepts of the subjective discount factor and the speed of convergence will be defined in Section 2.

α in literature vary widely between 2% and 40% on a per annum basis.[2] However, plugging these values into the basic exchange rate equation would return unrealistically large values for the subjective discount rate or the speed of convergence. This should come as no surprise in view of the (general) poor performance of the monetary model in the short run. The second approach, in which our estimation technique will be embedded, treats the underlying fundamentals as unobservable state variables. Gardeazabal *et al.* (1997) estimate a bivariate asset pricing model via the method of simulated moments. For five floating exchange rates vis-à-vis the US-dollar, they obtain subjective discount rates that are between 7.5% and 42% per annum.[3] Burda and Gerlach (1993) apply a state-space model to the dynamics of the Ostmark-DEM exchange rate prior to conversion within the German Monetary Unification of 1990. They estimate the rate of convergence at 1.235% on a daily basis or 445% on a yearly basis. This surprising figure, however, is likely to be the consequence of the specific nature of the institutional framework that implied multiple conversion rates and hence led to difficulties in identifying and econometrically implementing clean-cut conversion modalities.

Our empirical strategy is akin to the approach used in Burda and Gerlach (1993). However, we will consider experiments in which simple and clear conversion modalities allow for a straightforward econometric treatment. As such, an easy and unambiguous test of the conversion asset pricing model is rendered possible. The paper applies the theoretical model to the 1879-Resumption of Specie Payments in the USA in which paper greenbacks issued during the Civil War became fully convertible at par into gold coin on January 1, 1879. The second experiment deals with conversion of European currencies into Euro on January 1, 1999. It should be noted that these historical experiments are characterized by simple conversion modalities in the sense that a unique terminal value and a fixed conversion date were announced.

The empirical estimates reveal levels for the speed of convergence that are mostly (well) below 2% or close to values one could expect in a framework with imminent conversion at a pre-specified terminal price. We also show that such levels imply that the role of fundamentals in explaining asset prices will be extremely limited during the year preceding conversion.

The remainder of the paper is organized as follows. In section 2 we briefly outline the

[2] See, for instance, Meese (1986), West (1987) and Flood *et al.* (1991).

[3] It is to be noted that in their infinite-horizon framework, expectations cannot be singled out as we will be able to do within our theoretical and empirical framework.

applicable asset pricing model. In section 3 we link the theoretical pricing equation to the Kalman filtering state-space model. Section 4 first gives some details on the two conversion experiments and sample periods. Subsequently, we present and interpret estimation results. Finally, section 5 summarizes the main findings and gives some policy considerations.

2 A simple model of asset price dynamics under conversion

The way asset price dynamics will respond to the announcement of conversion will be examined within the well-known asset price equation:

$$p(t) = f(t) + \lambda \frac{E_t[dp(t)]}{dt}. \tag{1}$$

The log of the asset price at time t is denoted by $p(t)$ and $f(t)$ represents the (log) fundamental. The expectations operator at time t is given by E_t. If the asset is an exchange rate, the fundamental can be interpreted as an indicator of the relative supply to demand conditions of the home currency (see for instance Klein and Lewis (1993)). Within the monetary model of exchange rate determination the fundamental is specified using money demand equations, PPP and UIP. In the case where $p(t)$ is the price of a stock, $f(t)$ can be interpreted as the log of the dividend at time t. The parameter λ measures the sensitivity of the asset price to its own expected future change. By construction, $\frac{1}{\lambda}$ can be interpreted as the subjective discount factor (see for instance Svensson (1991) and Bertola (1993)).

Ruling out speculative bubbles, the unique saddle-path solution in the infinite-horizon case is given by (see Froot and Obstfeld (1991a,b)):

$$p(t) = \frac{1}{\lambda} \int_t^\infty E_t[f(s)] \exp\left\{-\frac{s-t}{\lambda}\right\} ds. \tag{2}$$

Equation (2) holds for all types of sequences of fundamentals and as such will also be useful in order to study the implications of conversion. Suppose that at time t_A an agent (credibly) announces that at some future, fixed date, T, he or she will convert a certain asset at a certain price, c. Assuming that conversion can also be done at any $t \geqslant T$ at the fixed conversion price c implies that $E_t[dp(i)] = 0$ for $i \geqslant T$. Substituting the latter condition in equation (2) then implies that $p(i) = c$ for $i \geqslant T$ such that $p(i) = c = f(i)$ for $i \geqslant T$. Substituting these equalities in equation (2) results in the saddle-path for the asset price prior to the regime switch:[4]

$$p(t) = \exp\left\{-\frac{T-t}{\lambda}\right\} c + \frac{1}{\lambda}\int_t^T E_t\left[f(s)\right] \exp\left\{-\frac{s-t}{\lambda}\right\} ds \quad \text{for } t_A \leqslant t \leqslant T. \tag{3}$$

The solution in equation (3) consists of two parts. The first one represents the discounted value of the asset's conversion value, while the second term gives the discounted value of expected fundamentals between t and T. The solution has the following intuition. Markets realize that at the conversion date the fundamental value of the asset is simply its conversion value. This value will subsequently be discounted to the present point of time. Current values of fundamentals between t and T then constitute an additional source of value.

One can simplify equation (3) by assuming that the fundamental follows driftless Brownian motion. This yields:

$$p(t) = \exp\left\{-\frac{T-t}{\lambda}\right\} c + \left(1 - \exp\left\{-\frac{T-t}{\lambda}\right\}\right) f(t). \tag{4}$$

The asset price is thus a convex combination of the conversion value and the current level of the fundamental. Note that weights will shift toward the conversion value as one gets closer to the conversion date T. At time T all weight will be placed on the conversion value as required by the rational expectations assumption. The crucial factor in the determination of the level and the displacement of the weights is the subjective discount rate $\frac{1}{\lambda}$. The smaller $\frac{1}{\lambda}$, *ceteris paribus*, the larger the weight of the conversion rate will be.

Equation (4) will be the starting point for our empirical analysis. So, we assume the fundamental to follow driftless Brownian motion which seems reasonable in view of the sample periods chosen (see below).

Finally, equation (4) allows us to give content to the notion of the speed or rate of convergence. We define the rate of convergence as the absolute value of the expected change of the log distance between the asset price and the conversion rate. This give us an idea of the (absolute value of the) instantaneous expected rate of change required in order to equate the asset price and the conversion rate at time T. Let us define $y(t) = p(t) - c$. Its expected change then can be calculated via equation (4), noting that $f(t)$ is assumed to follow driftless

[4] In section 1 of the appendix in De Grauwe *et al.* (1999) it is shown that this solution also follows if one alternatively assumes that the market for the asset ceases to exist at time T.

Brownian motion:[5]

$$E_t\left[dy\left(t\right)\right] = -\frac{1}{\lambda}\exp\left\{-\frac{T-t}{\lambda}\right\}\left[f\left(t\right)-c\right]. \tag{5}$$

The required expected change in $y(t)$ decreases toward convergence until it reaches zero or until the asset price and the conversion rate coincide.[6] Prior to conversion, $E_t\left[dy\left(t\right)\right]$ will depend on the relative position of the actual fundamental vis-à-vis the conversion rate. The intuition behind this is simple. If at some point of time the fundamental equals c, markets will expect no further movement in the asset price. If on the other hand the fundamental exceeds (falls below) the conversion rate, the rate of convergence has to be negative (positive) in expectation. The rate at which $y(t)$ is to alter then is given by, after taking the absolute value:

$$RC = \frac{1}{\lambda}\exp\left\{-\frac{T-t}{\lambda}\right\}$$

where RC denotes the rate of convergence.

