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The Global Financial Crisis: An Anatomy of Global Growth

Troy Matheson

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The Global Financial Crisis: An Anatomy of Global Growth

Prepared by Troy Matheson*

Authorized for distribution by Hamid Faruqee

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Abstract

The global financial crisis was a stark reminder of the importance of cross-country linkages in the global economy. We document growth synchronization across a diverse group of 185 countries covering 7 regions, and pay particular attention to the period around the global financial crisis. A dynamic factor model is used to decompose each country's growth into contributions from global, regional, and idiosyncratic shocks. We find a high degree of global synchronization over 1990 to 2011, particularly across advanced economies. Examining the period around the global financial crisis, we find global shocks had large and widespread effects on growth, with more diversity in growth experiences in the early part of the recovery. In a recursive experiment, we find rising global growth synchronization just prior to the crisis, largely resulting from a shift in the importance of global shocks between countries. In contrast, the crisis period caused a much more widespread increase in growth synchronization, and was followed by a similarly pervasive decrease in synchronization in the early recovery.

JEL Classification Numbers: C11, C32, E32, F42, F41

Keywords: Globalization, Financial Crisis, Growth Synchronization

Author's E-Mail Address: tmatheson@imf.org.

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Contents

Page

Tables

Figures

I. Introduction

The global financial crisis in 2008 caused a severe and synchronized reduction in global trade and growth, and served as a stark reminder of the importance of cross-country linkages in the global economy. Nevertheless, while the crisis undoubtedly had global ramifications, there was a diversity of different growth experiences across countries. The crisis was most keenly felt by advanced economies, where trade and financial linkages are strongest. As discussed by Blanchard and others (2010), the impact was more mixed across emerging and developing economies. In this paper, our objective is to document growth synchronization across a diverse group of 185 countries over 1990 to 2011. We examine the major factors driving growth across 7 different regions, paying particular attention to the period around the global financial crisis. We also describe how the degree of growth synchronization changed over the period from just prior to the crisis to the end of 2011.

Similar to Kose and others (2012), we employ a dynamic factor model to decompose each country's growth into a global factor (capturing fluctuations common to all countries), a regional factor (capturing fluctuations common to all countries in the region), and an idiosyncratic factor (capturing country-specific fluctuations). Our analysis, however, differs from previous work in some respects.

First, the focus of our study is on the period around the global financial crisis. Much of the previous literature on global business cycle synchronization focusses on how the degree of comovement in macroeconomic aggregates changed over much longer periods of time, and use different sample periods and groups of countries.[2] For example, Kose and others (2012) find that the importance of global shocks declined during the period of globalization (1985-2005) relative to a pre-globalization period (1960-1984). Instead, our focus lies solely in the period of globalization and, in particular, on synchronization in the period around the global financial crisis. Second, we use estimation methods that allow us to incorporate annual and quarterly data and deal with missing observations, and we explicitly model global and regional growth as PPP-weighted averages of country-level growth rates. By taking account of the size of each economy (through the use of PPP weights), we can evaluate how the various factors driving growth in each country impact on measured regional and global growth. Third, we discuss historical shock decompositions. Like Kose and others (2008) and (2012), we examine variance decompositions to assess the driving forces explaining the variance of growth in each country over the entire sample. Examining historical shock decompositions also lets us analyze the contributions to growth from each shock (past and present) at every point in the sample, allowing us to make a more detailed description of particular events in the sample – such as the global financial crisis.

We find a high degree of synchronization in global growth over our sample. Global shocks are found to explain a significant proportion of the variance of world growth (77 percent), growth in Advanced Europe (80 percent), and growth in the Western Hemisphere (66 percent). In contrast, regional and idiosyncratic shocks play a more important role in the

[2] See Kose and others (2008) for a brief survey of the literature.

Commonwealth of Independent States, Asia, Sub-Saharan Africa, and the Middle East and North Africa. The results show a higher degree of synchronization across industrial economies than emerging and developing economies, supporting the findings of Kose and others (2012). Historical shock decompositions confirm that the global financial crisis was predominantly driven by global shocks, and highlight some diversity in the degree of synchronicity in the early part of the recovery, with regional and idiosyncratic shocks playing a relatively more important role in some countries.

We next conduct a recursive experiment over the period from 2005 to 2011. As a robustness check on the time series properties of our model, we briefly assess its out-of-sample forecasting performance. The model generally forecasts well relative to a simple time series benchmark; forecasting performance also tends to be better for larger and more advanced economies, where global shocks tend to be more important drivers of growth than regional and country-specific shocks. The recursive experiment also shows the importance of global shocks rising across most countries in recent years. Interestingly, the global financial crisis in 2008 does not appear to be the only catalyst for this, with the importance of global shocks rising in the pre-crisis period, 2005-07. This was not due to increased globalization across all countries but more of a shift in the importance of global shocks between countries. The results confirm that the crisis led to a widespread increase in synchronization across countries with the collapse of global demand and trade. Growth synchronization fell in early part of the recovery, reflecting the rising importance of idiosyncratic, country-specific shocks driving growth. This is perhaps not surprising. The crisis had large effects across most countries, while experiences in the recovery likely depended on each country's economic conditions prior to the crisis, and differing fiscal and monetary policy responses to the crisis itself.

The paper proceeds as follows. Sections II and III outline the methodology and estimation strategy, and section IV describes the data. The results relating to the entire sample (1990-2011) are discussed in section V, and the results from the recursive estimation experiment (2005-2011) are discussed in section VI. Section VII concludes with the key findings of the paper.

II. METHODOLOGY

A. A Model of Global Growth

We use a dynamic factor model (DFM) to decompose each country's growth into global, regional, and idiosyncratic factors. The global factor reflects common sources of variation across all countries, the regional factor reflects common sources of variation across countries within a particular region (after taking account of common global variation), and the idiosyncratic factor is specific to each country. Specifically:

$$X_{i,j,t} = A_{i,j,t}F_t + B_{i,j,t}G_{i,t} + \psi_{i,j,t} \tag{1}$$

where $X_{i,j,t}$ is (detrended and standardized)[3] year-on-year growth in country j of region i at the quarterly frequency; F_t is a global factor; $G_{i,t}$ is an orthogonal regional factor in region i; and $\psi_{i,j,t}$ is an idiosyncratic shock to growth in country j of region i. Finally, F_t, $G_{i,t}$ and $\psi_{i,j,t}$ are all assumed to be AR(1) processes:[4]

$$\begin{aligned} F_t &= CF_{t-1} + \mu_t & \mu_t &\sim i.i.d.\ N(0,\sigma) & (2)\\ G_{i,t} &= D_i G_{i,t-1} + \mu_{i,t} & \mu_{i,t} &\sim i.i.d.\ N(0,\sigma_i) & (3)\\ \psi_{i,j,t} &= E_{i,j}\psi_{i,j,t-1} + \mu_{i,j,t} & \mu_{i,j,t} &\sim i.i.d.\ N(0,\sigma_{i,j}) & (4) \end{aligned}$$

Growth in each country is thus driven by 3 orthogonal shocks, μ_t, $\mu_{i,t}$, and $\mu_{i,j,t}$: the global shock, μ_t, impacts the global factor and growth in all countries; the regional shock, $\mu_{i,t}$, impacts the regional factor and growth in all countries in the region; and the idiosyncratic shock,$\mu_{i,j,t}$, is specific to each country.

B. Modeling Annual Variables

Data for some countries are only available at the annual frequency. Nevertheless, we can incorporate annual data by constructing partially-observed quarterly series from the annual data, similar to Mariano and Murasawa (2003) and Banbura and others (2011).

Specifically, we assume that annual growth is only observed in the last quarter of each year, and utilize the fact that annual growth, X_t^A, can be approximated by the sum of (unobserved) year-over-year growth rates, X_t, at the quarterly frequency, i.e:

$$X_t^A \approx \frac{1}{4}(X_t + X_{t-1} + X_{t-2} + X_{t-3}) \tag{5}$$

where $X_t = \log(x_t) - \log(x_{t-4})$ and x_t is the level of real GDP.

The unobserved year-over-year growth rates are assumed to adopt the same structure as the growth rates observed at the quarterly frequency, which implies:

$$\begin{aligned} X_{i,j,t}^A &= \frac{1}{4}\sum_{k=0}^{3}(A_{i,j}^A F_{t-k} + B_{i,j}^A G_{i,t-k} + \psi_{i,j,t-k}^A) & & (6)\\ \psi_{i,j,t}^A &= E_{i,j}\psi_{i,j,t-1}^A + \mu_{i,j,t}^A \qquad \mu_{i,j,t}^A \sim i.i.d.\ N(0,\sigma_{i,j}^A) & & (7) \end{aligned}$$

To link the observed annual data with the unobserved quarterly data, a partially-observed quarterly series is then constructed:

$$X_{i,j,t}^A = \begin{cases} X_{i,j,t}^A, & \text{t = 4,8,12,...} \\ \text{unobserved}, & \text{otherwise} \end{cases} \tag{8}$$

[3] The rationale for detrending the data is briefly discussed in section IV.

[4] The empirical findings are very similar when AR(4) processes are used for the global and regional factors.

C. Aggregation Equations

To examine the contributors to growth at the regional and global levels, we construct aggregation equations for regional and global growth. These PPP-weighted growth aggregates are available in our database, so we treat them as observable in estimation. The following aggregation equation is used to create growth in each region:

$$X_{i,t} = \frac{1}{s_i} \sum_{j=1}^{N_i} (s_{i,j} w_{i,j} X_{i,j,t}) + \zeta_{i,t} \tag{9}$$

where s_i is the standard deviation of growth in region i, $s_{i,j}$ and $w_{i,j}$ are the standard deviation of growth and the PPP weight of country j in region i, respectively, $\zeta_{i,t}$ is a measurement error for the regional aggregate (associated with the PPP weights being fixed in our specification and time varying in the data), and N_i is the number of countries in region i.[5] Likewise, world growth is a simply the weighted average of the regional growth aggregates:

$$X_t = \frac{1}{s} \sum_{i=1}^{N} (w_i X_{i,t}) + \zeta_t \tag{10}$$

where N is the number of regions.

Finally, the measurement errors associated with the regional and world growth aggregation equations (9 and 10) are assumed to follow AR(1) processes:

$$\zeta_{i,t} = E_i \zeta_{i,t-1} + \varepsilon_{i,t} \qquad \varepsilon_{i,t} \sim i.i.d.\ N(0, \sigma_i^{\varepsilon}) \tag{11}$$

$$\zeta_t = E \zeta_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim i.i.d.\ N(0, \sigma^{\varepsilon}) \tag{12}$$

D. Methodological Limitations

The determinants of growth in each country will depend on the regional classifications applied to each country. Thus, alternative groupings of countries will produce different results, particularly those relating to the importance of regional and idiosyncratic shocks. Moreover, the methodology is unable to capture the underlying source of global and regional shocks. For example, it is highly likely that the shock that caused the global financial crisis emanated from the United States. However, the model would attribute the strong comovement in growth that resulted from this shock to be a global event, not a shock specific to the United States that went on to have had global ramifications.

