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Forecasting Aggregate Demand in West African Economies: The Influence of Immigrant Remittance Flows and of Asymmetric Error Correction

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Abstract

In a panel of West African countries, we investigate whether data on immigrant remittance flows can be used to improve on predictive accuracy of aggregate demand in a systematic way. The results of the prediction experiments are compared to traditional significance tests of asymmetric error correction and of the exogenous remittance variable. We find that there is a considerable discrepancy between statistical hypothesis testing and the results from the forecast comparison. In particular, while remittances yield significant coefficients for at least some of the accounts aggregates, they do not contribute to improved forecasting accuracy.

Keywords
Remittances, time series, prediction, cointegration net exports

JEL Classification
C31, C53 055

Contents

1 Introduction

Several recent studies have examined the relationship between workers' remittances and national economies (e.g., see CHAMI *et al.,* 2003, or BOUHGA-HAGBE, 2004). Relying on economic theory and on utility-maximizing behavior, these authors have outlined several potential effects of remittance flows on the economies of workers' origin. Some of these effects are usually viewed as beneficial, such as a tendency of remittances to increase in episodes of economic downturns and thus to smoothen business cycles. Other effects are viewed as less beneficial, such as crowding out productive capacities and redirecting private expenditure to real estate, construction, and non-financial assets. It was even argued that remittances could have a negative impact on economic growth.

Given the importance that many economists and policy makers attribute to the flow of remittances to developing economies (e.g., AMUEDO-DORANTES AND POZO, 2004; ZARATE-HOYOS, 2004), one is tempted to conclude that data on remittances can be used to improve forecasts of economic growth in these economies. We study this possibility in the framework of data-driven autoregressions for the main demand aggregates. Such models are often routinely used for short-run forecasting. Adding remittances as exogenous variables, we evaluate the impact of that variable on the time-series systems. This modelling design permits a sharp focus on dynamic aggregate effects, while it deliberately abstracts from detailed links by excluding important 'channel' variables from the investigation such as wages, prices, or stocks of assets.

We hypothesize that a stable and reliable effect of remittances on an economy should be reflected in improved predictive accuracy of aggregate demand. The prediction comparison was applied to a set of West African countries. For each country, we consider several specifications of time-series model forecasts: a traditional linear error-correction model; this basic model with remittances introduced as an additional exogenous variable; a non-linear error-correction model with asymmetric adjustment; and a mix of the two extensions, i.e. remittances and asymmetry. Furthermore, we study the effects of the functional form of the exogenous remittances by considering their levels as well as their first differences. For the last six years of our sample, the predictive accuracy of these four specifications is compared via mean squared errors and robust criteria.

As a general principle, we do not rely on statistical hypothesis tests for selecting our models, apart from determining lag orders by information criteria. We rather utilize the models as forecasting tools and we compare their performance. Our approach is supported by the fact that some models without statistical support yield superior predictive performance in prediction, and *vice versa.* Potential statistical misspecification, however, may discourage drawing subject-matter conclusions from our study, and we do not intend them.

There is a twofold purpose in allowing for the possibility of asymmetries in adjustment to longer-run equilibrium conditions among macroeconomic sub-aggregates. Firstly, we are interested in whether a relatively ad-hoc extension in this direction yields major improvements in predictive accuracy. If such effects are found, this may be an incentive to consider more elaborate non-linear specifications in future work. Secondly, comparing such refinement of time-series dynamics and extending the model by including the exogenous remittances is informative. If the impact of remittances on prediction is really important, one would expect that their inclusion yields the stronger effect.

Our main finding is that forecasts do not improve systematically, if remittances are accounted for. The non-linear extension appears to have a stronger effect and to be more reliable in improving forecasts. Furthermore, we find that the functional specification of the remittances variable can be important. In most cases, growth of the remittances variable yields better results than its level. We also find that using both extensions simultaneously—i.e. remittances and asymmetry—results in unsatisfactory forecasting performance.

Another main finding is that there is little relation between the relative forecasting performance and traditional significance tests. Indeed, the effects of remittances appear to be sizeable and attain statistical significance for most countries. Conversely, there is little statistical support for the asymmetric error-correction model. Also, levels of remittances have a statistically stronger effect than their first differences. These features are surprisingly at odds with the relative performance in out-of-sample forecasting.

The apparent contradiction between our findings of statistical significance and of relative forecasting accuracy may be due to considerable changes in the reaction mechanism of the African economies to remittance shocks. Once more, it turns out that out-of-sample prediction experiments and statistical hypothesis tests convey different results, as they focus on different aspects of time-series modeling. It seems advisable to assign a key role to out-of-sample prediction evaluations when searching for good forecasting models, rather than to rely on statistical in-sample significance.

The paper is organized as follows. Section 2 introduces the time-series models. Section 3 describes the data sets and focuses on the role model of Ghana. Section 4 reports results from parallel analyses on the other countries. Section 5 considers some tentative explanations for the apparent contradiction between the statistical and the prediction methods. Section 6 concludes.

2 Methods

2.1 The linear error-correction model

The error-correction model has established itself as one of the main empirical tools in multivariate time-series modeling. It has also become the most common multivariate time-series model for macroeconomic forecasting (see, for example, Clements and Hendry, 2001). In the notation introduced by Johansen (1995), the error-correcting vector autoregression (EC-VAR) reads

$$\Delta Z_t = \mu + \alpha\beta' Z_{t-1} + \sum_{j=1}^{p-1} \Phi_j \Delta Z_{t-j} + \varepsilon_t, \tag{1}$$

where Z is an n–dimensional vector time-series variable. Its components are assumed to be either first-order integrated or stationary. The n–vector μ is an intercept constant, while the $n \times n$–matrices Φ_j describe some short-run reaction or inertia within the dynamic system. Of crucial importance are the $n \times r$–matrices α and β, with $r \leq n$. The matrix β contains the cointegrating vectors as its columns, which express long-run equilibrium relationships. The matrix α contains the adjustment coefficients that express how the system reacts to violations of equilibrium conditions.

In our application, Z_t contains the logarithms of the main components of aggregate demand in national accounts: private consumption c_t, gross fixed investment i_t, government consumption g_t, exports x_t, imports m_t. We aim at predicting gross domestic product Y, which is defined from

$$Y = C + I + G + X - M,$$

where we use capitals for the original variables, for example $C = \exp(c)$. The variable Y cannot be included as a sixth variable, as this would make the system singular. Extending this core system by using further variables is an unattractive option for various reasons. First, for developing economies, most other economic indicators are available for shorter time periods only. Moreover, many indicators, such as unemployment rates or price inflation, do not have clearly recognizable time-series properties. Some of them are bounded by definition or their order of integration is disputed. In contrast, logarithmic transforms of real demand aggregates are usually found to be first-order integrated and fit perfectly into the error-correction framework.