In the remainder of the paper, we will approximate RC by RC^*:

$$RC^* = \frac{1}{\lambda}.$$

Thus in the latter definition, the rate of convergence coincides with the subjective discount rate. In order to obtain this equation we had to remove the time-dependency of RC. This seems a reasonable assumption on behalf of two reasons. First, the sample periods considered here are relatively short. Second, estimation, as we will see below, yielded small values for the subjective discount factor $\frac{1}{\lambda}$. When combining these two observations, the mismeasurement involved in equating RC and RC^* will be fairly limited. Figure 1 illustrates this point. We show the percentage overestimation of RC through the use of RC^* for the last year preceding conversion when using subjective discount rates that are representative for our estimates of $\frac{1}{\lambda}$. The lines in figure 1 depict overestimation for discount rates of 8%, 6%, 4%, 2% and 1% respectively. The highest degree of overestimation is, of course, detected for the largest discount rate. Most of the discount rates detected below, however, amount at most to 2% in which case overestimation of RC by RC^* is smaller than 2.5%. From a practical point of view, we therefore feel confident that equating the subjective discount rate and the rate

[5] Or, $E_t\left[df\left(t\right)\right] = 0$.

[6] Note from section 2 that $p(i) = c = f(i)$ for $i \geqslant T$.

of convergence entails no substantial errors. Also from an intuitive point of view one would expect a close relation between these two concepts.

Insert figure 1

3 The estimation procedure

We opt for a state-space model in which the state of the nature, i.e. the fundamental, is seen as the unobservable driving force. This choice allows us to circumvent the theoretical and empirical difficulties encountered in explicitly defining the fundamental of the asset price.

The time series of the fundamentals and the asset price equation are estimated via a Kalman filtering estimation approach. We thereby adopt a discrete-time framework in which we assume the state variable to follow a driftless random walk, i.e. the discrete-time equivalent of a driftless Brownian motion:

$$p(t) = \exp\left\{-\frac{T-t}{\lambda}\right\} c + \left(1 - \exp\left\{-\frac{T-t}{\lambda}\right\}\right) f(t) + \varepsilon_t \quad (6)$$

$$f(t) = f(t-1) + \eta_t \quad (7)$$

Equation (6) is the observation equation in which the fundamental, i.e. the state of nature, is linked to the asset price according to our theoretical model. It is to be noted that the coefficients of the two inputs, the fixed value c and the fundamentals, vary over time in function of the remaining time to conversion and the rate of convergence, $\frac{1}{\lambda}$. Equation (6) is subject to the observation error, ε_t, that is assumed to be normally distributed with mean zero and decreasing variance $(T-t)\,\sigma_\varepsilon^2$, i.e. $\varepsilon_t \sim N\left(0, (T-t)\,\sigma_\varepsilon^2\right)$. Intuitively, one can interpret the observation error as noise in the markets' ability to correctly respond to the pricing inputs. Linking the variance factor to the remaining time until conversion reflects the learning process in which markets obtain a better view on the pricing process when the conversion date comes nearer. However, the decrease also logically has to follow from the specification of both the observation and the system equations as we will indicate below.

Equation (7) is called the system equation that governs the course of the state variable. We chose for a discrete-time random walk without drift as inclusion of a drift factor, both from a theoretical and an empirical point of view, seemed unwarranted. The system equation is also subject to an error, η_t, which is assumed to be normally distributed with constant variance, i.e. $\eta_t \sim N\left(0, \sigma_\eta^2\right)$. The latter assumption implies that we do not esteem it likely that variability in the fundamental process is to decrease in function of the remaining time until conversion. This assumption together with the decrease in the weight of the fundamental when $(T-t)$ grows smaller obviously implies that variability of the asset price will be decreasing for smaller $(T-t)$.[7] This argument also justifies the time-depending specification chosen for the variance of the observation equation error.

The estimation procedure used in our empirical set-up embodies a recursive strategy in which the fundamental is filtered in function of the three parameters that are to be estimated, *in casu* $\frac{1}{\lambda}$, σ_ε^2 and σ_η^2. Before we present the set of equations that describes the internal dynamics of the Kalman filter, we indicate the notation used. The factor $d(t)$ denotes $\exp\left\{-\frac{T-t}{\lambda}\right\}$. Note that $d\left(t\right)$ depends on one of the parameters to be estimated, notably on the subjective discount factor $\frac{1}{\lambda}$. The recursive endogenous parameters will be addressed through the use of a double time index in which the last index denotes the time point in which projection is made for the point of time represented by the first time index. Projected variables are characterized by the superscript $\widehat{c}$. As such, $\widehat{f}\left(t+1,t\right)$ denotes the projection for the fundamental in period $t+1$ based on information available at time t. The Kalman filter in our model then can be written as:[8]

$$\widehat{f}\left(t+1,t\right) = \widehat{f}\left(t,t\right)$$

$$P\left(t+1,t\right) = P\left(t,t\right) + \sigma_\eta^2$$

$$B\left(t+1,t\right) = \left(1-d\left(t\right)\right)^2 P\left(t,t\right) + \sigma_\varepsilon^2\left(T-t\right)$$

$$\widehat{\varepsilon}\left(t+1,t\right) = p\left(t+1\right) - d\left(t\right)c - \left(1-d\left(t\right)\right)\widehat{f}\left(t+1,t\right)$$

$$K\left(t+1\right) = P\left(t+1,t\right)\left(1-d\left(t\right)\right)B\left(t+1,t\right)^{-1}$$

$$\widehat{f}\left(t+1,t+1\right) = \widehat{f}\left(t+1,t\right) + K\left(t+1\right)\widehat{\varepsilon}\left(t+1,t\right)$$

$$P\left(t+1,t+1\right) = \left(1-K\left(t+1\right)\left(1-d\left(t\right)\right)\right)P\left(t+1,t\right)$$

[7] Indeed, under the assumption of credibility of the conversion value the only remaining source of variability originates from the evolution of the fundamental (see De Grauwe *et al.* (1999) for a more detailed treatment of this issue).

[8] The description follows Burmeister and Wall (1982). A concise derivation of the Kalman filter and its intuition is given in Meinhold and Singpurwalla (1983).

The variance-covariance matrix of the innovation in the observation equation is then given by $B(t+1,t)$, or

$$B(t+1,t) = E\left\{\widehat{\varepsilon}(t+1,t)^2\right\}.$$

Estimation of the parameters σ_ε^2, σ_η^2 and $\frac{1}{\lambda}$ is performed in an iterative manner. Hereto, we formulated a first guess for these three parameters and for the initial value of the fundamental and subsequently ran the above filter. The resulting innovations in the observation equation together with their variance-covariance matrix were plugged into the following loss function:

$$J\left(\theta^i\right) = -\frac{1}{2}\sum_{t=t_0}^{T-1}\left[\frac{\widehat{\varepsilon}(t+1,t)^2}{B(t+1,t)} - \ln\left(B(t+1,t)\right)\right],$$

where θ^i denotes the vector of parameter estimates for iteration i and t_0 represents the starting point of the sample period. The function $J\left(\theta^i\right)$ then can be maximized via maximum likelihood.[9] The improved parameter estimates in the vector θ^i re-enter the filter and subsequently the likelihood function until the required level of convergence is achieved.