[5] Allowing for time-varying weights significantly increases the computational cost of estimation. Since the weights are relatively stable over the sample period for most countries, for simplicity, we assume they are fixed. Experimentation with a model with time-varying weights and fewer countries suggests that relaxing this assumption would have very little impact on our empirical findings. Since $X_{i,j,t}$ is standardized, aggregation requires multiplying each country's standardized growth rate by its standard deviation.

III. Estimation

The model is estimated by maximum likelihood using the Expectation Maximization (EM) algorithm. Estimating via maximum likelihood allows us deal with missing observations, parameter restrictions, and serial correlation in the idiosyncratic components. The approach was proposed for large data sets by Doz, Giannone, and Reichlin (2012) and extended to deal with missing observations and serially correlated errors by Banbura and Modugno (2010). Essentially, the EM algorithm consists of iterating the two-step procedure proposed by Doz, Giannone, and Reichlin (2011): the factors and parameters are first estimated using principal components and OLS, then the factors are re-estimated using the Kalman Filter. The EM algorithm essentially repeats these two steps until the likelihood function is maximized.[6] See Banbura and Modugno (2010) for more details on the implementation of the EM algorithm, and Banbura, Giannone, and Reichlin (2011) for an application that employs a factor model with a block structure similar to that used in this paper.

IV. Data

The source of all data is the World Economic Outlook (WEO) database, and our sample begins in 1990Q1 and ends in 2011Q4. GDP data for 185 countries are categorized into the following 7 regions:[7]

1. Advanced Europe (24 countries)
2. Emerging Europe (14 countries)
3. Commonwealth of Independent States (13 countries)
4. Asia (34 countries)
5. Western Hemisphere (35 countries)
6. Sub-Saharan Africa (44 countries)
7. Middle East and North Africa (21 countries)

Year-over-year percentage changes are used to transform the series available at the quarterly frequency, while annual percentage changes are used to transform the series available at the annual frequency.[8] After transformation, many of the growth series for emerging and

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[6] We employ the same stopping rule as in Doz, Giannone, and Reichlin (2011). The EM algorithm converges in fewer than 20 iterations.

[7] The regional groupings used in the WEO are largely based on geographical groupings of countries. Analysis of different grouping of countries is beyond the scope of this paper and left for future work.

[8] Around one third of the countries in the sample have series available at the quarterly frequency. Note, the IMF has called on Argentina to adopt remedial measures to address the quality of its official GDP data.

developing economies show some degree of non-stationarity over our sample period, reflecting, for example, structural changes, and different stages of development. Thus, we detrend growth using potential output growth and then standardize each series.

We use one of 3 methods to estimate the potential output, depending on whether or not potential output data exist in the WEO database. If potential output does not exist, we employ an HP filter capable of incorporating judgement, with the smoothing parameters set to standard values for the quarterly and annual series. The algorithm used to detrend each series is:

- If WEO estimates of potential output growth exist for the full sample, use them to detrend growth;
- If WEO estimates of potential output growth do not exist, use the HP filter to estimate potential output with the following judgements:
  - fix the start point of potential growth match average GDP growth over the first 10 years of available data;
  - fix the end point of potential growth to match GDP growth in the final year of the WEO projection horizon, 2015Q4 (if projections do not exist, use average GDP growth over the last 10 years of available data);
- If WEO estimates of potential output exist but the available sample size is smaller than that of GDP, use HP-augmented WEO estimates (i.e., fill in gaps in the WEO potential output data with HP-filtered estimates, using the same assumptions as above).

V. Results, 1990-2011

A. Variance Decompositions

A useful way of examining the driving forces behind growth is to look at variance decompositions, which allow us to decompose the variance of growth into contributions from global, regional, and idiosyncratic shocks. Table 1 shows variance decompositions for the growth aggregates at various horizons, ranging from 1 to 20 quarters ahead, and unconditional variance decompositions. The unconditional variance decompositions for each individual country can be found in appendix I.

We find that idiosyncratic shocks tend to explain a large share of growth variation at shorter horizons, and global shocks become increasingly important at longer horizons. Global shocks explain a significant proportion of the unconditional variance of world growth (77 percent), growth in Advanced Europe (80 percent), and growth in the Western Hemisphere (66 percent). In contrast, regional and idiosyncratic shocks play a more important role in the Commonwealth of Independent States, Asia, Sub-Saharan Africa, and the Middle East and North Africa.

Overall, the results suggest that global shocks are more important for industrial economies than they are for emerging and developing economies, supporting the findings of Kose and others (2012). Indeed, the median share of growth explained by global shocks is 64 percent across industrial economies and only 13 percent across emerging and developing and developing economies.[9] Put differently, this shows industrial economies tend to have greater importance in the global factor and that industrial economies share much greater linkages with each other than with emerging and developing economies.

Table 1: Forecast Error Variance Decomposition, Annual Growth (quarters ahead), 1990-2011

	1	4	8	12	20	40
WORLD						
World	0.33	0.68	0.74	0.76	0.77	0.77
Regional	0.04	0.07	0.07	0.07	0.07	0.07
Idiosyncratic	0.64	0.25	0.19	0.17	0.17	0.16
ADVANCED EUROPE						
World	0.29	0.74	0.81	0.82	0.81	0.80
Regional	0.02	0.05	0.07	0.08	0.10	0.11
Idiosyncratic	0.69	0.20	0.12	0.10	0.09	0.09
EMERGING EUROPE						
World	0.09	0.32	0.44	0.48	0.50	0.50
Regional	0.01	0.03	0.05	0.06	0.07	0.08
Idiosyncratic	0.90	0.65	0.51	0.46	0.44	0.43
COMMONWEALTH OF IND STATES						
World	0.04	0.12	0.15	0.16	0.16	0.16
Regional	0.11	0.33	0.38	0.38	0.37	0.37
Idiosyncratic	0.85	0.55	0.47	0.46	0.46	0.47
ASIA						
World	0.06	0.21	0.26	0.28	0.30	0.30
Regional	0.07	0.22	0.25	0.26	0.26	0.26
Idiosyncratic	0.87	0.57	0.48	0.45	0.44	0.43
WESTERN HEMISPHERE						
World	0.23	0.56	0.62	0.64	0.66	0.66
Regional	0.01	0.02	0.01	0.01	0.01	0.01
Idiosyncratic	0.76	0.43	0.36	0.34	0.33	0.33
SUB-SAHARAN AFRICA						
World	0.03	0.07	0.10	0.11	0.11	0.11
Regional	0.13	0.37	0.51	0.55	0.56	0.56
Idiosyncratic	0.84	0.55	0.39	0.35	0.33	0.33
MIDDLE EAST/NORTH AFRICA						
World	0.03	0.07	0.10	0.11	0.12	0.12
Regional	0.19	0.46	0.57	0.59	0.58	0.57
Idiosyncratic	0.79	0.47	0.32	0.30	0.30	0.31

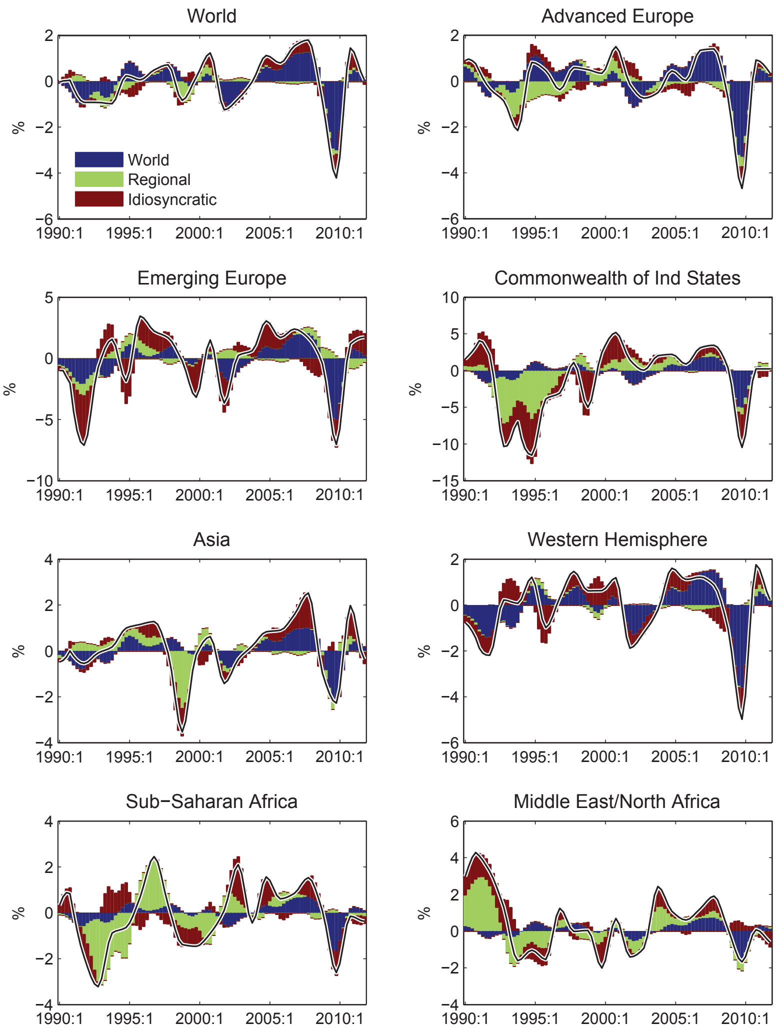
B. Historical Shock Decompositions

Annual growth in each region is decomposed into contributions from global, regional, and idiosyncratic shocks in figure 1. Historical shock decompositions for each country can be found in the appendix II (figures 5 to 19). The strong period of global growth just prior to the global financial crisis (2003 to 2007) was predominantly driven by global factors across most regions. While global shocks were important in boosting growth in Asia over this period, idiosyncratic shocks also had a relatively important role to play in the region.

With the onset of the crisis in 2008, we see a sharp slowdown in growth across all regions, largely driven by global shocks. In contrast, the early part of the recovery seems only partly

[9] The group of industrial economies includes all countries in the Advanced Europe region, Australia, Canada, Japan, New Zealand, and the United States.