A five-dimensional EC-VAR can have up to four cointegrating vectors. Empirically, we found two such vectors for most of our country cases. For homogeneity across the panel, we therefore work with $r = 2$ for all countries. Besides, we tentatively identified the nature of the two vectors. One of them is $x - m$, or at least close to that vector. An economic interpretation would be that countries are concerned with their external balances and that therefore the economy adjusts in one way or other, if external balances are deteriorating. While the vector $x - m$ is not confirmed statistically for all countries under study, we impose it for the whole panel, again in the interest of homogeneity for the forecasting experiment. In order to identify a second vector, we set its coefficient on the variable m to zero. This second vector can be interpreted as explaining the sources for longer-run growth in the economy. We allow its shape to vary across countries. Economic theory would predict that c, i, g grow in approximate proportion and would thus support a third cointegrating vector in the system. We neither found strict proportionality in growth, not even in the longer run, nor did we find convincing evidence for a third vector. Therefore, we use a freely estimated vector with an identifying restriction of $\beta_{52} = 0$, i.e. no influence of imports, as the second error-correcting vector or as the second column of β. In summary, we have

$$\beta = \begin{bmatrix} 0 & 1 \\ 0 & \beta_{22} \\ 0 & \beta_{32} \\ 1 & \beta_{42} \\ -1 & 0 \end{bmatrix}$$

2.2 The asymmetric error-correction model

The modeling concept can also be extended in order to capture nonlinear dynamic effects. Such extensions may be related to the vectors of β, in the sense that the true long-run equilibrium is a nonlinear function of the variables. This extension is plausible if that equilibrium is derived from *a priori* considerations. For an example, see Jumah and Kunst (2004). Other extensions may be related to the adjustment mechanism in α. For example, variables may adjust faster or slower, depending on whether the economy is farther away from its equilibrium. In other applications, reaction may depend on the sign of the disequilibrium.

Nonlinearities in the adjustment coefficients in α are easier to handle than β nonlinearities. In the usual framework for estimation and testing due to Johansen (1995), β is estimated from canonical correlations between ΔZ_t and Z_{t-1}. This estimation step is severely complicated by nonlinearities. In contrast, α can be efficiently estimated by least squares. Nonlinear specifications of α often require only minor modifications of this regression.

Here, we explore the possibility that reaction in α may depend on an internal threshold in the sense that some coefficients in α change with the sign of the disequilibrium $\beta_k' Z_{t-1}$, where β_k is a given column of β. This would yield a system such as

$$\Delta Z_t = \mu + \alpha\beta' Z_{t-1} + \sum_{j=1}^{p-1} \Phi_j \Delta Z_{t-j} + \tilde{\alpha}_k \beta_k' Z_{t-1} I\left(\beta_k' Z_{t-1} > \xi\right) + \varepsilon_t, \quad (2)$$

where ξ is a threshold value, for example $\xi = 0$ or a distributional center of $\beta_k' Z$. β_k is one of the columns of β, or $1 \leq k \leq r$. For given ξ and given β_k, these systems can be estimated efficiently in two steps. Firstly, identification of β_j, $j \neq k$, is conducted conditional on $\beta_k' Z_{t-k}$. Secondly, linear regression yields estimates of all remaining parameters μ, α, $\tilde{\alpha}_k$, Φ_j, $j = 1, \ldots, p-1$.

We restrict attention to the first column of β, i.e. on the external-balances vector $\beta_1' = (0, 0, 0, 1, -1)$ and on thresholds in the variable $x - m$. Furthermore, we determine ξ

2.3 Specifications with exogenous remittances

In order to assess the effects of remittances on prediction, we introduce the variable re_t as an additional regressor in the linear model

$$\Delta Z_t = \mu + \alpha\beta' Z_{t-1} + \sum_{j=1}^{p-1} \Phi_j \Delta Z_{t-j} + \gamma g\left(re_t\right) + \varepsilon_t,$$

and similarly in the asymmetric model (2). We found that the results are sensitive to the choice of the function $g(.)$. In the reported tables, we consider two specifications: firstly, the first lag of logarithmic remittances re_{t-1}; secondly, the first lagged logarithmic difference $re_{t-1} - re_{t-2}$. Current values of remittances would make the system unusable for prediction, while further lags would use up too many degrees of freedom in our relatively short time-series data. The time series of remittances sometimes convey an impression of severe irregularities, with sudden increases or decreases between years. Therefore, their order of integration cannot be established by statistical methods, and we have to consider both levels and differences specifications.

The obvious suggestion to extend the core model by including remittances as a potentially endogenous sixth variable is not attractive. Remittances are available for shorter time spans than the variables in Z_t, so that such an extension would use up too many degrees of freedom. Furthermore, remittances are very irregularly behaved series and could critically affect the internal dynamics of the accounts aggregates. Finally, for the panel dynamics were very short, with $p = 1$ or $p = 2$, therefore such an extension would only affect single-step forecasts on remittances and not on GDP.

3 The data

The data was obtained from the World Bank Development Indicators data base. We use national accounts series at constant prices for gross domestic product (GDP, Y) and its main components: private consumption (C), gross fixed capital formation (I), government expenditure on goods and services (G), exports (X), and imports (M). According to the construction of national accounts and ignoring some minor positions, the components should be related to GDP by

$$Y = C + I + G + X - M. \tag{3}$$

Unfortunately, the available data reveal a difference between the left and right sides of this equation that cannot be explained by changes in inventories etc. In other words, there is a sizeable statistical discrepancy. If demand components are used to predict the total series, it is appropriate to discuss which variable to focus on. If Y is the target variable, this would require a special model for predicting the statistical discrepancy. Consequently, we generally assume that forecasting targets the sum of the demand components on the right side of equation (3). In more detail, we will focus on a logarithmic transform of the sum on the right side. We will denote logarithms of the defined variables by corresponding small characters: c for log consumption, g for log government expenditure, i for log investment, x for log exports, and m for log imports.

The series of remittances were deflated by the U.S. consumer price index. This kind of deflation appears to be the most reasonable in preserving the real or goods value of the remittances.

4 Empirical results

4.1 Forecasting Ghana

We use Ghana as a role-model case. Therefore, we describe all results in some detail, in order to explain more general features. For the remaining countries, results will be summarized more concisely.

Model specification relies on the time range ending in 1995, while the data from 1996 were reserved for the prediction evaluation. In order to achieve a fully out-of-sample evaluation of one-step errors, the parameter estimates were continually updated, while the main model structure was preserved.