In this paper we initially included also the initial value of the fundamental in the vector of parameters to be estimated. We subsequently re-ran the iterative procedure using the estimate for $f(t_0)$ as its (fixed) initial value as the Hessian in the first run mostly failed to invert. We thus finally estimated the vector $\left[\frac{1}{\lambda} \quad \sigma_\varepsilon^2 \quad \sigma_\eta^2\right]'$.

4 Data and estimation results

Before presenting estimation results, we provide more details on the conversion experiments, the sample periods chosen and give a qualitative discussion of the evolution of these asset prices (section 4.1). Section 4.2 then gives the estimation results together with additional information on the pricing weights and the role of fundamentals.

4.1 Data and sample periods

The 1879-Resumption of Specie Payments in the USA is our first conversion experiment. On January 14, 1875 Congress decided that paper greenbacks issued during the Civil War were to become fully convertible at par into gold coin on January 1, 1879. Estimation will focus on the period January 1, 1878 - December 31, 1878. We thus restrict attention to

[9] See Burmeister and Wall (1982), p. 271, for the necessary conditions.

the year preceding conversion. We have two reasons for doing so. First, our theoretical model assumes credibility of the announcement which, from the accounts of Mitchell (1908), was not immediately established after the decision was communicated. As the last year was characterized by the material preparations of conversion, credibility could no longer be doubted. Second, disregarding the issue of (partially) lacking credibility of the announcement we also estimated the model for various earlier starting dates. Estimates, however, hardly differ from those that will be reported below.

The data series is taken from Mitchell (1908) who reports daily prices of greenbacks expressed in percent of par. Figure 2 shows the evolution of the greenback price for our sample period.[10] The conversion value is represented by the horizontal line at 100. The figure embodies the main predictions from our theoretical model. First, already a year prior to conversion the asset price found itself relatively close to the ultimate asset price as a result of the strong weight of the latter in pricing.[11] Second, the model predicts that the weight of the conversion value will be exponentially linked to the subjective discount factor and the remaining time to conversion. Thus, the price would converge in an exponential manner toward the conversion rate. This clearly is the dominating feature of figure 2.

Insert figure 2

The second conversion experiment is the creation of the Euro on January 1, 1999. At that date, the individual currencies of the initial EMU-members were fixed in terms of the Euro. However, the embedded bilateral conversion rates, i.e. of the Belgian franc in terms of the German mark for instance, were announced earlier, namely on May 1, 1998. At this date authorities decided that prevailing bilateral ERM-parities would also be the bilateral conversion rates. These values are given in table 1. We examine bilateral exchange rates vis-à-vis the German mark and thus present results for nine currencies. Our sample period runs from January 1, 1998 until September 2, 1998. This period thus starts prior to the actual announcement of bilateral conversion rates. Hence, we assume that this information was already known at the beginning of the sample period. This presumption is justified by the observation as to

[10] Mitchell (1908) reports both the daily highest and the daily lowest prices. We chose to use daily highest values, a choice that in no way affected neither the visual impression nor the estimation results.

[11] Some numerical examples illustrate this. Plugging in subjective discount rates of 10%, 5% and 2% in the first term of equation (4) returns weights for the conversion rate of 90%, 95% and 98%, respectively already one year prior to conversion.

which various accounts suggested that at that time there was a broad agreement on both the number of participating countries and the conversion rates to be used.[12] The sample ends on September 2, 1998, i.e. four months prior to conversion. We chose this date as at that point of time one could still observe differences in convergence to the announced conversion rates (see below).

Insert table 1

Insert figure 3

The daily exchange rate data were taken from Datastream and are depicted in figure 3. In this figure we depict the local currency price of the German mark in percent of the bilateral conversion rates. The conversion rate, again, is represented by the horizontal line at 100. In order to facilitate comparison across currencies all panels have the same scale with the exception of the Irish punt and the Italian lira. For the latter two currencies a somewhat wider scale had to be chosen. For the remaining seven currencies one can observe that already one year prior to conversion exchange rates were extremely close to the ultimate conversion rates. In the case of the Dutch guilder, the Belgian franc and, especially, the Austrian schilling exchange rates were hardly distinguishable from the conversion rates. For the Portuguese, Spanish and Finnish currencies a limited amount of convergence was necessary and also observable in figure 3. Finally, for the Irish punt and the Italian lira the need for convergence was somewhat larger and not completely achieved in September 1998. The reason can be found in the remaining (substantial) interest rate differential with Germany.

4.2 Estimation results

The first three columns of table 2 present the estimates for the log of the three parameters. The standard errors are given within brackets and were computed based on the inverse of the Hessian. The fourth column shows the implied annualized value for the subjective discount rate $\frac{1}{\lambda}$ as estimation was pursued using daily data. We subsequently indicate the implied weight of the conversion value c at the beginning of the respective sample periods (column a) and at 120 days prior to conversion (column b).

[12] For the Irish punt situation was somewhat complicated by the fact that the parity of the punt was revalued on March 16, 1998. We pursue estimation with the revalued parity. This choice reflects the agreement in markets that the old parity was unlikely to be chosen as the conversion rate. The realignment, more or less, merely brought the parity in line with the actual level of the punt.

In all cases, the variance estimate for the observation equation is only a fraction of its counterpart of the system equation. This indicates that the fundamental experienced substantial, albeit still limited in extent, variability when compared to the asset price. This comes as no surprise as the theoretical model already predicted that only a small fraction of variability in the fundamental would spill over to the asset price. As a result prediction errors in the observation equation and their variance should be limited in extent and (much) smaller that those in the system equation.

Insert table 2

From figures 2 and 3 we recall that prices were always in a very narrow range with respect to the ultimate conversion price. The sole exceptions, albeit that differences were fairly limited, were the Irish punt and the Italian lira on the one hand and the greenback price on the other hand. In the case of the two currencies, the Kalman filter estimation approach explains the difference with respect to the conversion value via both larger variance of system equation errors, σ_η^2, and larger subjective discount rates, $\frac{1}{\lambda}$. The intuition is simple: throughout most of the estimation period markets saw a (strong) need for depreciation due to the fact that interest rates in Ireland and Italy still (substantially) exceeded their German counterparts which could be interpreted as the benchmark for EMU interest rates. Markets therefore required substantially larger discount rates in holding these two assets. As a result, the larger speeds of convergence implied also larger degrees of variability in the system equation. For the greenback, on the contrary, convergence was ultimately completely achieved as we estimated until the conversion date. Hence, the Kalman filter explained the 3 percentage point rise in the price over that year solely via a larger estimate for the rate or speed of convergence.