Figure 1: Historical Shock Decompositions, Annual Growth



driven by global shocks with some diversity across countries, reflecting differences in contributions from regional and idiosyncratic shocks. The initial recovery in growth was relatively weak across the Commonwealth of Independent States, Sub-Saharan Africa, and the Middle East and North Africa.

The rising importance of idiosyncratic shocks across Emerging Europe, Asia, and the Western Hemisphere may partly reflect differing policy responses to the crisis. For example, China's policy response to the crisis was widely viewed as being particularly large, helping to boost domestic growth in China amid a massive deterioration in global trade. This is supported by historical shock decompositions for China (figure 9), where idiosyncratic shocks acted to boost growth through the crisis and the early part of the recovery.

Looking more closely at the impact of regional shocks, we see particularly large contributions in the earlier part of the sample across most regions. Moreover, many of the episodes with strong regional contributions to growth can be traced back to significant economic events for each region. Some examples of such events are: the significant slow down in growth in the early 1990s in Advanced Europe, with recessions in many key countries including Germany and the United Kingdom; the sharp reduction in growth in the Commonwealth of Independent States following the break up of the Soviet Union in 1991; the sharp reduction in growth in Asia following the Asian crisis in 1997; the significant slowdown and recovery in Sub-Saharan Africa in the mid 1990s, largely following the economic fortunes of South Africa and Kenya; the strong growth in the early 1990s in the Middle East and North Africa, with Iran rebuilding after the ending of the Iran-Iraq war and both Iran and Saudi Arabia boosting oil production after the Iraqi invasion of Kuwait in 1990.

VI. A Recursive Experiment

The results discussed so far show a high degree of global growth synchronization over a sample spanning 1990Q1 to 2011Q4. In this section, we assess the forecasting performance of our model and evaluate how the importance of the various factors driving growth have changed over the past 6 years, covering a few years prior to the global financial crisis, the crisis itself, and the early phase of the recovery. In the experiment, we recursively estimate the model each quarter over an out-of-sample period spanning 2005Q4 to 2011Q4, producing 25 different estimates of the global, regional, and idiosyncratic factors, together with forecasts of growth. Each time the model is estimated, the start of the sample is fixed to 1990Q1: for example, the first sample in the out-of-sample period contains data ranging from 1990Q1 to 2005Q4 and the final sample contains data ranging from 1990Q1 to 2011Q4.[10]

A. Forecast Evaluation

As a robustness check on the time series properties of our model, we evaluate its forecasting performance by comparing Root Mean Squared Errors (RMSEs) for year-ahead growth to RMSEs from a simple autoregressive benchmark, an AR(1).[11] For the series observed at the annual frequency, the autoregressions are estimated using the recursively-computed quarterly growth estimates from the DFM, and the factor model forecasts are evaluated against quarterly growth estimated over the entire sample.

The results of the forecasting experiment are displayed in table 2. The second column shows the RMSEs of the aggregate groups relative to those of the benchmark model, where a

[10]The results are qualitatively similar when a rolling estimation scheme is used, where the sample size is fixed to match that of the first quarter of the out-of-sample period. We chose to present results for a recursive scheme to help preserve degrees of freedom for the series that are observed at the annual frequency. For example, fixing the sample to 15 years means we would only have 15 observations for the countries with annual data each time the model is estimated, and even fewer observations for countries with annual data that begin after 1990.

[11]In preliminary analysis, we experimented with using several different information criteria to determine the lag length of the AR, with lags ranging from 1 to 4. We also tried fixing the lag length of the AR to 4, and using a more naive forecast where growth was forecast to be its historical average. We found that the simple AR(1) generally outperformed, often very significantly, the other benchmarks considered.

number less than one indicates relatively good forecasting performance from the DFM; the final column of the table shows the share of countries in each aggregate for which the DFM produces better forecasting performance than the benchmark. The relative forecasting performance for each country can be found in the appendix I (the final column of the table).

While the out-of-sample period is rather short, the results at the aggregate level are striking. For all aggregate groups except the Middle East and North Africa, we find that the DFM produces lower RMSEs than the benchmark model. The results are slightly less emphatic at the country level, with the DFM outperforming the benchmark in only 60 percent of countries in our sample. However, the vast majority of countries where the DFM performs relatively poorly are emerging and developing economies, where idiosyncratic shocks tend to be relatively important. The model performs much better for larger and more advanced economies. For example, the DFM outperforms the benchmark for all but one of the 24 countries in the Advanced Europe region, and the larger economies in Sub-Saharan Africa (South Africa and Kenya). Indeed, the DFM outperforms the benchmark for all G-20 countries, with Indonesia, Turkey, and Saudi Arabia being the only exceptions.

Table 2: Forecasting Performance, Annual Growth, 2005Q4-2011Q4

	RMSE, year ahead (relative to AR)	Lower RMSE for DFM (share of countries)
World	0.52	0.60
Advanced Europe	0.53	0.96
Emerging Europe	0.64	0.64
Commonwealth of Ind. States	0.54	0.62
Asia	0.61	0.53
Western Hemisphere	0.58	0.83
Sub-Saharan Africa	0.45	0.45
Middle East and North Africa	1.95	0.19

B. How Have the Factors Driving Growth Changed?

To evaluate how the contributors to growth have changed over the past 6 years, figure 2 displays (unconditional) variance decompositions for the aggregate series, computed at the end of each year from 2005 to 2011. The heat map in the bottom panel shows results for changes in the share of growth variance explained by global shocks for each country from 2005 to 2011. The changes are classified into four categories, based on the magnitude and sign of the change in question: *less* and *more* reflect changes in the share of variance explained that are less than -5 percent and more than 5 percent, respectively; *slightly less* and *slightly more* reflect changes that are between -5 percent and 0 and 5 percent and 0, respectively.

The top panel of figure 2 shows that the importance of global shocks has increased at the global level, while the importance of regional shocks has fallen. The rise in importance of global shocks is slightly larger than the fall in importance of regional shocks, leaving country-specific shocks slightly less important at the end of the sample than in 2005. Interestingly, the rising importance of global shocks is not only the result of the global financial crisis in 2008, with the share of variance explained by global shocks rising in each year prior to crisis. We also find that the degree of global synchronization peaks in 2009 and begins to edge down over 2010 and 2011.

Looking across regional aggregates, we find growing global synchronization across Advanced Europe, the Commonwealth of Independent States, Asia, and the Western Hemisphere. In contrast, the importance of global shocks remained at relatively low levels across Emerging Europe, Sub-Saharan Africa, and the Middle East and North Africa. However, within these regions, the degree of regional synchronization seems to have increased slightly, with a slight fall in the importance of country-specific shocks. The bottom panel of figure 2 shows that the increase in importance of global shocks was indeed widespread across countries over 2005 to 2011, with some countries in Africa and the Middle East, and India, being notable exceptions.

To better evaluate changes in growth synchronization, we look at changes in the importance of global shocks and total synchronization (the importance of both global and regional shocks) over three periods: pre-crisis (2005-2007), crisis (2007-2009), and post-crisis (2009-2011). Figures 3 and 4 show changes in global and total growth synchronization around the crisis, respectively, where the classifications of the changes are the same as in the bottom panel of figure 2.

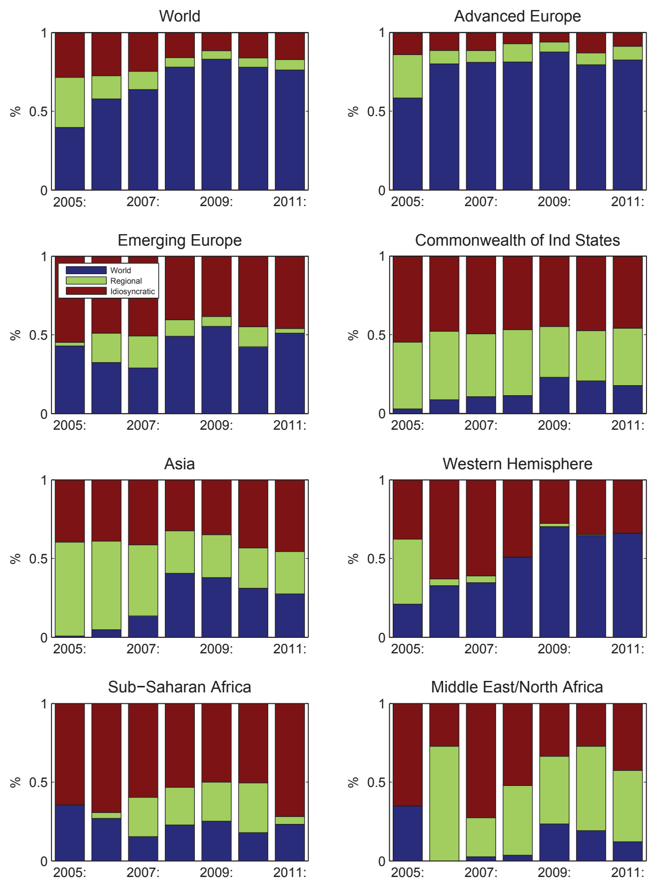
In the pre-crisis period, we see that parts of South America, Europe, central Africa, and Mexico and Russia became more synchronized with the rest of the world, with a slight fall in synchronization across the United States and Canada and large parts of Asia. In Asia, Japan became more synchronized with the rest of the world, which helps to explain the rising importance of global shocks in the pre-crisis period for the Asia region as a whole (see figure 2). Overall, we see the rising importance of global shocks at the aggregate level in the pre-crisis period was not due to increased globalization across all countries but more a shift in the importance of global shocks across countries.

Not surprisingly, the crisis period shows a widespread increase in the importance of global shocks. The effects of the global shocks were seen in the majority of countries, with notable exceptions being some emerging and developing countries in Africa and the Middle East, and India. In contrast, the post-crisis period showed a broad-based decline in the importance of global shocks, suggesting a diversity of experiences across countries in the early part of the recovery. This, too, is perhaps not surprising. The crisis had large effects across the most countries in the world, while experiences in the recovery likely depended on each country's economic conditions prior to the crisis, and differing fiscal and monetary policy responses to the crisis itself.