Standard cointegration analysis in the spirit of the Johansen (1995) procedure was applied to a five-variables model that contains c, g, i, x, and m. Guided by the AIC information criterion, a specification search over different lag lengths resulted in a first-order VAR structure, i.e. in an error-correction model without any lagged differences. This selection may be due to the short data time range but it was confirmed by the t–values of lagged differences in higher-order models. All individual variables were found to be first-order integrated.

The number of cointegrating vectors is indicated by the number of non-zero canonical roots of differences and lag levels. A cursory inspection of the five canonical roots reveals that two roots are very small, while three roots appear to be different from zero. However, due to the relatively small sample, a direct application of the significance points that were provided by Johansen (1995) implies non-rejection of the hypothesis of no cointegration. It seems advisable to overrule this statistical decision, following theoretical properties and also visual evidence. Time plots of tentatively identified error-correction variables convey a stationary impression, at least for the first two components that correspond to the two largest canonical roots. Therefore, we will work under the assumption of two cointegrating vectors.

Economic theory would suggest at least two cointegrating relationships. Firstly, the 'great ratios' $i-y$ and $c-y$ should be constant in the longer run. If y is omitted, the two great ratios imply stationarity of $c-i$. For the observed sample, stationarity of $c-i$ was rejected clearly. Therefore, instead of the theoretical vector $c-i$, we allow for the presence of other demand components such as g and x in the relationship, with freely estimated coefficients. For the sample ending in 1995, we obtain

$$c - 0.23g - 0.10i - 0.18x.$$

Coefficients on investment and exports have the expected signs, as exports and investment increase the productive capacity of an economy, which should cause an increase in income that, in turn, should engender an increase in consumption. In theory, the effect of government consumption is more ambiguous, as this may be a substitute for private consumption as well as a source of private income. In the identified vector, the impact of g on c is positive. The investment coefficient is marginally significant, with a t–value of 1.7, while the other two coefficients are clearly significant. This vector ties the dynamic evolution of consumption to the evolution of government expenditure, investment, and exports, and serves a convenient purpose in stabilizing the system. A similar long-run domestic growth vector was found, for example, by Kunst and Neusser (1990) in a macroeconomic system of a developed economy.

As a second cointegrating vector, we assume the net exports ratio $x - m$ to be stationary. This is the second vector suggested by theory, as the political system may be interested in the external balance. While a freely estimated cointegrating vector digresses somewhat from our pattern, it is comforting that the two cointegrating vectors are not rejected in a formal test within the cointegration model with a cointegrating rank of two.

The adjustment coefficients are also interesting, as they indicate which of the variables adjust to deviations from the two equilibrium relationships. It appears that adjustment to the domestic growth vector is performed by g, m, and x, while imports and consumption respond to external imbalances. The influence of investment is altogether weak. The variable i shows little reaction to disequilibrium terms, and it is also only marginally significant in the cointegration vectors. Therefore, i is not only approximately weakly exogenous for the cointegration vectors but its behavior is almost completely described as a univariate random walk with a drift.

From the model, one-step forecasts were obtained for the years 1996–2001. In re-estimating the model, some changes occurred over the forecasting interval. For example, the coefficient on investment in the first error-correction vector decreased and became altogether insignificant, as observations at the end of the sample were added.

With regard to the net exports vector, we also investigated asymmetric adjustment. An obvious idea would be that the political system is not so much concerned with positive net exports (a trade surplus) as with negative net exports (a trade deficit). However, Ghanaian net exports were only positive in 1972. It seems more reasonable to split the series $x - m$ into two parts, according to whether $x - m$ was below or above its longer-run mean. Over the entire sample range, the average is -0.457, while the sample median is -0.459. Hence, we assume that the economic system responds differently for values below -0.46 than for values above -0.46. Formally, the suggested system has three error-correction vectors: the freely estimated domestic growth vector, net exports in the regime of a large trade deficit, and net exports in the regime of comparatively balanced trade. The nonlinear error-correction model

$$\begin{aligned} \Delta X_t &= \mu + \alpha_1 \beta_1' X_{t-1} + \alpha_2 (x_{t-1} - m_{t-1}) \\ &\quad + \alpha_3 I (x_{t-1} - m_{t-1} > -0.46) (x_{t-1} - m_{t-1}) + \varepsilon_t \end{aligned}$$

can be efficiently estimated by least squares, conditional on $\beta_1' X_{t-1}$, as the nonlinear error-correction variables are known.

Estimation of the complete model can be conducted by simply extending the linear cointegration model with one more exogenous variable. This conditioning step modifies the first error-correction vector β_1 to

$$c - 0.22g - 0.12i - 0.16x$$

for the sample ending in 1995. All coefficients are close to the linear version. The vector α_3 contains relatively small coefficients, such that the asymmetric extension is not supported by statistical tests. The only larger coefficient is for consumption, which may be interesting. Consumption is found to react strongly to external imbalances, in the sense that it is reduced when the trade deficit widens. If $x - m$ exceeds -0.46, however, this reaction is found to disappear. Therefore, while the asymmetric reaction pattern fails to achieve statistical significance, it may be interesting to explore its influence on prediction.

Figure 1 shows the results from prediction experiments using the linear as well as the asymmetric error correction models. Both models show a tendency to over-predict in the years around 1995 and to under-predict toward the end of the sample. The target variable is the calculated Ghanaian GDP, which is obtained from the sum of the components according to the basic national accounts identity. It was already outlined that this series differs from the GDP series in the official data base. The differences between the two forecast models are small. On average, the squared prediction error is slightly smaller for the linear version, with 0.000539 as compared with 0.000544. We note, however, that the asymmetric model performs better for the recession in 1997 and toward the end of the sample.

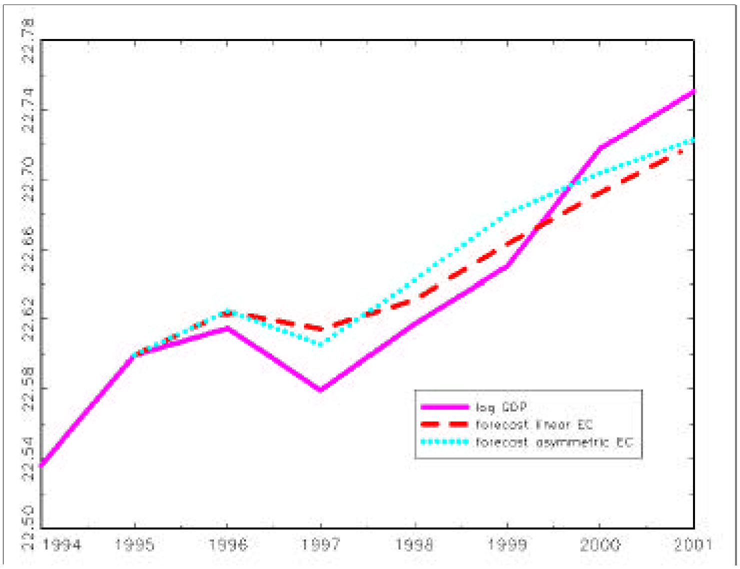

Figure 1: Ghanaian GDP and predictions from linear and from asymmetric error-correction models.