Annualized subjective discount factors are within a range of 0.2% up to 8%, but mostly around or below 1%. These values seem reasonable in view of the remaining time until conversion and are well in line with intuition. The limited extent of remaining convergence could indeed not have warranted large rates of convergence. Calculation of the weight of the conversion rate in pricing illustrates this point. Columns (a) and (b) reveal that at all times the weight of c was above 93% and mostly over 99%.[13] Thus, in view of the fact that

[13] Recall that Burda and Gerlach (1993) obtained a discount factor of over 400% which implied that on January 24, 1990 still 83% of the price of the Ostmark was attributed to future fundamentals (see Burda and Gerlach (1993), p. 427). This finding seems the more peculiar in view of the cited accounts on the imminence

asset prices were close to the ultimate conversion price a low rate of convergence was to be expected, and also detected, which in itself would imply that the weight of the conversion rate were close to unity, and vice versa.

We continue by visualizing the role of the fundamentals in pricing. As we have filtered the sequence of the underlying fundamentals and estimated the rate of convergence, we can directly calculate the part of the asset price explained by fundamentals. This contribution is given by the second term on the RHS of equation (4). In figures 4 and 5 we depict this quantity in percent of the actual asset price.

Insert figures 4 and 5

Figure 4 deals with the 1879-Resumption in which the number of days remaining until conversion is represented on the horizontal axis. We see that (unobservable) fundamentals already one year prior to conversion have only a limited role to play with a maximum value of only 6%. As predicted the importance of fundamentals quickly declines and reaches zero at the conversion date. The virtual irrelevance of fundamentals in pricing when conversion is to come is even more strikingly apparent in figure 5 which focuses on the nine EMU-currencies. The role of fundamentals until four months prior to conversion is generally limited to 1%, again with the exception of the Irish punt and the Italian lira for reasons indicated earlier. As expected the contribution of fundamentals decreases toward conversion.

5 Conclusions

This paper seeks to shed more light on the general asset pricing view and more in particular on one of its crucial parameters, notably the sensitivity of the asset price to its own expected change. The asset pricing model sees the current asset price as depending on actual (unobservable) fundamentals and its own expected price change *a rato* of λ. We examine this framework in the context of asset conversion at a pre-specified date and at a known value as developed in a broader framework in De Grauwe *et al.* (1999). Their asset price equation then depends on current fundamentals, the conversion value, the time to conversion and the subjective discount rate $\frac{1}{\lambda}$. Hence, we can directly assess expectations (formation). Moreover, the unknown factor $\frac{1}{\lambda}$ can straightforwardly be isolated in the empirical application. We also

of monetary union. However, the econometric treatment and the complexity of convergence modalities are to be seen as the main driving source for their finding.

show theoretically that the factor $\frac{1}{\lambda}$ can be interpreted as a close approximation to the rate of convergence of the asset price to its announced target rate, i.e. the conversion value.

The theoretical model is translated into an empirically testable model through assuming that the fundamental follows driftless Brownian motion. The empirical model is set up in a discrete-time Kalman filtering framework. This approach frees us from the need of having to specify the notion of asset price fundamentals. This is a worthwhile exercise as empirical applications of for instance the monetary model of exchange rate determination, to our view, imply unrealistically large values for the rate of convergence. This observation is likely to be due to the failure of the monetary model of exchange rate determination in the short run such as caused for instance by the failure of PPP at this frequency. Our model circumvents this difficulty and allows us to directly estimate the speed of convergence.

We apply our framework to the currencies that participate in the first wave of EMU and to the 1879-Resumption of Specie Payments in the USA. Estimates for the speed of convergence in the case of European currencies are sensible and mostly below 1% for the last year preceding the start of EMU on January 1, 1999. Also reasonable estimates were obtained for the 1879-Resumption in which paper greenbacks were converted at par in gold coin. The theoretical model together with the low estimates of the rate of convergence also imply that the role of fundamentals in pricing when conversion is to be pursued in a not to far away future is limited to at most 6%, but mostly even below 1%.

One of the obvious implications of our theoretical and empirical results is the limited sensitivity of asset prices to shocks in fundamentals when conversion is to occur. Indeed, the combination of a fixed conversion date together with a pre-determined conversion rate acts as a strong coordination device in forming exchange rate or asset price expectations. This observation is then likely to explain the relative calm of intra-European foreign exchange markets in 1997 and 1998 despite worldwide asset market turbulence that in the past often also led to strong tensions within the ERM.[14] The paper thus embodies some clear lessons for future entries into EMU or, more in general, for other instances of asset price conversion. The announcement of a clear conversion timetable together with the conversion value to be applied will strongly limit asset price variability as variability spill-overs from fundamentals are sharply reduced. This argument, however, hinges on the ability of agents to create credibility

[14] More details on the relation between the convergence procedures and intra-European exchange rate behavior can be found in De Grauwe *et al.* (1998).

on the conversion modalities. If markets on the contrary question the announced conversion rate, variability linked to the expected conversion rate may even boost overall asset price variability.

References

[1] Bertola, Giuseppe (1993) Continuous-time Models of Exchange Rates and Intervention, in: Van Der Ploeg, Frederick (ed.) *The Handbook of International Macroeconomics*, Blackwell, Oxford (UK) and Cambridge (USA), 251-298.

[2] Burda, Michael and Stefan Gerlach (1993) Exchange Rate Dynamics and Currency Unification: The Ostmark - DM Rate, *Empirical Economics*, **18**, 417-429.

[3] Burmeister, Edwin and Kent D. Wall (1982) Kalman Filtering Estimation of Unobserved Rational Expectations with an Application to the German Hyperinflation, *Journal of Econometrics*, **20**, 255-284.

[4] De Grauwe, Paul, Hans Dewachter and Dirk Veestraeten (1998) Explaining Recent European Exchange Rate Stability, CES University of Leuven, *mimeo.*

[5] De Grauwe, Paul, Hans Dewachter and Dirk Veestraeten (1999) Price Dynamics under Stochastic Process Switching: Some Extensions and an Application to EMU, *Journal of International Money and Finance*, forthcoming.

[6] Deutsche Bundesbank (1998) *Monatsbericht Mai 1998*, Frankfurt am Main.

[7] Flood, Robert P., Andrew K. Rose and Donald J. Mathieson (1991) An empirical exploration of exchange rate target zones, *Carnegie-Rochester Series on Public Policy*, **35**, 7-66.

[8] Froot, Kenneth A. and Maurice Obstfeld (1991a) Stochastic Process Switching: Some Simple Solutions, *Econometrica*, **59**, 241-250.

[9] Froot, Kenneth A. and Maurice Obstfeld (1991b) Exchange Rate Dynamics under Stochastic Regime Shifts: A Unified Approach, *Journal of International Economics,* **31,** 203-229.

[10] Gardeazabal, Javier, Marta Regúlez and Jesús Vázquez (1997) Testing the Canonical Model of Exchange Rates with Unobservable Fundamentals, *International Economic Review*, **38**, 389-404.

[11] Klein, Michael W. and Karen K. Lewis (1993) Learning About Intervention Target Zones, *Journal of International Economics,* **35,** 275-295.

[12] Meese, Richard A. (1986) Testing for Bubbles in Exchange Markets: A Case of Sparkling Rates?, *Journal of Political Economy*, **94**, 345-373.