There is more diversity across regions with respect to the importance of synchronization more generally, after accounting for contributions from both global and regional shocks. By this measure, an increase/decrease in the importance of global and regional shocks necessarily implies a decrease/increase in the importance of idiosyncratic shocks. In the

Figure 2: Recursive Variance Decompositions, Annual Growth

(a) Aggregates



(b) Change in Importance of Global Shocks, 2005-2011

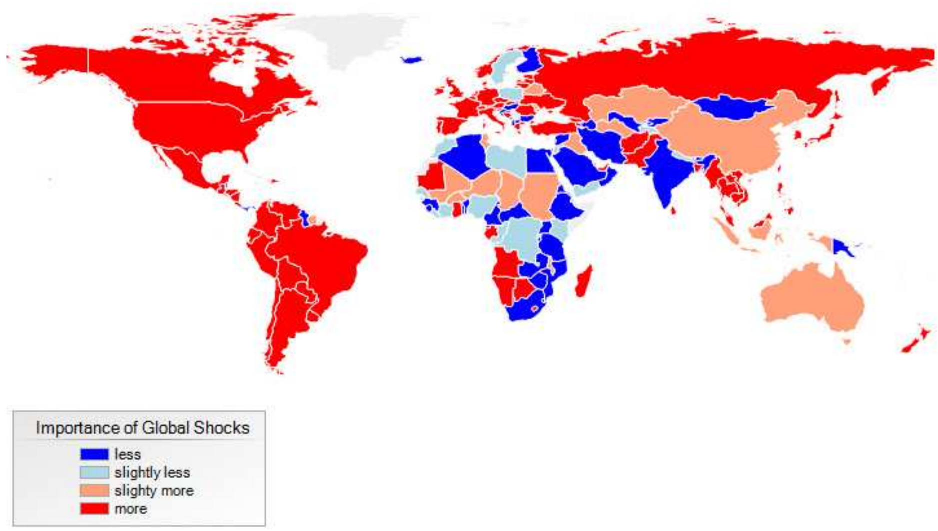
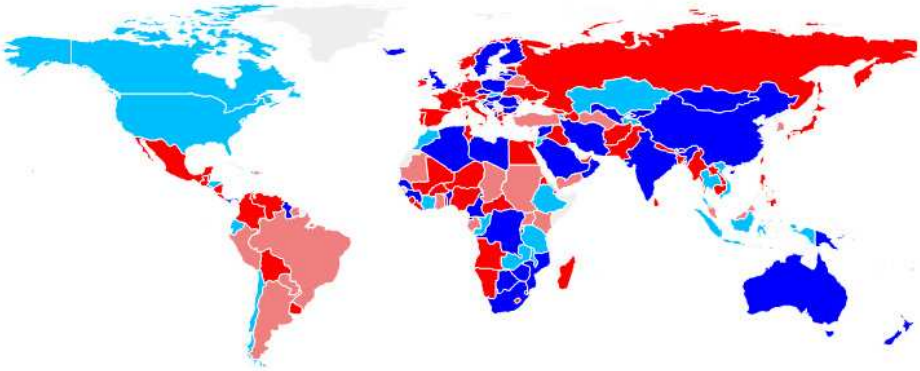
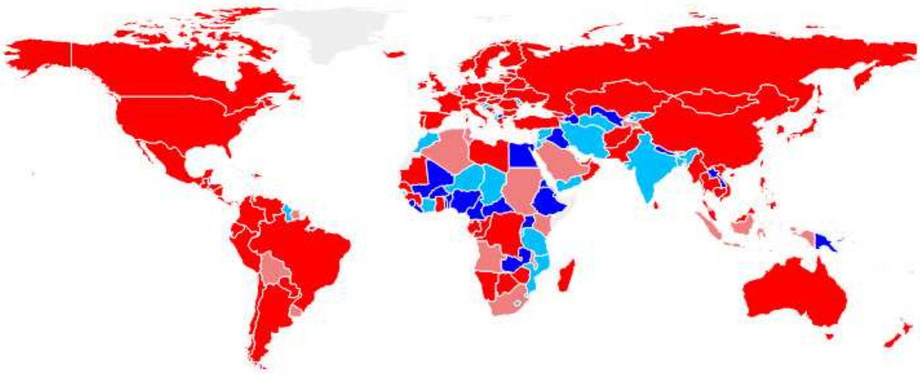


Figure 3: Change in Importance of Global Shocks

(a) Pre-Crisis, 2005-2007



(b) Crisis, 2007-2009



(c) Post-Crisis, 2009-2011

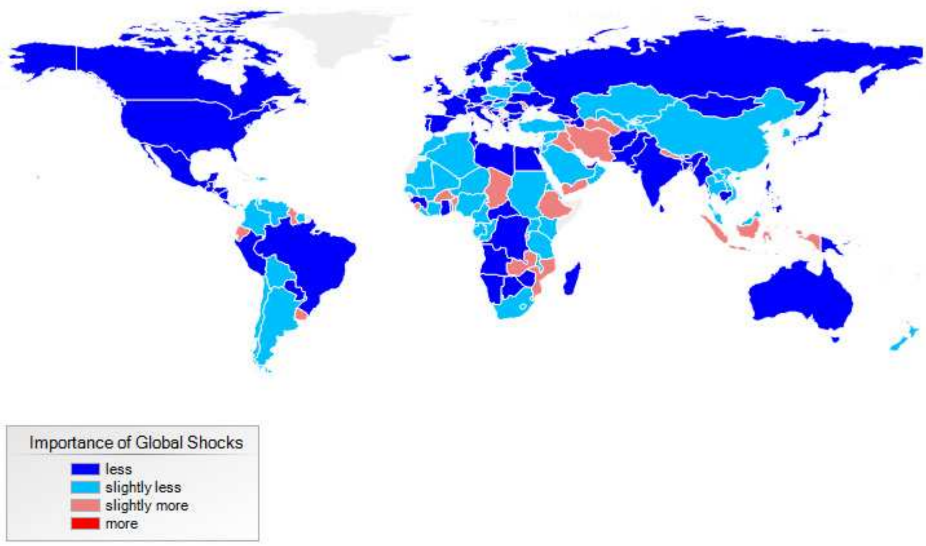
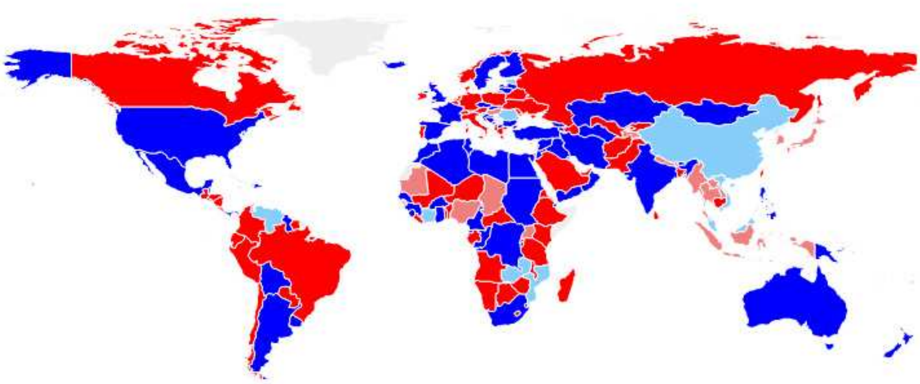
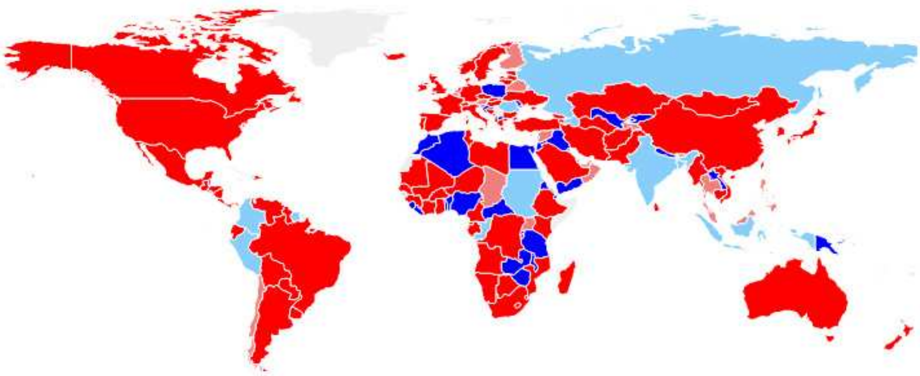


Figure 4: Change in Total Synchronization

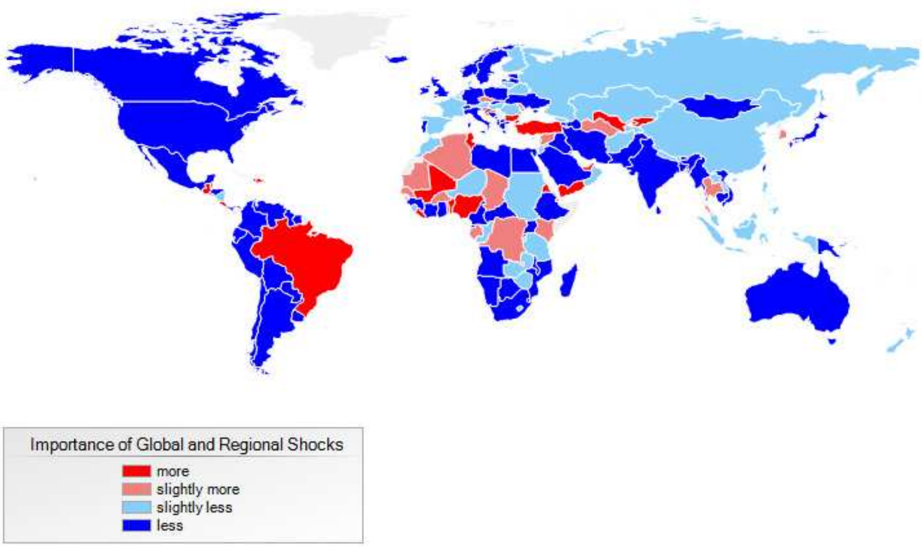
(a) Pre-Crisis, 2005-2007



(b) Crisis, 2007-2009



(c) Post-Crisis, 2009-2011



pre-crisis period, we find broadly similar results to the findings for global synchronization. Total synchronization increased in parts of South America (e.g., Brazil and Chile), Africa, the Middle East, and Europe. Interestingly, several advanced economies that experienced rapidly-increasing house prices in the pre-crisis period (the United States, United Kingdom, Spain, Australia, and New Zealand) became less synchronized (more idiosyncratic). Contrasting the results with our findings for global synchronization, we see some countries (notably, Canada, Saudi Arabia, and Indonesia) became slightly less synchronized globally, but this was more than offset by an increase in regional synchronization. Looking at the results for Advanced Europe, we also see that while France and Spain became more synchronized globally, and this was offset by a reduction their importance in the region.

Similar to the results for global synchronization, we find a widespread increase in total synchronization across countries in the crisis period. Notable differences between the results for global and total synchronization include a reduction in the importance of Russia in the Commonwealth of Independent States and Indonesia in Asia. Similarly, as with global synchronization, total synchronization fell in most countries in the post-crisis period. Some countries in Africa and Brazil became more synchronized after the crisis, despite becoming less synchronized globally, reflecting their rising importance in their respective regions.