Introducing remittances as an exogenous variable into the error-correction systems results in insignificant coefficients, if remittances are used in the same time period as the other variables. It appears that the full effect of remittances needs one year to unfold. This is also convenient for prediction, as last year's remittances are already known when the next period is forecast. Like all other variables, remittances are used in their logarithmic form (r).

Lagged remittances were introduced in the linear as well as in the asymmetric model. For both models, remittances have a sizeable impact, though surprisingly not on private consumption c. The largest reaction is the one on imports m. Regarding this effect, there are subtle differences between the linear and the asymmetric model. In the asymmetric model, remittances tend to boost exports, while remittances are a substitute for imports in the linear version. Such dynamic effects are at odds with economic theory, which would predict remittances to boost imports and to cause some deterioration in the trade balance. Like other statistical effects in time-series models, one should refrain from interpreting them as structural *ceteris paribus* reaction, due to the complex dynamic interaction within the VAR, to the sampling frequency that may be slower than actual reaction, but primarily due to the deliberate simplification of the core model that omits many important economic links. Similar remarks apply to all other unintuitive effects found in this study.

While remittances have an important and statistically significant impact on demand components, this fact unfortunately is not reflected in improving forecasting performance. Indeed, the mean squared errors increase to 0.00379 for the linear model and to 0.00431 for the asymmetric variant. This almost tenfold increase is rooted in the years 1998 and 1999, where the reaction to remittances apparently did not coincide with the patterns that were observed in earlier years.

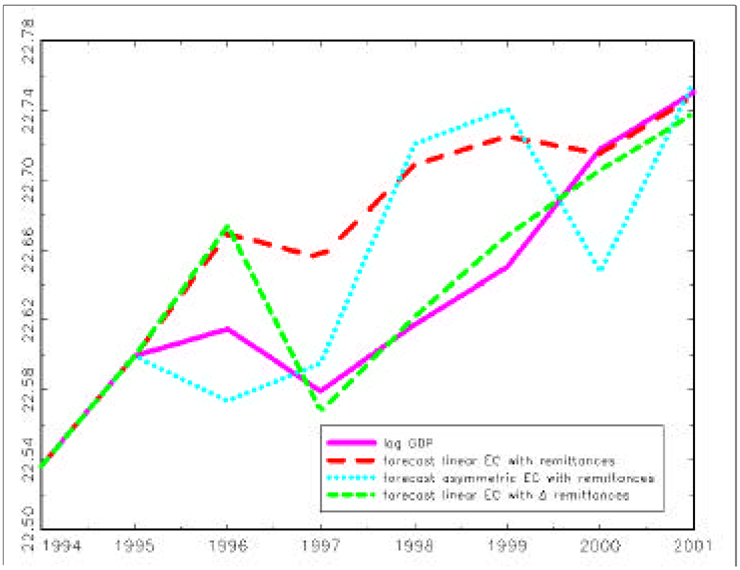

Figure 2: Ghanaian GDP and predictions from linear and from asymmetric error-correction models, accounting for the exogenous variable of lagged remittances.

It may be of interest that, for the years 2000 and 2001, forecasts were appealingly good for the models that include remittances. As can be seen from Figure 2, for the linear variant the forecasts track the true data closely. This insinuates that the idea of accounting for remittances should not be discarded prematurely. Evidence on other countries and for longer time spans will show whether this in an idea that deserves attention. A summary of the prediction experiments for all countries is given in Table 1, while some characteristic features of the EC-VAR models are provided in Tables 2 and 3.

4.2 Forecasting Benin

In analogy to some of the other countries in our data set, time-series models for the Benin economy are restricted by the availability of investment data, which start from 1982. Remittance data start from 1974. For brevity, we refrain from adding all parameter estimates to this paper. A brief summary of the main effects for all countries is provided in Tables 2 and 3.

Due to the shortness of the sample, we cannot follow the recommendation by the AIC criterion to use a second-order VAR. A first-order VAR is assumed throughout. In the linear error-correction model, the balanced-growth vector and the net exports vector are statistically accepted as error-correcting vectors. We note, however, that the severely passive Benin trade balance was getting more active over the sample. For the sample ending in 1995, the balanced-growth vector is

$$c + 0.60g - 0.18i - 0.18x.$$

This means that fiscal expansion has a negative effect on private consumption in the longer run. Adjustment to this equilibrium path is performed via government expenditure and investment. Reacting to the net-exports error-correction vector, it is imports that tend to decrease in order to counteract a more severe trade balance deficit.

The average value of the $x - m$ variable, which we use in cointegration analysis for net exports, turned out as -0.6, which was used as the central location point for the asymmetric model. Thus, we considered the possibility that reaction of macroeconomic aggregate might differ for values of $x - m$ above and below -0.6. The idea was not supported by the data. The linear and asymmetric versions of the error-correction model turned out nearly identical.

The influence of remittances within the error-correction framework turned out to be significant. Remittances appear to have a negative influence on government expenditure and less significant effects on other variables. We note that the reaction of the core model variables becomes more intense and diversified as the sample is extended at the end. For a comparison, consult Tables 2 and 3. Unfortunately, these observations cannot be used to improve prediction. Using lagged remittances as an exogenous variable causes statistical rejection of the imposed cointegration vectors and implies an implausible balanced-growth vector, with consumption dropping out as insignificant. These features, in turn, cause a sizeable deterioration in forecasting performance. MSE measures more than double in comparison to the version without remittances. The largest and thus worst value corresponds to a model with remittances and asymmetry, which means that mixing the two ideas yields the least attractive model.

4.3 Forecasting Burkina Faso

For Burkina Faso, demand aggregates are available from 1965 to 2001. For some years with missing investment data, investment was re-constructed as the total of GDP minus the remaining aggregates. For the other years, the original GDP series was replaced by the sum of the demand components, in order to avoid an internal inconsistency of the data set.