[13] Meinhold, Richard J. and Nozer D. Singpurwalla (1983) Understanding the Kalman Filter, *The American Statistician*, **37**, 123-127.

[14] Mitchell, Wesley C. (1908) *Gold, Prices, and Wages under the Greenback Standard*, The University Press, Berkeley.

[15] Svensson, Lars E. O. (1991) Target zones and interest rate variability, *Journal of International Economics*, **31**, 27-54.

[16] West, Kenneth D. (1987) A Standard Monetary Model and the Variability of the Deutschmark-Dollar Exchange Rate, *Journal of International Economics*, **23**, 57-76.

Table 1: Bilateral conversion rates vis-à-vis the German mark as announced on May 1, 1998.

Currency	100 German mark =
Portuguese escudo	10250.5
Spanish peseta	8507.22
Finnish markka	304.001
French franc	335.386
Irish punt	40.2676
Italian lira	99000.2
Dutch guilder	112.674
Austrian schilling	703.552
Belgian franc	2062.55

Source: Deutsche Bundesbank (1998), p. 23.

Table 2: Estimation results, sample period: January 1, 1878 - December 31, 1878 (greenback), January 1, 1998 - September 2, 1998 (exchange rates).

Asset	$\ln(\sigma^2_\varepsilon)$	$\ln(\sigma^2_\eta)$	$\ln(\frac{1}{\lambda})$	$\frac{1}{\lambda}$ (annualized)	weight of c (in %) (a)	weight of c (in %) (b)
Greenback	−19.9672 [0.1723]	−7.3224 [0.2022]	−8.3981 [0.0736]	0.08111	93.359	97.332
Portuguese escudo	−20.4401 [0.1283]	−7.2490 [0.5397]	−10.4121 [0.1764]	0.01082	99.117	99.640
Spanish peseta	−20.0184 [0.1244]	−7.3072 [0.4918]	−10.4634 [0.1024]	0.01028	99.161	99.658
Finnish markka	−22.8480 [0.3534]	−7.0688 [0.2865]	−10.0851 [0.0921]	0.01501	98.778	99.501
French franc	−21.7343 [0.1233]	−7.5405 [0.3846]	−10.9875 [0.1002]	0.00609	99.502	99.797
Irish punt	−22.4507 [1.9559]	−5.1818 [0.1994]	−9.0460 [0.0833]	0.04243	96.583	98.596
Italian lira	−22.4542 [0.6674]	−6.7940 [0.3082]	−9.6295 [0.0930]	0.02367	98.079	99.214
Dutch guilder	−23.4549 [0.3574]	−7.2217 [2.9193]	−10.2766 [1.4652]	0.01240	98.989	99.588
Austrian schilling	−26.8487 [0.1932]	−8.0444 [2.6781]	−12.0956 [1.3472]	0.00201	99.835	99.933
Belgian franc	−21.5876 [0.1399]	−7.4099 [6.5458]	−10.8153 [3.3120]	0.00723	99.409	99.759

Note: Standard errors are given within brackets.

Figure 1: Percentage overestimation of the rate of convergence by the time-independent approximation for subjective discount rates of 8%, 6%, 4%, 2% and 1% over the last year prior to conversion.

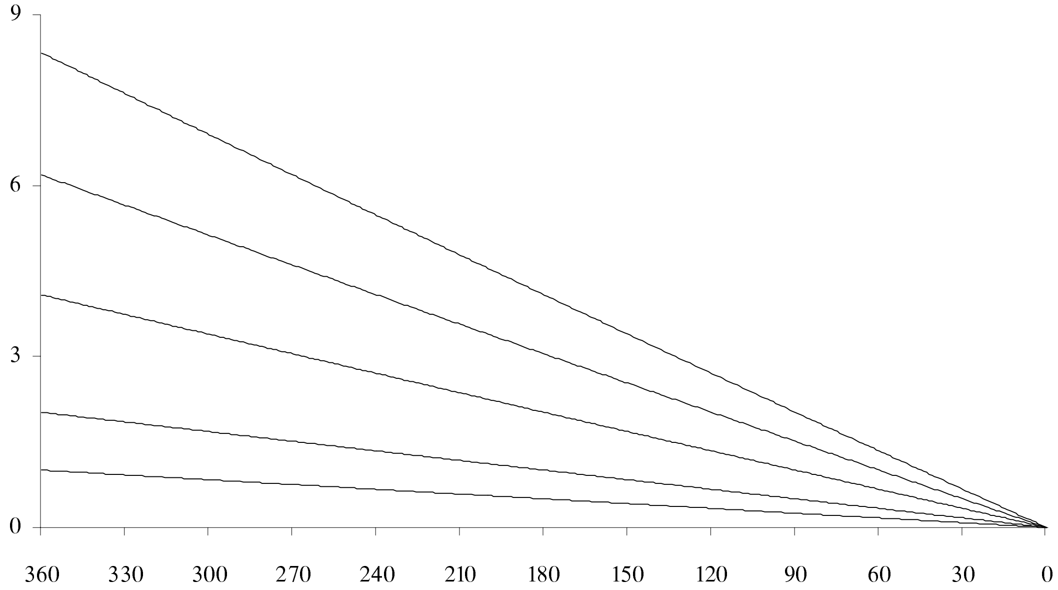


Figure 2: Value of paper greenbacks (in percent of gold coin par) and the conversion value, January 1, 1878 - December 31, 1878.

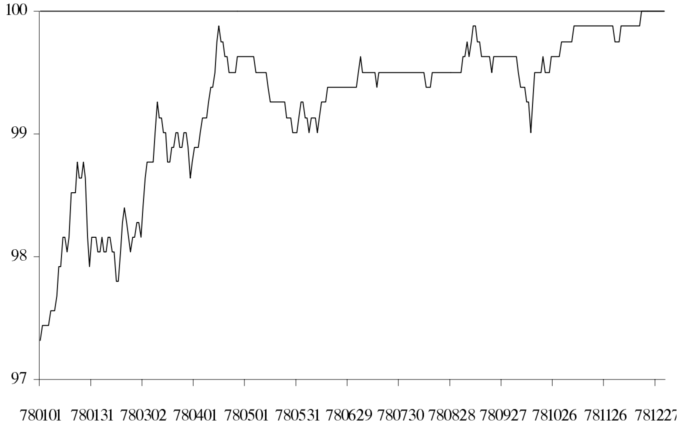


Figure 3: Local currency price of German marks in percent of the conversion rate, January 1, 1998 - September 2, 1998.