Overall, the results show that, for many countries, not only did global growth synchronization fall in early part of the recovery but growth also became more idiosyncratic relative to the crisis period. The scale and breadth of the global financial crisis represented a truly global shock and highlighted the importance of cross-country linkages and globalization. The evidence presented here suggests that globalization forces were at work in the few years prior to the crisis.

VII. Summary and Conclusion

We examined global growth synchronization across a diverse group of 185 countries, and found a high degree of synchronization over the period from 1990 to 2011. Global shocks were found to explain a significant proportion of the variance of world growth (77 percent), growth in Advanced Europe (80 percent), and growth in the Western Hemisphere (66 percent). In contrast, regional and idiosyncratic shocks were found to play a more important role in the Commonwealth of Independent States, Asia, Sub-Saharan Africa, and the Middle East and North Africa. The results show a higher degree of synchronization across industrial economies than emerging and developing economies, thus supporting the findings of Kose and others (2012). An analysis of historical shock decompositions confirmed that global financial crisis was predominantly driven by global shocks, and also highlighted some diversity in growth experiences in the early part of the recovery, with regional and idiosyncratic shocks playing an increasingly important role in some countries.

In a recursive experiment over 2005 to 2011, we found that our model produced good forecasting performance relative to a simple time series benchmark, and that the model tended to forecast better for larger and more advanced economies, where global shocks tend to be more important drivers of growth. The recursive experiment also showed the importance of global shocks rising across most countries in recent years. The global financial crisis does not appear to be the catalyst for this, with the importance of global shocks rising in the years just prior to the crisis. Moreover, we find that this was not due to increased synchronization across all countries but more of a shift in the importance of global shocks between countries. The results also showed that the crisis led to a widespread increase in global growth synchronization and a similarly pervasive fall in synchronization in the early part of the recovery. The growing diversity of experiences in the recovery likely reflects each country's economic conditions prior to the crisis, and differing fiscal and monetary policy responses to the crisis itself.

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Appendix I. Variance Decompositions and Forecasting Performance, Annual Growth, 1990-2011

Region/Country	Variance Decomposition, Unconditional			RMSE, Year-Ahead
	World Factor	Regional Factor	Idiosyncratic	(relative to AR)
Advanced Europe				
Advanced Europe	0.80	0.11	0.09	0.53
Austria	0.69	0.21	0.09	0.39
Belgium	0.72	0.10	0.18	0.86
Cyprus	0.22	0.02	0.76	0.47
Czech Republic	0.64	0.01	0.35	0.47
Denmark	0.71	0.00	0.29	0.87
Estonia	0.36	0.07	0.58	0.38
Finland	0.82	0.01	0.17	0.50
France	0.66	0.18	0.16	0.65
Germany	0.64	0.19	0.18	0.48
Greece	0.12	0.05	0.83	1.13
Iceland	0.29	0.00	0.71	0.35
Ireland	0.65	0.15	0.20	0.53
Italy	0.57	0.12	0.31	0.66
Luxembourg	0.42	0.28	0.30	0.40
Malta	0.61	0.04	0.35	0.69
Netherlands	0.85	0.07	0.08	0.46
Norway	0.65	0.00	0.35	0.54
Portugal	0.19	0.38	0.43	0.71
Slovak Republic	0.54	0.01	0.45	0.70
Slovenia	0.79	0.00	0.21	0.31
Spain	0.61	0.32	0.07	0.44
Sweden	0.73	0.03	0.24	0.50
Switzerland	0.62	0.06	0.32	0.77
United Kingdom	0.58	0.01	0.42	0.60
Emerging Europe				
Emerging Europe	0.50	0.08	0.43	0.64
Albania	0.05	0.59	0.35	9.98
Bosnia and Herzegovina	0.47	0.02	0.51	0.53
Bulgaria	0.37	0.16	0.46	0.44
Croatia	0.21	0.23	0.56	0.77
Hungary	0.42	0.15	0.43	1.24
Kosovo	0.01	0.20	0.79	6.13
Latvia	0.59	0.02	0.40	0.36
Lithuania	0.65	0.06	0.28	0.37
Macedonia, Former Yugoslav Republic of	0.50	0.00	0.50	2.02
Montenegro, Rep. of	0.66	0.24	0.10	0.47
Poland	0.37	0.32	0.31	0.76
Romania	0.29	0.50	0.20	0.60
Serbia	0.27	0.38	0.36	0.70
Turkey	0.21	0.07	0.72	1.23
Commonwealth of Ind States				
Commonwealth of Independent States (CIS)	0.16	0.37	0.47	0.54
Armenia	0.58	0.14	0.27	0.44
Azerbaijan	0.09	0.52	0.39	1.65
Belarus	0.14	0.46	0.39	0.61
Georgia	0.63	0.00	0.36	0.64
Kazakhstan	0.04	0.76	0.21	1.01
Kyrgyz Republic	0.01	0.79	0.20	0.83
Moldova	0.00	0.52	0.48	1.09
Mongolia	0.74	0.01	0.25	0.98
Russia	0.21	0.39	0.40	0.66
Tajikistan	0.00	0.99	0.01	0.77
Turkmenistan	0.01	0.62	0.37	1.53
Ukraine	0.38	0.02	0.60	0.73
Uzbekistan	0.03	0.70	0.27	4.66
Asia				
Asia	0.30	0.26	0.43	0.61
Afghanistan	0.41	0.33	0.26	1.04
Australia	0.23	0.03	0.74	0.71
Bangladesh	0.42	0.02	0.56	1.84
Bhutan	0.16	0.00	0.84	0.54
Brunei Darussalam	0.07	0.26	0.66	0.63
Cambodia	0.64	0.03	0.33	0.60
China	0.14	0.06	0.80	0.63

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Table 3 – continued from previous page

Region/Country	Variance Decomposition, Unconditional			RMSE, Year-Ahead
	World Factor	Regional Factor	Idiosyncratic	(relative to AR)
Fiji	0.04	0.03	0.93	1.19
Hong Kong SAR	0.28	0.50	0.21	0.83
India	0.29	0.00	0.71	1.54
Indonesia	0.01	0.77	0.23	0.78
Japan	0.43	0.18	0.40	0.61
Kiribati	0.05	0.25	0.70	1.47
Korea	0.08	0.70	0.22	1.25
Lao Peoples Democratic Republic	0.16	0.23	0.61	2.84
Malaysia	0.14	0.81	0.05	1.07
Maldives	0.42	0.01	0.56	0.97
Myanmar	0.15	0.15	0.70	1.03
Nepal	0.00	0.05	0.95	1.17
New Zealand	0.18	0.30	0.52	0.69
Pakistan	0.33	0.03	0.65	1.16
Papua New Guinea	0.08	0.00	0.92	4.98
Philippines	0.46	0.22	0.33	0.90
Samoa	0.31	0.03	0.66	0.40
Singapore	0.36	0.34	0.31	1.00
Solomon Islands	0.25	0.00	0.75	0.45
Sri Lanka	0.43	0.04	0.53	1.02
Taiwan Province of China	0.41	0.11	0.48	0.86
Thailand	0.10	0.80	0.10	0.77
Timor-Leste, Dem. Rep. of	0.33	0.08	0.59	1.52
Tonga	0.01	0.01	0.98	2.86
Tuvalu	0.01	0.12	0.87	1.33
Vanuatu	0.29	0.03	0.68	4.10
Vietnam	0.14	0.14	0.72	0.71
WESTERN HEMISPHERE				
Western Hemisphere	0.66	0.01	0.33	0.58
Antigua and Barbuda	0.50	0.37	0.13	0.75
Argentina	0.18	0.00	0.82	0.61
Bahamas, The	0.49	0.00	0.50	1.03
Barbados	0.76	0.02	0.22	1.10
Belize	0.01	0.13	0.86	2.30
Bolivia	0.14	0.00	0.86	0.28
Brazil	0.36	0.34	0.30	1.02
Canada	0.49	0.03	0.48	0.63
Chile	0.23	0.18	0.59	0.66
Colombia	0.26	0.09	0.64	0.72
Costa Rica	0.34	0.26	0.40	0.71
Dominica	0.10	0.22	0.68	0.53
Dominican Republic	0.16	0.01	0.83	0.90
Ecuador	0.10	0.17	0.74	0.60
El Salvador	0.40	0.02	0.57	0.62
Grenada	0.20	0.17	0.63	0.45
Guatemala	0.51	0.11	0.39	0.55
Guyana	0.01	0.10	0.89	0.72
Haiti	0.00	0.15	0.85	0.71
Honduras	0.37	0.00	0.63	0.67
Jamaica	0.25	0.14	0.61	0.91
Mexico	0.30	0.00	0.70	0.75
Nicaragua	0.63	0.02	0.35	0.72
Panama	0.11	0.17	0.73	0.70
Paraguay	0.38	0.35	0.27	0.44
Peru	0.37	0.20	0.43	0.75
St. Kitts and Nevis	0.50	0.02	0.47	0.39
St. Lucia	0.21	0.11	0.68	0.53
St. Vincent and the Grenadines	0.11	0.20	0.69	1.24
Suriname	0.06	0.13	0.80	0.91
Trinidad and Tobago	0.36	0.27	0.36	0.70
United States	0.62	0.00	0.38	0.49
Uruguay	0.25	0.00	0.75	1.04
Venezuela	0.12	0.03	0.85	0.32
Anguilla	0.66	0.28	0.06	0.82
SUB-SAHARAN AFRICA				
Sub-Saharan Africa	0.11	0.56	0.33	0.45
Angola	0.25	0.38	0.37	1.48
Benin	0.03	0.31	0.66	2.30
Botswana	0.30	0.16	0.54	0.47
Burkina Faso	0.01	0.53	0.46	1.24
Burundi	0.02	0.05	0.94	1.59
Cameroon	0.19	0.37	0.45	1.73

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Table 3 – continued from previous page