An AIC lag-order search supports a first-order VAR for the Burkina Faso data. The balanced-growth vector was estimated as

$$c + 1.55g - 0.47i - 2.56x, \tag{4}$$

which differs considerably from the typical form that we found for some of the other countries. We note that investment and exports have a positive longer-run influence on private consumption, which is reasonable. The existence of two cointegrating vectors is supported statistically, and also the form of the vectors is confirmed. Government expenditures, investment and imports react to the balanced-growth vector, while imports and also investment adjust to the net exports vector. Thus, consumption and exports behave approximately like drifting random walks and are weakly exogenous for the error-correction coefficients.

Burkina Faso has a passive trade balance for the whole sampling period. There is evidence on a slight deterioration in recent years, yet the overall mean location of $x - m$ appears to be close to -0.64. This value was taken as the critical point for possible asymmetries in reacting to net exports. Such asymmetries failed to gain significance in the error-correction model. The asymmetric model performs slightly worse, with the MSE rising from 0.000350 to 0.000464.

Remittances are particularly interesting in the case of Burkina Faso, as they show a decreasing trend over the last decade, quite contrary to the developments in other countries in our sample. The statistical effect of lagged remittances in the error-correction model is apparently weak, with a slight negative impact on household consumption. Again, this effect is at odds with theoretical predictions, and our above remarks continue to apply. Nevertheless, augmenting the model with remittances improves prediction considerably. The MSE falls to 0.000194, while it remains close to the mark for the linear model in the version with added asymmetric effects. We found that the improved forecasting performance is due to the fact that remittances remove the tendency of the standard VAR models to under-predict GDP for the years under investigation.

4.4 Forecasting Cameroon

Unfortunately, investment data is not available before 1975, which restricts degrees of freedom. An AIC search yields a VAR of order two for the five-variable system. Therefore, *one* lag of differences should be included in VEC modeling. The short sample prevented serious specification testing, hence we could not statistically identify the cointegration rank. We again assume a rank of two, with a balanced-growth vector and net exports. The estimated balanced-growth vector for 1975–1995 turned out as

$$c - 0.15g - 0.01i - 0.38x.$$

In analogy to the Ghanaian data, the influence of investment is weak and statistically insignificant. We keep i for theoretical reasons. Private consumption is found to adjust to the growth vector significantly, while investment adjusts to the external balance. When the sample is extended at the end, the vector changes and becomes uninterpretable for some years. We also note that the net exports vector $x - m$ is rejected as a cointegration vector statistically, probably due to a longer-run tendency of the Cameroon trade balance toward a more active value. Trade balance deficits dominate in the 1980s, while surpluses appear in the 1990s. We keep the net exports vector for theoretical reasons.

The asymmetric version of the error-correction model is unattractive statistically, as the asymmetry effects remain insignificant. However, the asymmetric model improves prediction. While the linear model achieves a mean squared error (MSE) of 0.00179 for the years 1996–2001, this value decreases to 0.00104 for the asymmetric model. Similarly, the mean absolute error (MAE) falls from 0.0355 to 0.0266. Both models tend to under-predict actual GDP output. This tendency is particularly strong in 1996, when time-series models predict a recession, probably based on the information of low investment in 1995, while the real economy actually grew smoothly over the whole evaluation period.

Because data on remittances were not available for the most recent years, a comparison with error-correction models that account for remittances is not feasible in the case of Cameroon.

4.5 Forecasting Mali

For Mali, demand aggregates are available from 1967. Investment data were missing for some years, such that they had to be calculated as residuals from the total GDP and the remaining components. Toward the end of the sample, original data tend to be very volatile and implausible. For example, if GDP is calculated as the sum of its aggregates, real growth in 2000 would surpass 20%. Reported GDP is somewhat smoother, therefore we rely on reported total GDP rather than on GDP calculated from components for the last few years. To avoid internal inconsistency, one or more of the components have to be adapted. Because it appears that the implausibly large growth rate are mainly due to investment, we calculated capital formation as

$$I = Y - C - G - X + M$$

for this time period. We feel that, although data construction involved several rather arbitrary breaks, the result comes closer to real economic behavior than any other choice.

For the sample 1967–1995, an AIC search yields a first-order VAR for $(c, i, g, x, m)'$, which suggests an error-correction model without any lags of differences. We use two cointegration vectors: firstly, a logarithmic variant of net exports $x - m$; secondly, the growth vector

$$c - 0.22g - 0.74i + 0.49x.$$

Unfortunately, the coefficient on exports has the 'wrong' sign, which is difficult to interpret, as consumption and exports are unlikely to be substitutes. The two imposed vectors, however, are supported by a statistical restriction test. Reaction to the growth vector is strongest for investment, while both i and m are found to adjust to net exports.

Logarithmic net exports $x - m$ are negative throughout the sample, although the trade balance has been improving considerably in the 1990s. The average for 1967–2001 is -0.7 for this variable, which we took as a possible threshold value for asymmetric reaction. Asymmetric error correction comes close to significance for three variables: consumption, investment, and exports. Other features of the error-correction model remain nearly unaffected. It is interesting that asymmetry has a sizeable and positive influence on prediction. Asymmetric adjustment reduces the MSE from 0.00402 to 0.000178.

Remittance series are available from 1975. After a long increase, remittances leveled out in the later 1990s. The impact of lagged remittances on the error-correction model is statistically significant. It affects i, g, and m, in all cases negatively. There is a sizeable forecast failure in 1996, while prediction yields satisfactory results for more recent years. On the whole, the MSE (0.00681 for the symmetric model and 0.00442 for the asymmetric model) falls slightly behind the version without remittances.

4.6 Forecasting Niger

For the Niger economy, national accounts components are available from 1960, excepting investment. For 1960–1979, we construct investment as the residual from the national income identity. For the years 1980–1999, we replace GDP by the sum of its components to preserve internal consistency. Unfortunately, data from 2000 are not yet available, excepting GDP, which restricts the forecast evaluation to the years 1996–2000. Thus, for Niger we only evaluate five one-step forecasts instead of six.

The imposed restrictions on the cointegrating space are formally rejected on statistical grounds. For 1960–1995, we obtain the relatively implausible growth identity

$$c - 0.03g + 0.21i + 0.26x,$$

where both i and x have the wrong sign. This vector influences the increases of g, i, and x significantly, while the net exports vector affects x and m. Again, consumption appears to be weakly exogenous. Effects of asymmetry are insignificant, and the impact on prediction is marginal. The exception is 1997, where the asymmetric model yields the more accurate prediction. The MSE for the linear model is 0.00253, while for the asymmetric model it is 0.00232. None of the models correctly predicts the downturn of the Niger economy in 2000.