(a) Portuguese escudo

(b) Spanish peseta

(c) Finnish markka

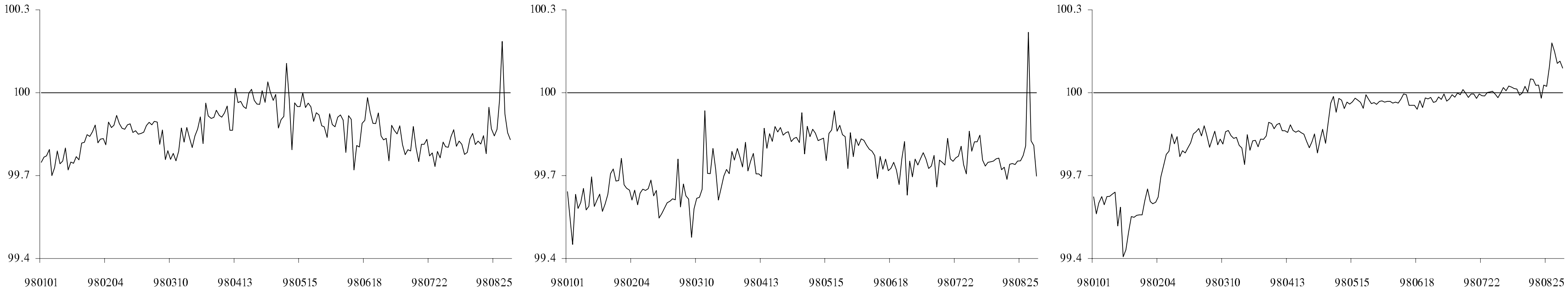
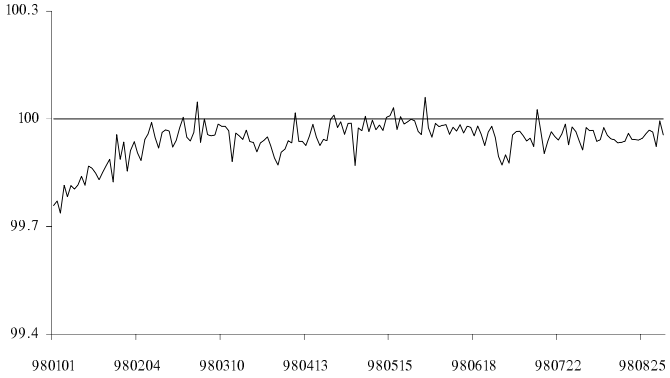
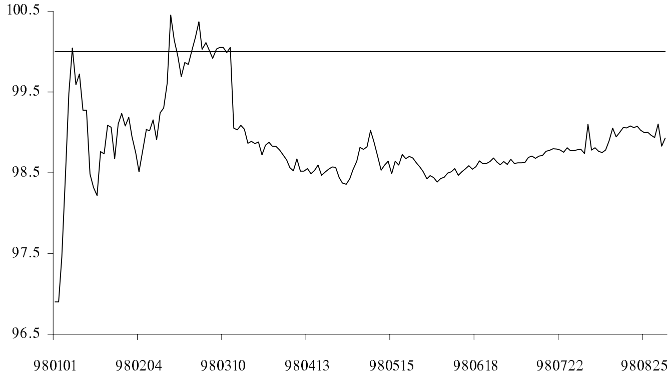


Figure 3: continued

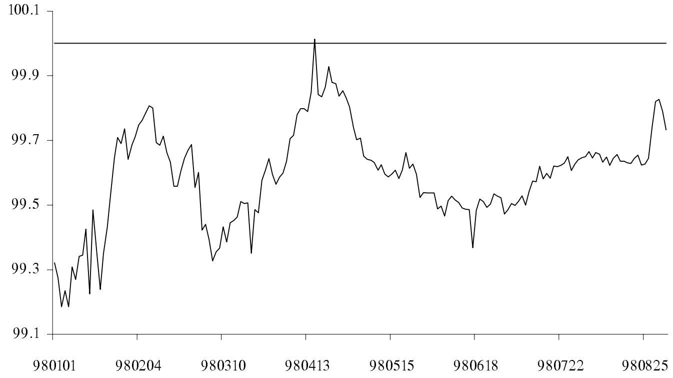
(d) French franc



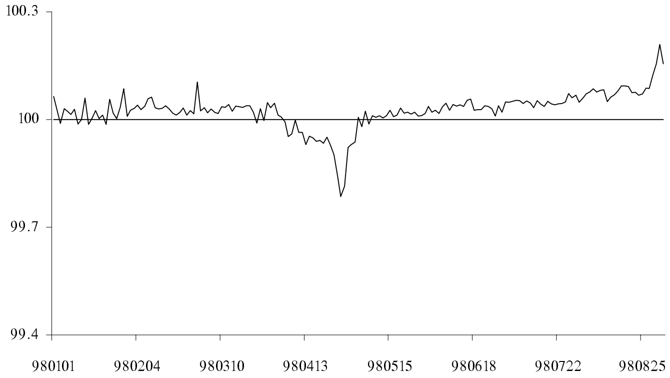
(e) Irish punt



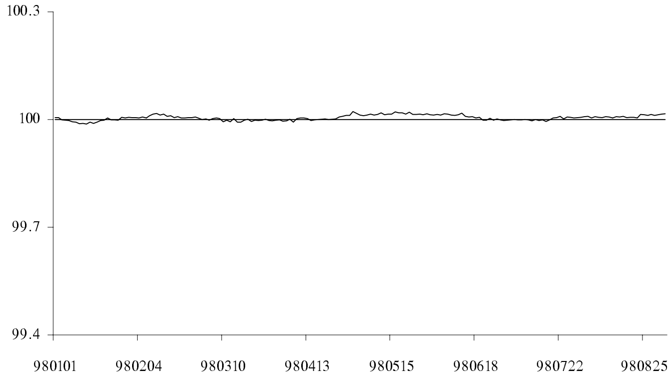
(f) Italian lira



(g) Dutch guilder



(h) Austrian schilling



(i) Belgian franc

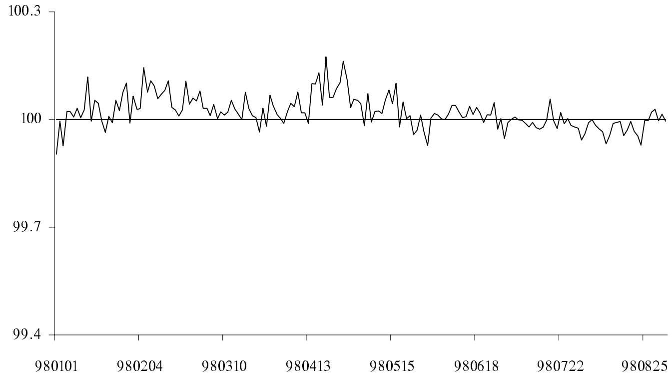


Figure 4: Remaining contribution of the fundamental to pricing of paper greenbacks (in percent of the price), January 1, 1878 – December 31, 1878.