Region/Country	Variance Decomposition, Unconditional: World Factor	Regional Factor	Idiosyncratic	RMSE, Year-Ahead (relative to AR)
Cape Verde	0.35	0.00	0.65	0.87
Central African Republic	0.16	0.03	0.80	3.74
Chad	0.03	0.00	0.97	0.38
Comoros	0.02	0.00	0.98	1.70
Congo, Democratic Republic of	0.26	0.33	0.41	1.67
Congo, Republic of	0.04	0.14	0.82	0.68
C?te dIvoire	0.01	0.14	0.86	0.89
Equatorial Guinea	0.03	0.09	0.88	0.96
Eritrea	0.01	0.00	0.99	0.65
Ethiopia	0.04	0.19	0.77	8.19
Gabon	0.16	0.22	0.63	0.52
Gambia, The	0.01	0.16	0.83	0.64
Ghana	0.08	0.00	0.92	0.54
Guinea	0.23	0.09	0.67	0.49
Guinea-BiSub-Saharan Africau	0.00	0.02	0.97	3.86
Kenya	0.31	0.26	0.43	0.96
Lesotho	0.09	0.25	0.66	1.01
Liberia	0.02	0.24	0.74	4.69
Madagascar	0.26	0.02	0.72	0.58
Malawi	0.01	0.47	0.52	0.98
Mali	0.03	0.45	0.52	7.38
Mauritius	0.00	0.66	0.34	0.66
Mozambique	0.00	0.48	0.52	2.96
Namibia	0.33	0.13	0.54	0.47
Niger	0.03	0.05	0.93	1.45
Nigeria	0.05	0.14	0.81	2.64
Rwanda	0.00	0.37	0.63	2.22
Senegal	0.11	0.02	0.87	0.58
Seychelles	0.15	0.06	0.79	0.71
Sierra Leone	0.02	0.04	0.94	7.16
South Africa	0.16	0.17	0.67	0.80
Swaziland	0.00	0.02	0.98	1.38
S?o Tom? and Pr?ncipe	0.01	0.03	0.96	3.07
Tanzania	0.01	0.64	0.35	1.76
Togo	0.14	0.07	0.79	7.89
Uganda	0.04	0.25	0.70	1.07
Zambia	0.02	0.16	0.83	5.60
Zimbabwe	0.04	0.20	0.76	0.92
MIDDLE EAST/NORTH AFRICA				
Middle East/North Africa	0.12	0.57	0.31	1.95
Algeria	0.03	0.00	0.97	1.20
Bahrain	0.00	0.05	0.95	2.27
Djibouti	0.00	0.00	1.00	1.16
Egypt	0.05	0.02	0.93	2.17
Iran, Islamic Republic of	0.00	0.79	0.20	2.22
Iraq	0.08	0.37	0.55	2.24
Israel	0.28	0.09	0.63	0.83
Jordan	0.00	0.12	0.88	1.88
Kuwait	0.03	0.48	0.49	3.09
Lebanon	0.14	0.10	0.76	3.49
Libya	0.06	0.65	0.29	1.82
Mauritania	0.10	0.10	0.80	0.73
Morocco	0.00	0.12	0.88	2.20
Oman	0.05	0.02	0.93	0.64
Qatar	0.23	0.13	0.64	1.77
Saudi Arabia	0.03	0.75	0.23	1.34
Sudan	0.03	0.01	0.96	1.29
Syrian Arab Republic	0.09	0.04	0.87	2.10
Tunisia	0.04	0.11	0.85	1.70
United Arab Emirates	0.22	0.52	0.26	1.72
Yemen, Republic of	0.00	0.00	1.00	0.85

APPENDIX II. HISTORICAL SHOCK DECOMPOSITIONS, ANNUAL GROWTH

Figure 5: Historical Shock Decompositions, Advanced Europe

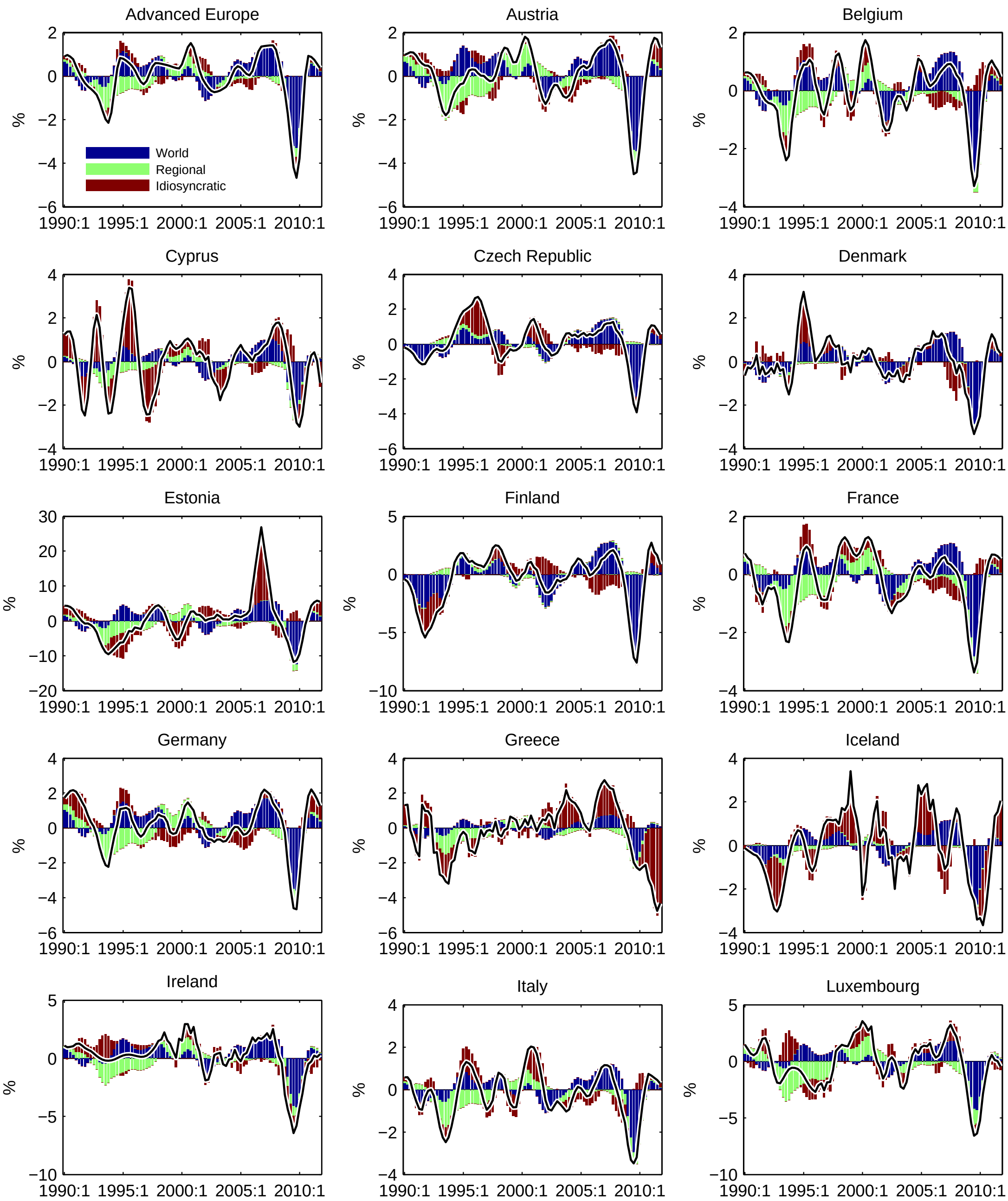

Figure 6: Historical Shock Decompositions, Advanced Europe (cont.)