For Niger, remittance data are available from 1975. Adding them to the error-correction model does not only result in a significant negative effect on imports. The augmented model also shows a different reaction to the error-correction variables.

Net exports affect imports and government expenditure, while the growth relationship now influences the very same two variables. Apart from c, also g and x become weakly exogenous. The versions with remittances over-predict the years 1999 and 2000 considerably, which results in worse MSE values than for the versions without remittances. These values are 0.00501 for the asymmetric version and 0.00285 for the symmetric version.

4.7 Forecasting Nigeria

Nigerian data on national accounts components are available from 1960 until 1998. Gross domestic product is available for some more years, while some of its components have not yet been compiled. Therefore, Nigerian data allow prediction experiments only from 1996 until 1999.

For the sample ending 1995, the imposed cointegrating vectors are statistically rejected. The growth vector amounts to

$$c - 0.56g + 0.39i - 0.04x.$$

Investment has the wrong sign, and exports are insignificant. Government expenditure and imports are found to respond to both this growth vector and net exports, while investment reacts to net exports only. Consumption and exports are weakly exogenous in the linear specification.

Nigerian net exports have often been positive, while some years have experienced a sizeable trade deficit. Thus, the threshold could be set at zero. The effect of the asymmetry term turned out to be strong, particularly on investment. Nevertheless, the asymmetric model did not perform well in forecasting. Both error-correction variants under-estimate the year of 1996, while they over-estimate the year 1999. On the whole, the MSE is slightly better for the linear specification.

Data on remittances are available from 1978. Remittances have a strong negative effect on government expenditures, which is once more not reflected in improved forecasting performance, as the implied MSE remains slightly above the one for the linear model without remittances. The asymmetric model with remittances is unstable for the time range ending in 1995, which results in an impressive forecast failure for 1996. For later years, the estimated structure becomes stable again.

4.8 Forecasting Senegal

National accounts data for Senegal are available from 1960 to 2001. The first five years of investment data had to be re-constructed. For the remaining years, GDP was redefined as the sum of its components, in order to preserve internal consistency. The statistical discrepancy is small and nearly constant over the time range 1965–2001.

The linear error-correction model shows a statistically satisfactory performance. The two imposed cointegration vectors are not rejected at a 10% significance level. The growth vector

$$c + 0.55g - 0.13i - 2.08x$$

shows an extraordinarily large contribution from exports. All variables excepting consumption react to this vector. Investment, exports, and imports adjust also to the net exports vector. Net exports are negative for the whole time range. The variable $x - m$ centers around -0.25, which serves as the criterion value for the asymmetry threshold. Asymmetries turn out to be influential for imports, while adding the asymmetry vector also substantially modifies the error-correction effects for the other variables. The two versions of the error-correction model yield almost identical predictions. The asymmetric model is slightly superior with regard to the

MSE criterion, while both versions show a tendency to under-predict over the whole prediction time range 1996–2001.

Data on remittances are available from 1975. When added as conditional variable to the error-correction model, lagged remittances in logarithms are influential for all variables excepting investment. Again, however, remittances fail to improve predictive accuracy. The model that jointly uses remittances and asymmetry performs slightly better than the pure remittances model. However, both models fall short of the error-correction models without remittances.

4.9 Forecasting Togo

Accounts data for Togo are available from 1960 to 2001, excepting capital formation, which had to be re-constructed from 1960 to 1979. From the sample 1960–1995, a growth error-correction vector was estimated as

$$c + 7.16g - 0.19i - 5.62x.$$

It is obvious that consumption and investment play a minor role here. Rather, the vector appears to describe a relationship between g and x. There is little statistical support for the vector, and its main effects are on imports and exports. On the other hand, the strongest effect of the net exports vector is on imports but fails to gain statistical significance. Consequently, all three domestic demand variables c, g, and i are weakly exogenous in the Togo economy.

In order to gauge asymmetric effects, we consider the logarithmic net-exports variable $x - m$. Except for 1973–1975, the trade balance was always passive. The mean of $x - m$ is around -0.4, which was taken as the criterion value for the asymmetry threshold. While asymmetric effects remain weak according to their t–values, reaching a maximum for g and x, the nonlinear model passes all specification tests that reject for the linear version. Indeed, the asymmetric model achieves a slightly better fit in prediction than the linear rival.

For Togo, data on remittances is available from 1974. Adding the lagged remittance series to the error-correction model implies a sizeable reaction in government expenditures g. Again, the forecasting performance of the extended model does not fulfil expectations. While the model performs reasonably well for most observations, there is a considerable prediction failure in 1999. The prediction failure is replicated, although on a lesser scale, by the asymmetric remittances model.

5 Why do remittances not help in prediction?

Results for all countries have been summarized in Tables 1–3. Table 1 compares the predictive performance across the four considered models. For five out of nine countries, the asymmetric error-correction model yields the best results. While only mean square errors are tabulated, the ranking of models is very similar for mean absolute values. Models with lagged remittances usually perform worse, with one noteworthy exception.

Table 2 gives some inference results for samples ending in 1995. This corresponds to the first forecasting experiment, when the sample ending in 1995 is used to predict the 1996 value. For the later time points, coefficient estimates are updated and also the inference statistics change. We give two likelihood ratio (LR) test statistics: one for testing the asymmetric model versus the linear error-correction model, and one for testing the presence of remittances as an exogenous variable. Under their null hypotheses, both statistics are asymptotically distributed as chi-square with five degrees of freedom. For most cases, remittances are significant, while asymmetry is not, which is to be contrasted with the conflicting outcome of the forecast evaluation in Table 1. Finally, Table 2 summarizes the variables that react to the error-correcting vectors in the basic linear model and to remittances in the model that has been extended by remittances. The set of affected variables varies somewhat across countries.

Table 3 repeats this exercise for the full sample ending in 2001. This full sample is not available to a hypothetical forecaster in our prediction experiments but its influence on the results may nevertheless be of interest. Comparing Tables 2 and 3 reveals sizeable changes. The variables that are found to adjust to disequilibrium conditions differ, and so do the variables that adjust to exogenous remittances. There are also important discrepancies among the LR statistics. Generally, it appears that the influence of remittances as well as of asymmetry has weakened over the most recent years. This weakening provides a partial explanation of the comparatively poor performance in forecasting. It is obvious that forecasting is sensitive toward structural changes in model dynamics. If a certain dynamic link, in this case the one from remittances to the endogenous national-accounts system, is affected critically, omitting such a link will be beneficial for prediction.