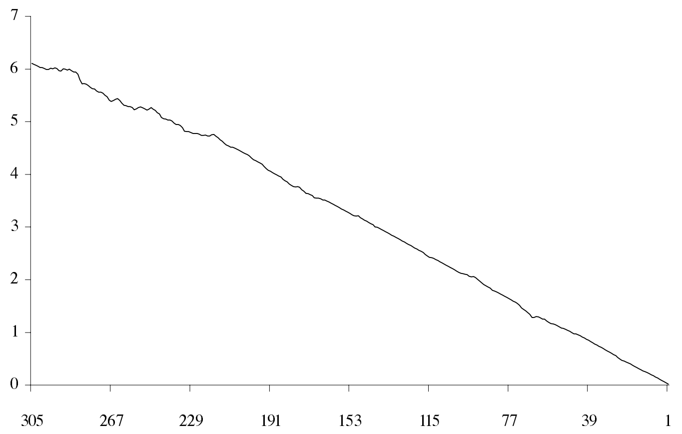
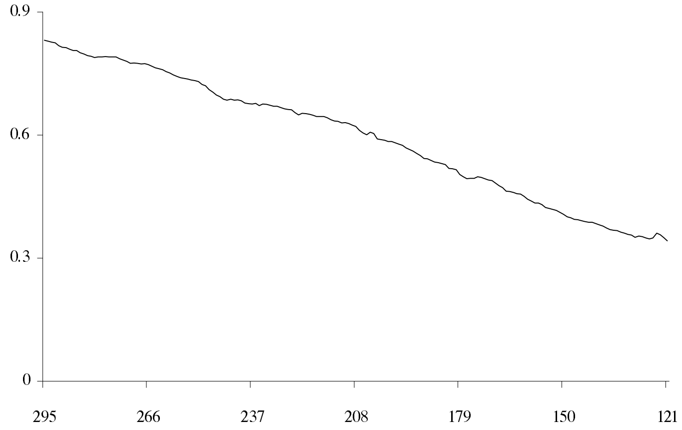
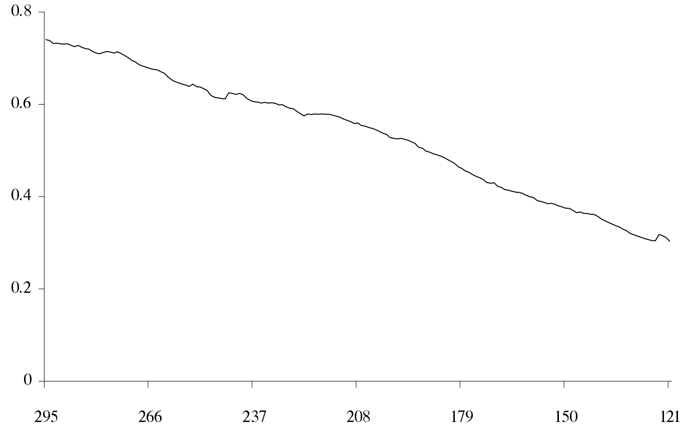


Figure 5: Remaining contribution of the fundamental to exchange rate pricing (in percent of the exchange rate), January 1, 1998 - September 2, 1998.

(a) Portuguese escudo



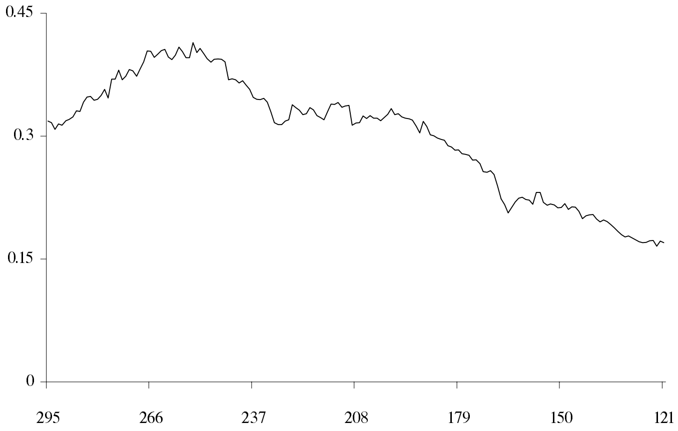
(b) Spanish peseta



(c) Finnish markka

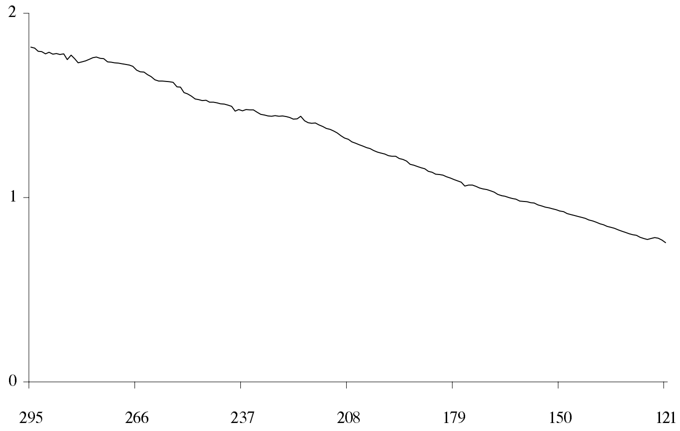
Figure 5: continued

(d) French franc

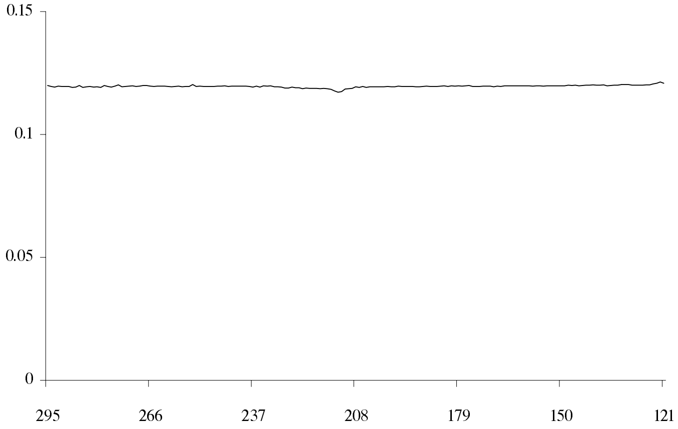


(e) Irish punt

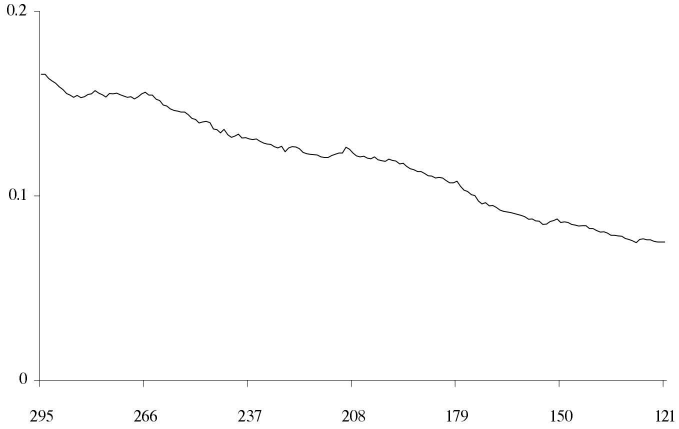
(f) Italian lira



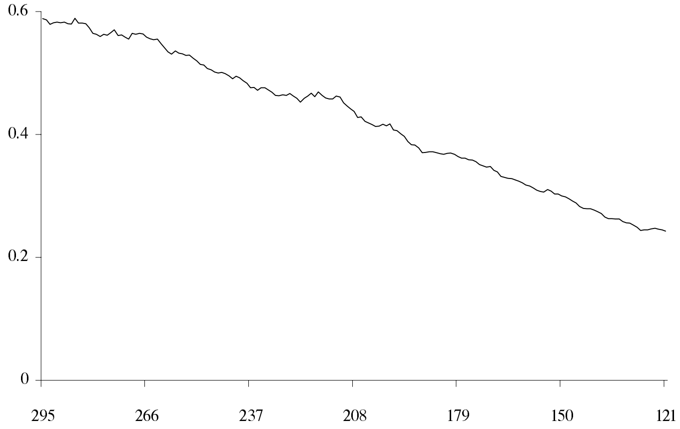
(g) Dutch guilder



(h) Austrian schilling



(i) Belgian franc



DISCUSSION PAPERS 1998

DPS 98.01 Louis Baeck, *Thematisation and Canon Building in Post-War Development Studies*, January (Development Economics).