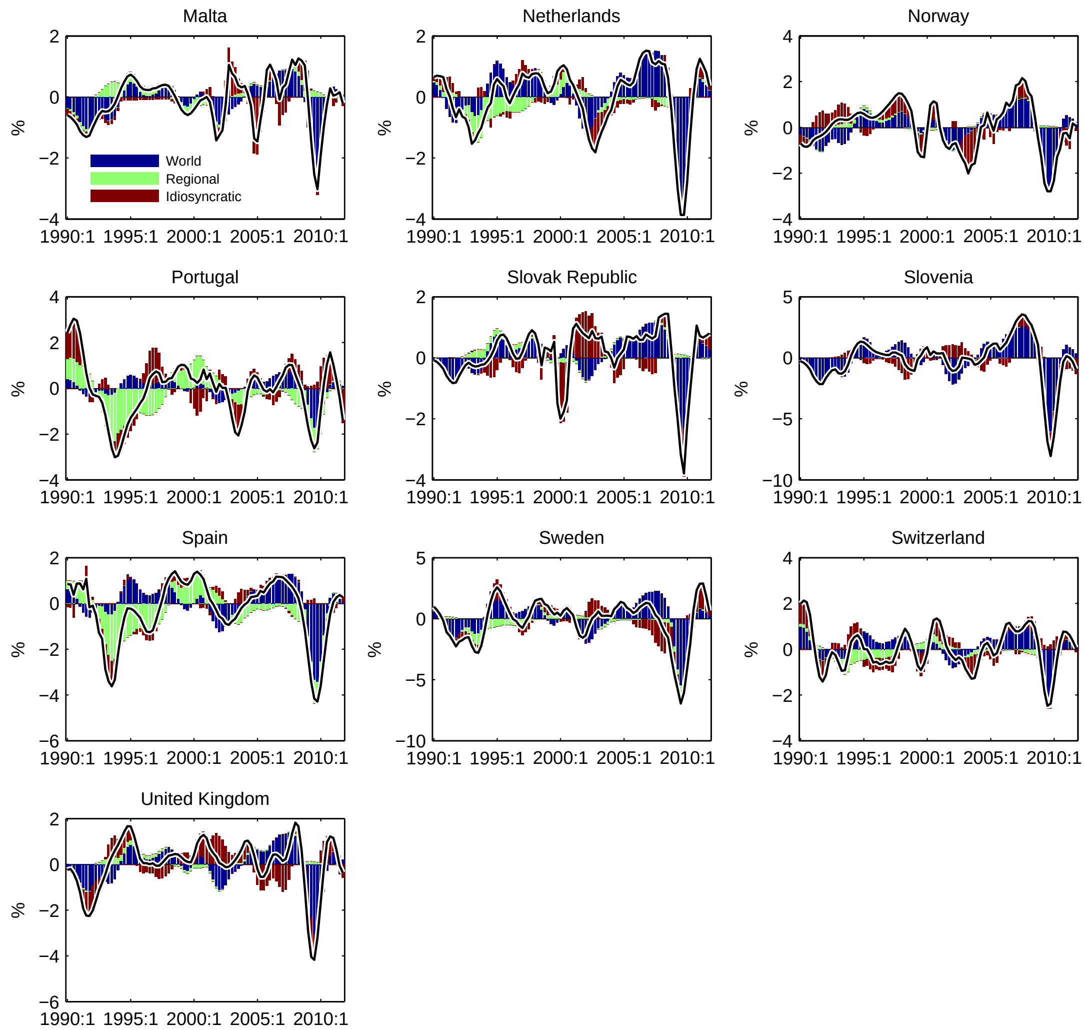

Figure 7: Historical Shock Decompositions, Emerging Europe

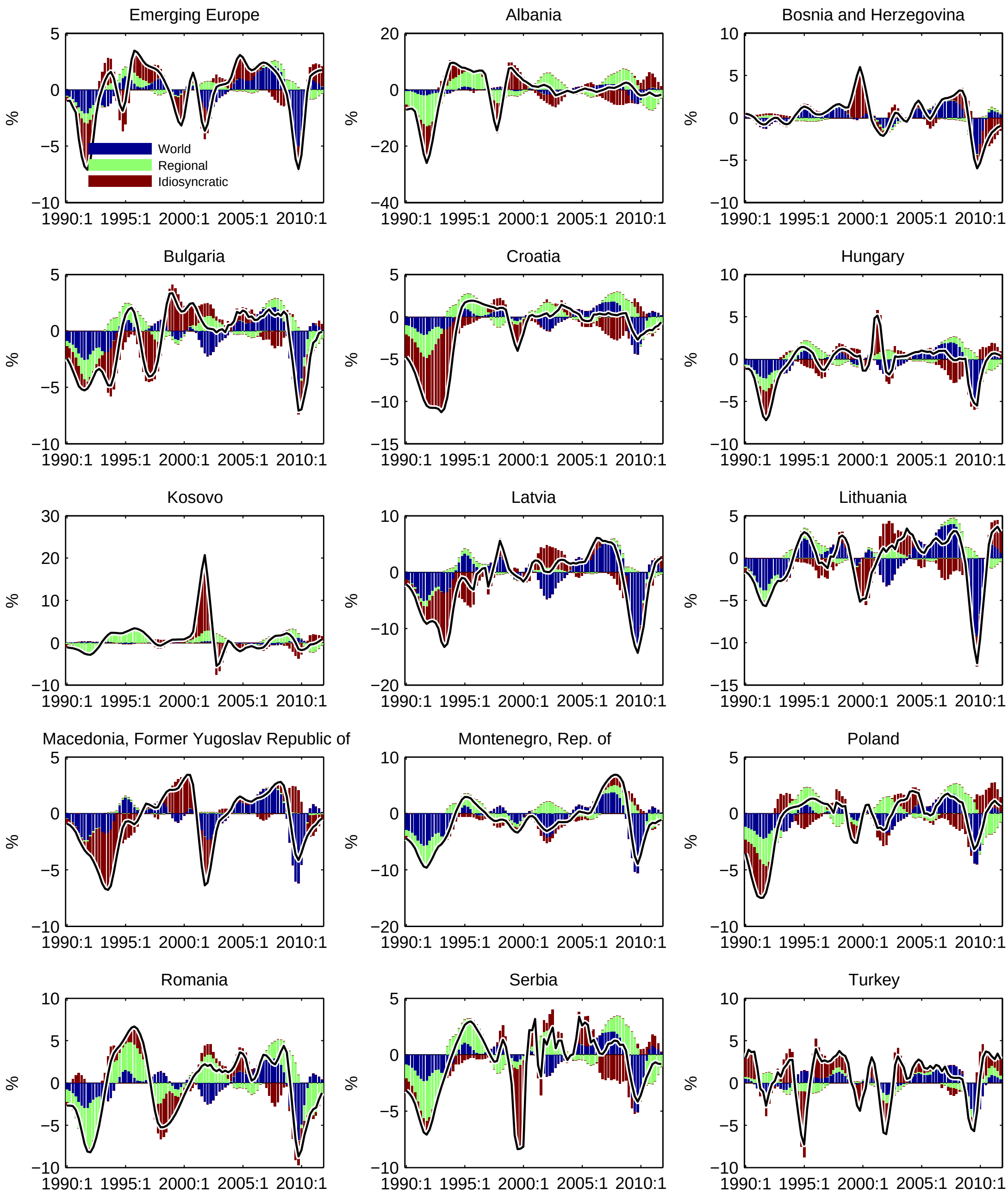

Figure 8: Historical Shock Decompositions, Commonwealth of Independent States

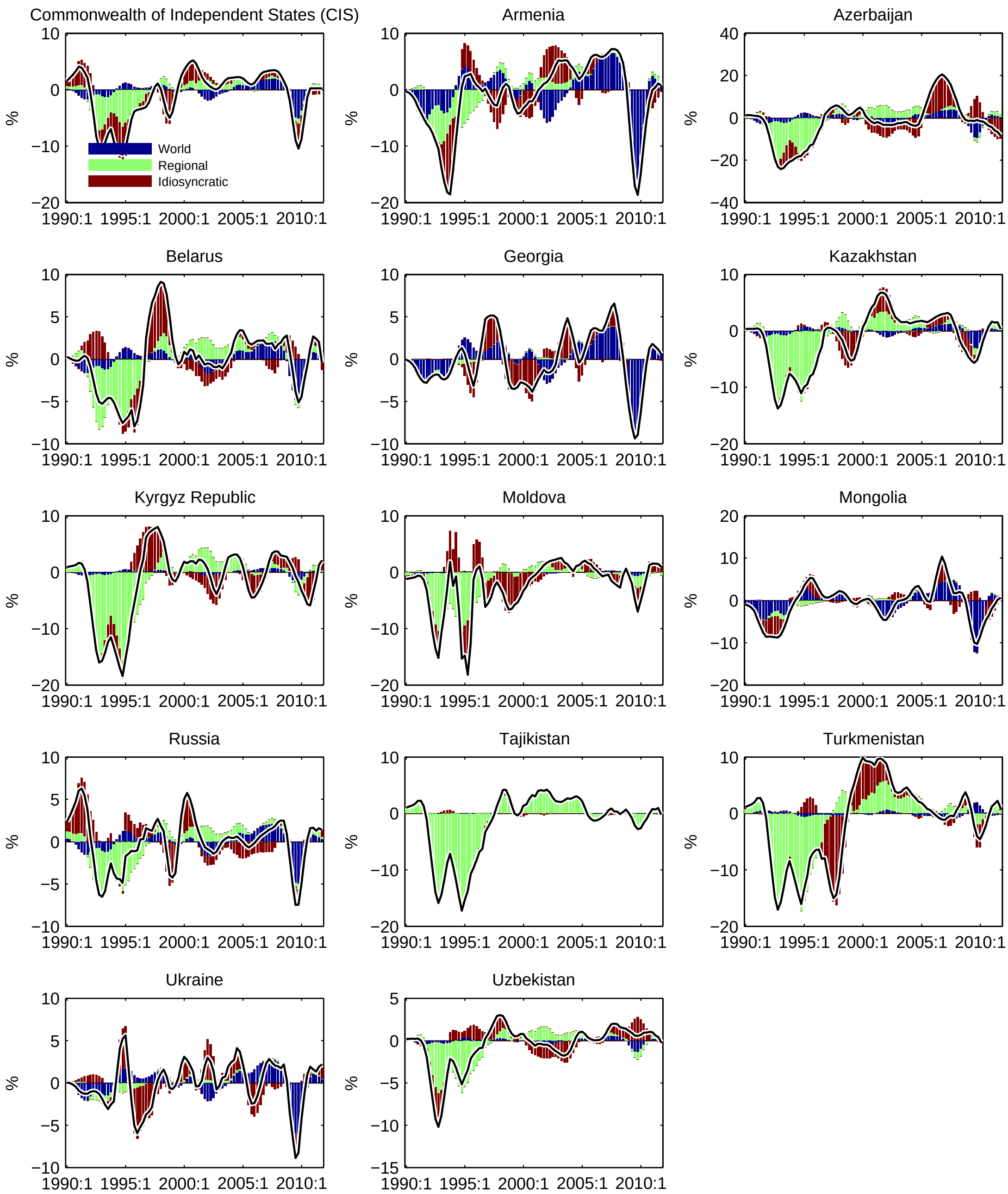

Figure 9: Historical Shock Decompositions, Asia

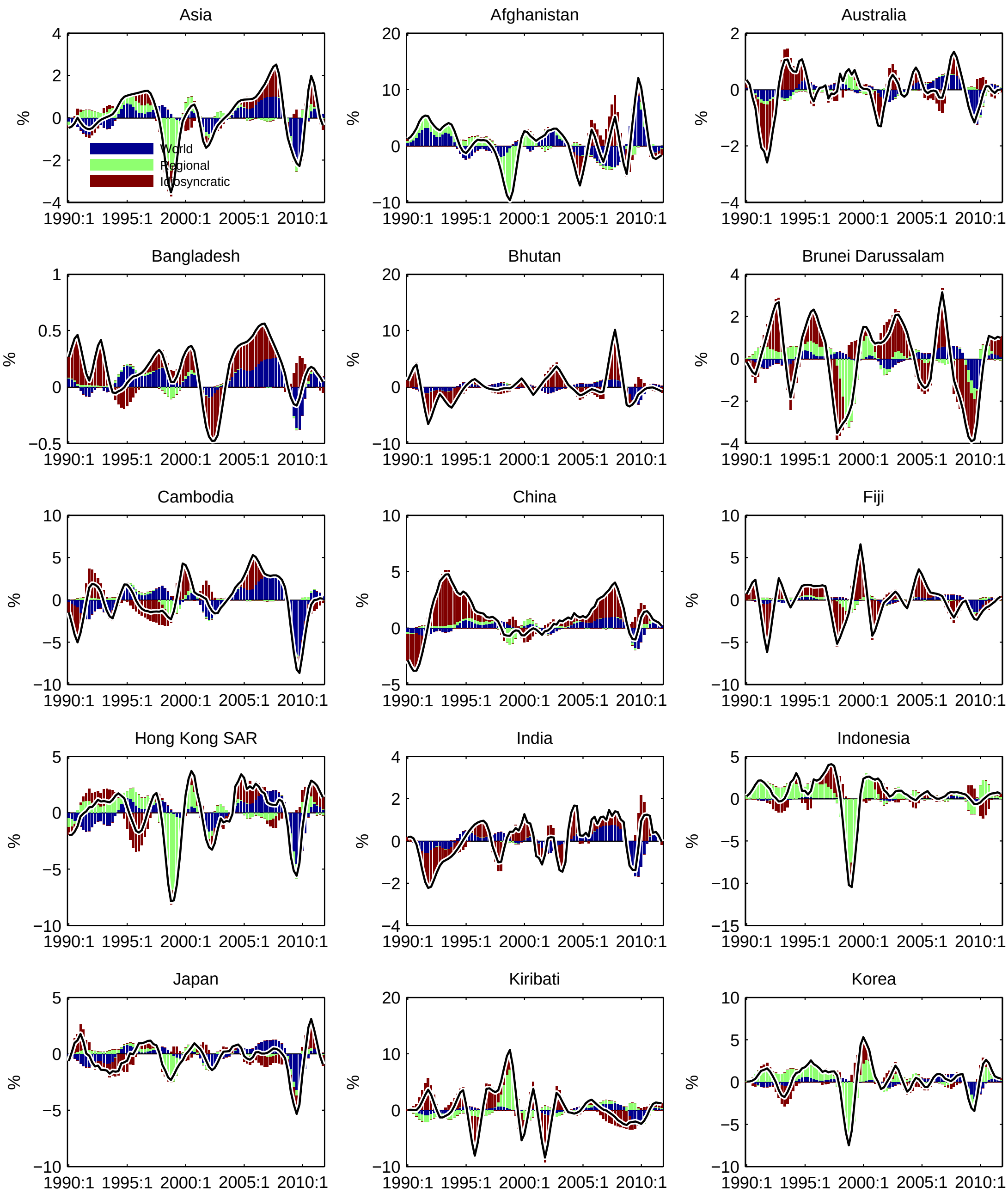

Figure 10: Historical Shock Decompositions, Asia (cont.)