The fact that the asymmetric error-correction model wins five out of nine horse races is impressive. We note that the asymmetric model could be refined further, as we selected the threshold value from a crude calculation of descriptive sample statistics for net exports. Thus, it pays to consider nonlinear reaction to cointegrating vectors in prediction, even though the gain in accuracy is small on average. On the other hand, the bad performance of the models with remittances suggests that plugging in exogenous variables into error-correction VARs can be dangerous. This warning even applies if the exogenous variable attains convincing statistical significance.

The full amount of the problem is highlighted in Figures 3 and 4. In Figure 3, LR statistics for the model without remittances against the one with remittances are used on the abscissa. Ratios of the MSE for the remittances models over the MSE for the asymmetric models, which are usually the best ones, are used on the ordinate. Usually, one would expect a negative relationship, as good statistical evidence on the exogenous variables should yield good relative performance for the corresponding VAR, with MSE ratios smaller than one for large LR statistics. It is evident that the two variables are only loosely related. The diagram even tends to support a positive relationship, in the sense that statistical support for remittances impacting on GDP implies inferior forecasting performance of forecasting models that account for the very same remittances variable. Figure 4 gives a similar graphical display for the models that use remittances in first differences. The point in the northwest of the diagram corresponds to Mali where remittances are totally insignificant according to the LR test and the remittances model confirms this by inferior forecasting performance. Apart from this case, however, the relationship appears to be vaguely positive. The two well performing remittances models for Nigeria and Burkina Faso have insignificant LR statistics, while the relative performance deteriorates for the cases with strong significance.

Several possible reasons might be mentioned for the described effects. Firstly, the models may be seriously misspecified, such that the statistical properties of the LR statistics are invalid. While the models are certainly not specified correctly in all statistical aspects and some evidence on misspecification is reported in the paper, this explanation is unlikely to be fully responsible for the effect. The significance of the remittances effect is too strong for this explanation.

Secondly, sampling variation is a good candidate for mismatches between prediction properties and inference properties. However, sampling variation affects the parameters of the pure VAR without exogenous variables as well as the extended VAR. Degrees of freedom decrease for the more complex models, for two reasons. Firstly, remittances are available for a shorter time period relative to national-

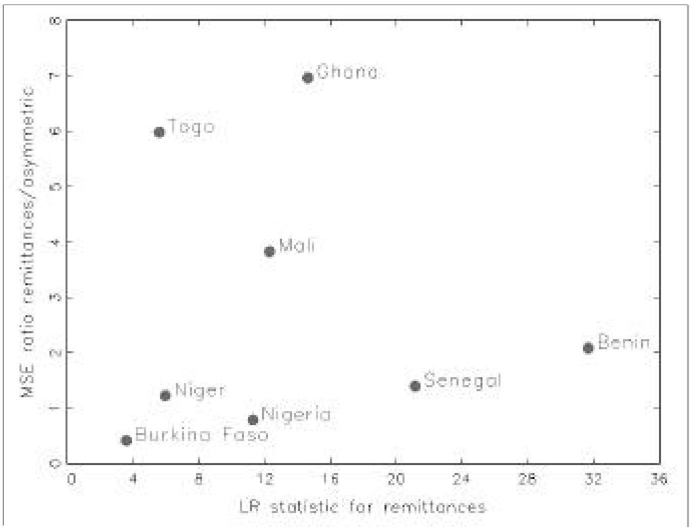

Figure 3: Scatter plot of LR statistics for the inclusion of re_{t-1} (x–axis) and MSE ratios of the linear models with re_{t-1} and the asymmetric models without remittances (y–axis).

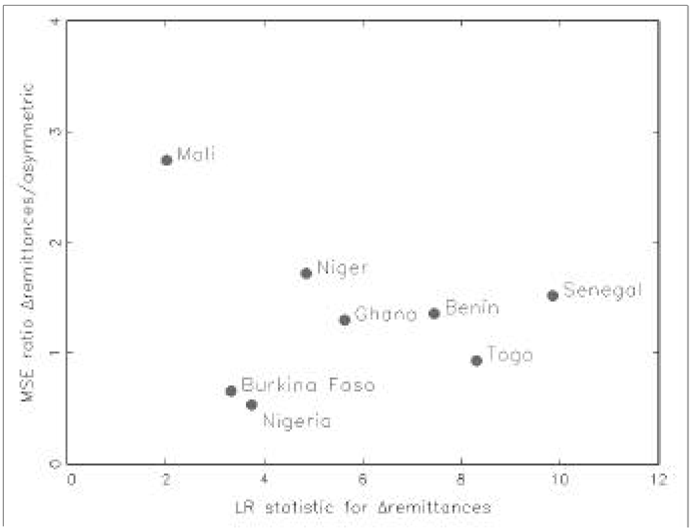

Figure 4: Scatter plot of LR statistics for the inclusion of Δre_{t-1} (x–axis) and MSE ratios of the linear models with Δre_{t-1} and the asymmetric models without remittances (y–axis).

accounts data. Secondly, five more parameters are estimated. Note that the LR statistics as shown in Table 2 and Figures 3 and 4 refer to shortened samples for both models, which mitigates the first point. For example, if remittances were available from 1975, the likelihood for the VAR refers to a sample from 1975 to 1995, as does the likelihood for the VAR augmented by remittances. The five additional coefficients, however, may use up a sizeable portion of the available degrees of freedom, which is a matter of concern. We certainly support the usual recommendation that care should be taken in forecasting to preserve a useful amount of degrees of freedom, and to avoid overly complex models. The asymmetric model uses up an identical degrees of freedom, without showing the deterioration of predictive accuracy from the remittances structures. The effect may play a role for the asymmetric remittances models, which yield an inferior forecasting performance indeed.

Thirdly, the coefficients relating to the conditional model may be more unstable than the VAR coefficients. In order to investigate this important aspect, we compare three sets of coefficients: the adjustment coefficients α_1 to the first error-correction vector, the adjustment coefficients α_2 to the second vector, and the coefficients for the lagged remittances. A problem with the first set is that the size of the coefficients is undetermined in principle. It can be identified through normalizing the cointegration vectors to unity, while typical econometric software routines prefer fixing one of the cointegrating vector coefficients to one. This is the solution adopted for this part of the study with respect to consumption c. For the second cointegrating vector $x - m$, the problem does not arise.

For the exemplary case of Togo, Figure 5 allows an impression of the size of this problem. Coefficient estimates for the samples ending in 1995–2000 are summarized by the squared norm for each of the three sets of coefficients. The size of the adjustment coefficients remains approximately constant and hardly changes to new incoming information. Conversely, the size of the remittances coefficients varies strongly. The relatively small data point in 1999 changes them completely, such that the total impact is decreased by a factor of more than 10. Together with the intrinsic standard variation of remittances, which is approximately 20 times the standard deviation of the accounts aggregates, the disappointing performance of remittance-augmented forecasting models is explained.