DPS 98.02 Hans Dewachter and Hanno Lustig, *Sticky Prices and the Nominal Effects of Real Shocks*, January (International Economics).

DPS 98.03 Ilse Frederickx, *Health in Rural Tanzania: The Determinants of Health Status, Health Care Demand and Health Care Choice,* January (Development Economics).

DPS 98.04 Paul De Grauwe, *European Unemployment. A Tale of Demand and Supply,* February (International Economics).

DPS 98.05 João Cocco, Francisco Gomes and Pascal Maenhout, *Consumption and Portfolio Choice over the Life-Cycle,* March (Financial Economics).

DPS 98.06 Yunus Aksoy and Hanno Lustig, *Circular Aspects of Exchange Rates and Market Structure,* January (International Economics).

DPS 98.07 André Decoster and Frederic Vermeulen, *Evaluation of the Empirical Performance of Two-Stage Budgeting AIDS, QUAIDS and Rotterdam Models Based on Weak Separability,* April (Public Economics).

DPS 98.08 Erik Schokkaert and Luc Van Ootegem, *Preference Variation and Private Donations,* April (Public Economics).

DPS 98.09 Erik Schokkaert, *Mr. Fairmind is Post-Welfarist: Opinions on Distributive Justice,* April (Public Economics).

DPS 98.10 Dirk Van de gaer, Michel Martinez and Erik Schokkaert, *Measuring Intergenerational Mobility and Equality of Opportunity*, April (Public Economics).

DPS 98.11 Paulo Augusto Nunes, *Testing the Validity of WTP values from a Contingent Valuation Survey in Portugal*, April (Public Economics).

DPS 98.12 Paulo Augusto Nunes, *Measuring the WTP for Recreation and Biodiversity Protection Programs,* April (Public Economics).

DPS 98.13 Laurens Cherchye and Tom Van Puyenbroeck, *Learning from Input-Output Mixes in DEA: A Proportional Measure for Slack-Based Efficient Projections,* February (Public Economics).

DPS 98.14 Jerzy Mycielski and Yohanes Riyanto, *On the Interaction between Taste and Distance and Its Implications on the Vertical Distribution Arrangement*, May (Financial Economics).

DPS 98.15 Jerzy Mycielski, Yohanes Riyanto and Filip Wuyts, *Product Differentiation and the Equilibrium Structure of the Manufacturer-Retailer Relationship,* May (Financial Economics).

DPS 98.16 Hans Degryse and Patrick Van Cayseele, *Relationship Lending within a Bank-based System: Evidence from European Small Business Data,* April (Financial Economics).

DPS 98.17 Pramila Krishnan, Tesfaye Gebre Selassie and Stefan Dercon, *The Urban Labour Market During Structural Adjustment: Ethiopia 1990-1997*, April (Development Economics).

DPS 98.18 Bart Capéau and Stefan Dercon, *Prices, Local Measurement Units and Subsistence Consumption in Rural Surveys: An Econometric Approach with an Application to Ethiopia*, March (Development Economics).

DPS 98.19 Stefan Dercon and Pramila Krishnan, *Changes in Poverty in Rural Ethiopia 1989-1995: Measurement, Robustness Tests and Decomposition*, March (Development Economics).

DPS 98.20 Jenke R. ter Horst, Theo E. Nijman and Marno Verbeek, *Eliminating Biases in Evaluating Mutual Fund Performance from a Survivorship Free Sample,* June (Econometrics).

DPS 98.21 Hilke Vandenbussche and Jozef Konings, *Globalization and the effects of national versus international competition on the labour market. Theory and evidence from Belgian firm level data,* August (Financial Economics).

DPS 98.22 Wim Moesen and Laurens Cherchye, *The Macroeconomic Performance of Nations Measurement and Perception,* August (Public Economics).

DPS 98.23 Anneleen Peeters, *Interim Employment and a Leading Indicator for the Belgian Labour Market*, September (International Economics, IERP 137).

DPS 98.24 Wessel Marquering and Marno Verbeek, *An Empirical Analysis of Intertemporal Asset Pricing Models with Transaction Costs and Habit Persistence,* September (Econometrics).

DPS 98.25 Filip Abraham and Joeri Van Rompuy, *Is Belgium ready for EMU? A look at national, sectoral and regional developments,* September (International Economics, IERP 138).

DPS 98.26 Sara Ochelen, Stef Proost and Kurt Van Dender, *Optimal Pricing for Urban Road Transport Externalities,* September (Public Economics).

DPS 98.27 Knud Munk, *Optimal Support to Low-skilled Households*, July (Public Economics).

DPS 98.28 Wim Moesen and Philippe Van Cauwenberge, *The Status of the Budget Constraint, Federalism and the Relative Size of Government: A Bureaucracy Approach,* September (Public Economics).

DPS 98.29 Laurens Cherchye, *The Measurement of Macroeconomic Performance: Comparison of DEA-Based Alternatives,* August (Public Economics).

DPS 98.30 Jürgen Janssens, *Volatility and Risk Premia on Belgian Secondary Long Term Government Bond Markets,* October (Financial Economics).

DPS 98.31 Stef Proost and Kurt Van Dender, *Effectiveness and Welfare Impacts of Alternative Policies to Address Atmospheric Pollution in Urban Road Transport* (Public Economics).

DPS 98.32 Inge Mayeres and Stef Proost, *Marginal Tax Reform, Externalities and Income Distribution*, (Public Economics).

DPS 98.33 André Decoster and Guy Van Camp, *The unit of analysis in microsimulation models for personal income taxes: fiscal unit or household?* (Public Economics).

DPS 98.34 Paul De Grauwe, Hans Dewachter and Yunus Aksoy, *The European Central Bank: Decision Rules and Macroeconomic Performance*, (International Economics).

DPS 98.35 Laurent Franckx, *The use of ambient inspections in environmental monitoring and enforcement when the inspection agency cannot commit itself to announced inspection probabilities*, (Public Economics).

DPS 98.36 Reginald Loyen, *Macro-economische functieverschuivingen in de haven van Antwerpen. Reconstructie van een databank en eerste analyse van de maritieme overslag (1900-1997)*, (Quantitative Economic History).

DISCUSSION PAPERS 1999

DPS 99.01 Laurens Cherchye and Tom Van Puyenbroeck, *Product Mixes as Objects of Choice in Nonparametric Efficiency Measurement*, January (Public Economics).

DPS 99.02 Hans Dewachter and Dirk Veestraeten, *Measuring Convergence Speed of Asset Prices toward a Pre-Announced Target*, January (International Economics).

DPS 99.03 Philip Verwimp, *Estimating Returns to Education in Off-Farm Activities in Rural Ethiopia*, January (Development Economics).