Thus, the main reasons for the prediction failure of the remittance-augmented error-correction model is the considerable change in the correlation between accounts variables and remittances during the prediction interval. A forecaster who makes the choice among models in 1995 cannot see this change. What is visible even in 1995, however, is the variance of the exogenous regressor, which dwarves the variance of all endogenous variables. While high variation in a regressor is usually taken as beneficial for estimation and as supporting statistical significance of a regression coefficient, in this case it also points to instabilities in dynamic interaction.

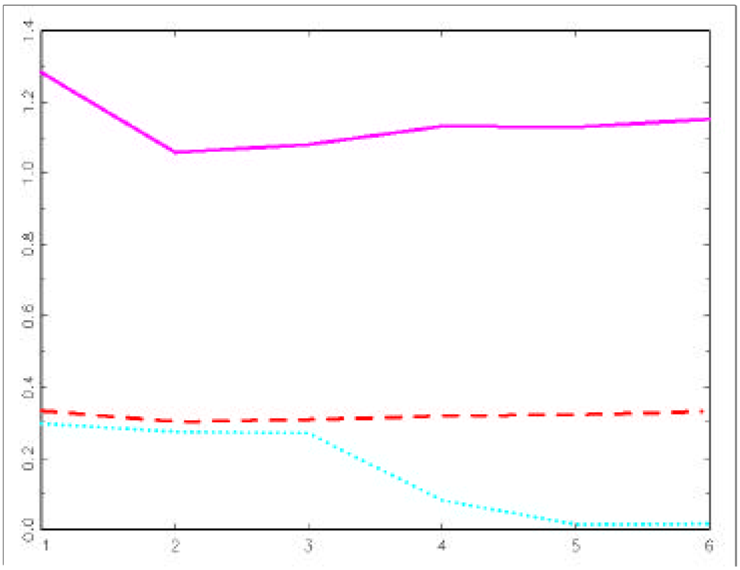

Figure 5: Estimated adjustment coefficients to error-correction terms (solid and dashed) and estimated reaction coefficient to exogenous remittances (dotted), as the sample is gradually extended from 1995 to 2000.

6 Summary and conclusion

In a panel of West African countries, we investigate the forecastability of aggregate demand. In particular, we are interested in whether data on remittance flows can be used to improve on prediction in a systematic way. We also explore the potential of asymmetric error correction with respect to prediction. The results of the prediction experiments are compared to traditional significance tests of asymmetric error correction and of the exogenous remittance variable.

We find that hypothesis tests do not indicate strongly that asymmetric adjustment plays a role in these economies. The information from the prediction experiments is slightly at odds with this finding. Predictive accuracy improves in most cases when asymmetry is accounted for.

For remittances, we find the converse result. While remittances yield significant coefficients for at least some of the accounts aggregates, they do not contribute to improved forecasting accuracy. On the contrary, prediction deteriorates considerably when remittances are added to the system. Using remittances in first differences instead of levels causes another discrepancy. While first differences are less significant than levels, this transformation causes a considerable improvement in predictive accuracy.

We review various possible sources for this discrepancy between forecasting performance and statistical tests. It appears that statistical significance of a dynamic link between economic variables is not a sufficient condition for improving predictive accuracy. If forecasting is the target of econometric modeling, comparative evaluations for parts of the available sample are a useful addendum to a pure description of the full sample.

Our results should not be seen as implying that remittance flows are unimportant in African or other economies. They simply indicate that it may be difficult to integrate this variable into econometric time-series models that are designed for forecasting. No policy recommendations should be based on these statistical results.

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Tables

Table 1: Prediction mean squared errors for single-step forecasts for the years 1996-2001, based on several variants of error-correction models.

	error correction		EC with remittances		
	linear	asymmetric	linear	asymmetric	linear Δ
Benin	0.000423*	0.000424	0.000884	0.001080	0.000576
Burkina Faso	0.000350	0.000464	0.000194*	0.000328	0.000307
Cameroon	0.00179	0.00104*			
Ghana	0.000539*	0.000544	0.00379	0.00431	0.000707
Mali	0.00402	0.00178*	0.00681	0.00442	0.00488
Niger	0.00253	0.00232*	0.00285	0.00501	0.00399
Nigeria	0.00208	0.00280	0.00222	24.565	0.00150*
Senegal	0.00226	0.00224*	0.00314	0.00276	0.00340
Togo	0.00253	0.00183	0.01094	0.00806	0.00171*

Asterisks indicate the lowest MSE value.

Table 2: Model selection statistics for the variants of the error-correction prediction models, as based on the time range ending 1995.

				variables reacting to			
	LR_{la}	LR_{lr}	$LR_{l\Delta r}$	EC_1	EC_2	re	Δ re
Benin	4.78	31.68	7.45	g, i	g, m	g	i
Burkina Faso	8.40	3.57	3.32	g, i	g	-	m
Cameroon	25.58			c	i		
Ghana	12.90	14.64	5.63	g, m, x	c, m	m	-
Mali	4.38	12.31	2.01	i	i, m, x	g, i, m	-
Niger	3.01	5.94	4.85	m	m	m	g, i
Nigeria	11.21	11.29	3.74	g, m	g, m, i	g	-
Senegal	6.15	21.17	9.86	m, x, g, i	m, i, x	m, g, x, c	m, x
Togo	20.71	5.58	8.31	x, m	m	g	i, m

Statistics LR_{la} are LR_{lr} are twice the likelihood ratio for testing the linear EC model against the asymmetric model and the EC model with remittances, respectively. Variables affecting EC_j are those, for which the t–value in the loading vectors is significant at 5%. EC_1 refers to the balanced-growth vector, while EC_2 refers to net exports. The last column gives the variables that are affected by lagged remittances.

Table 3: Model selection statistics for the variants of the error-correction prediction models, as based on the time range ending 2001.

			variables reacting to			
	LR_{la}	LR_{lr}	EC_1	EC_2	re	Δ re
Benin	"0"	6.85	m	c, m	c, g, m, x	i, m
Burkina Faso	14.71	3.02	g, i, m	i, m	-	-
Cameroon	7.43		c	i		
Ghana	8.91	3.96	m, x	c, m	m	-
Mali	3.95	9.58	i, x	i, x	g, i	-
Niger	3.73	1.49	m, x	m, x	$-$	g
Nigeria	4.51	14.78	g	i, m	g	-
Senegal	10.58	17.21	g, i	g, i	g, m, x	m, x
Togo	16.39	1.46	g, m	c, g, x	g	-

See Table 2.

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