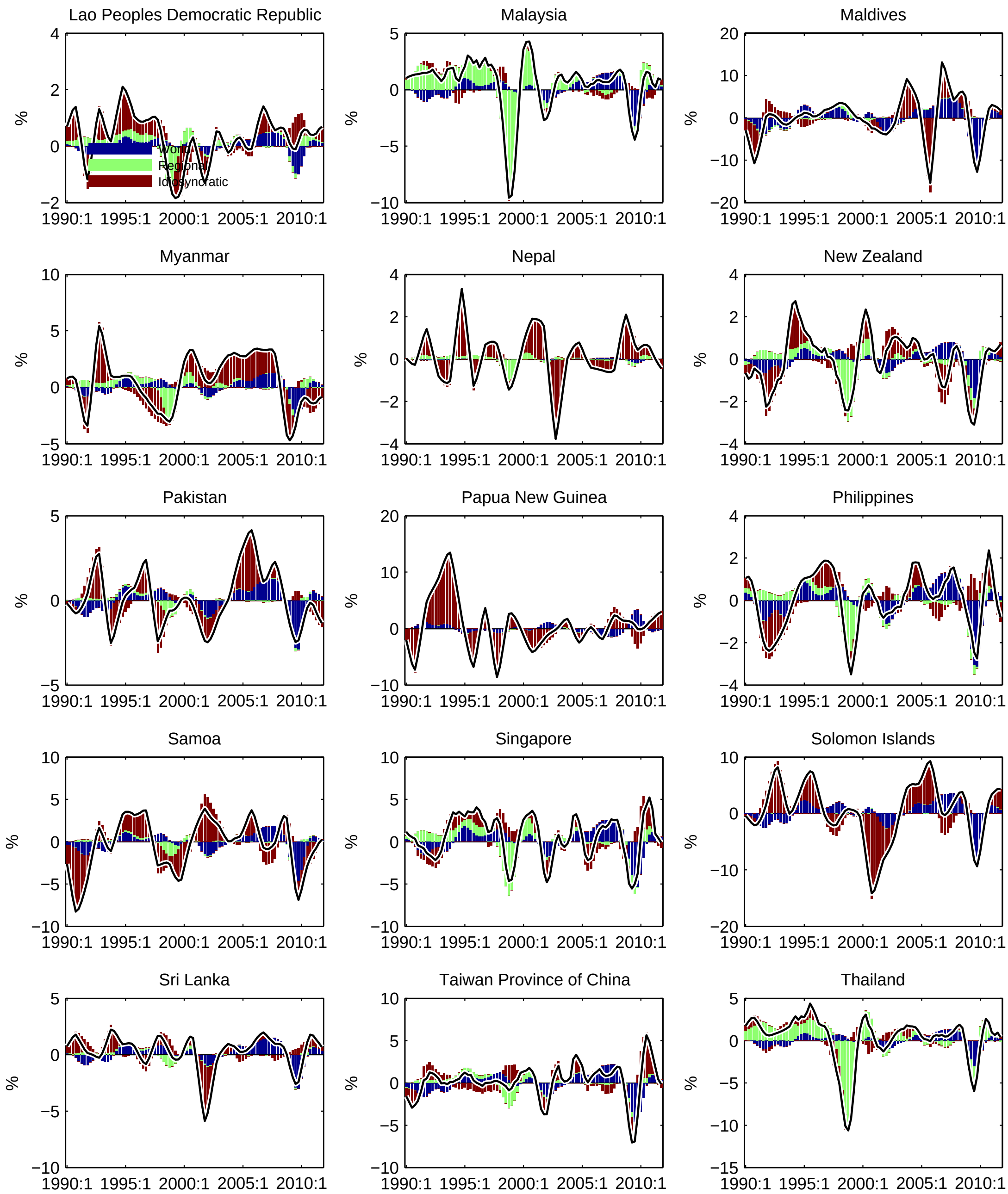

Figure 11: Historical Shock Decompositions, Asia (cont.)

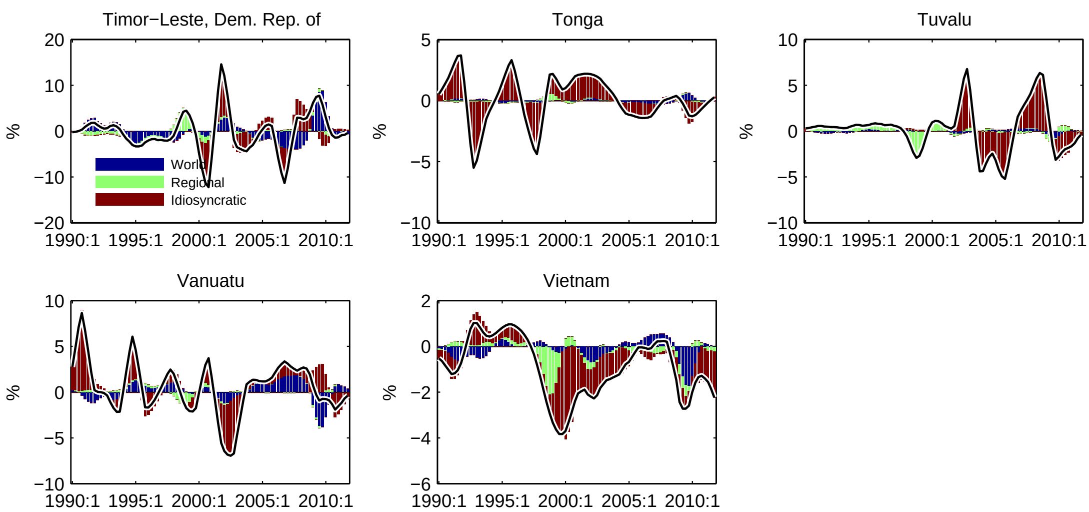

Figure 12: Historical Shock Decompositions, Western Hemisphere

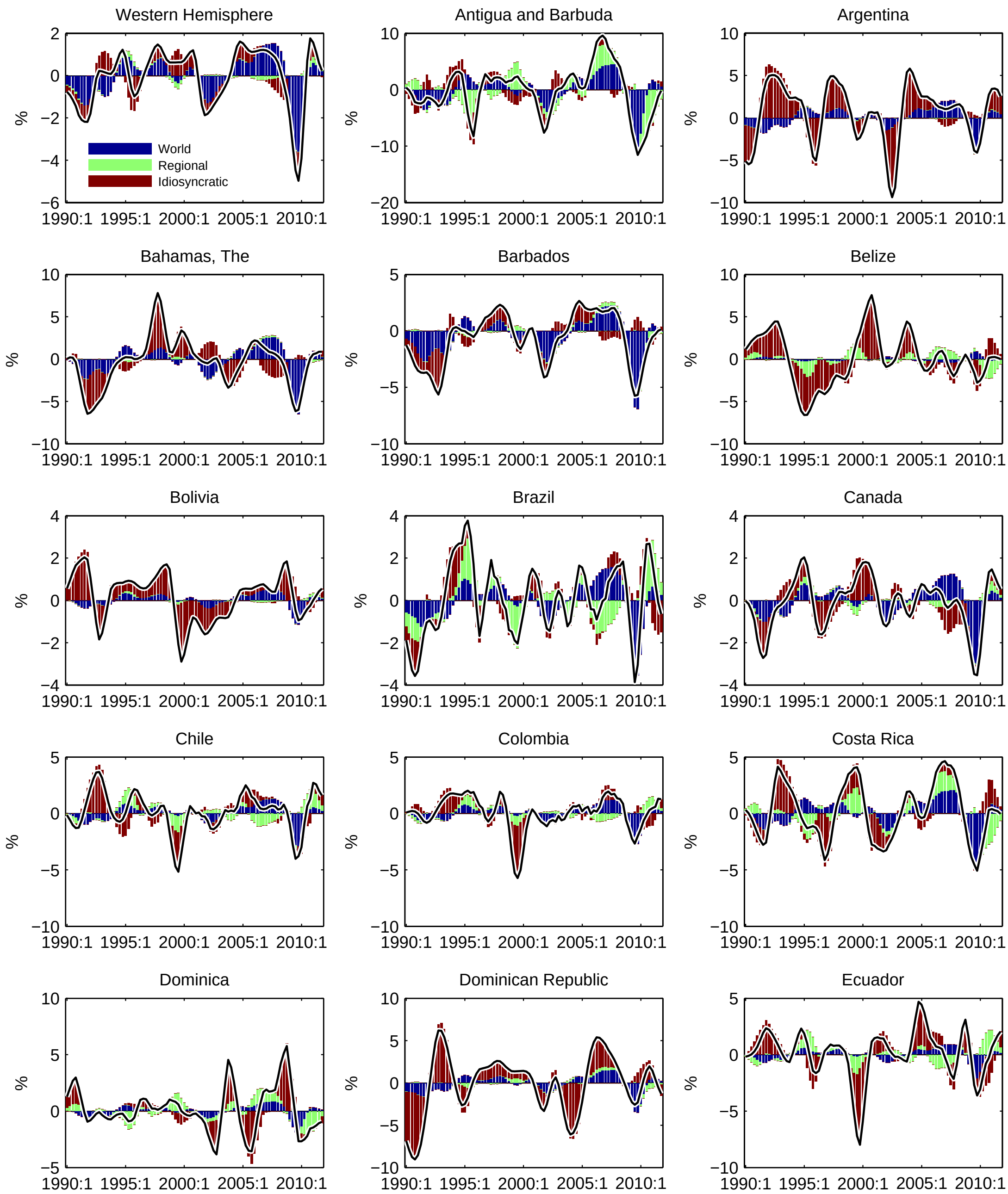

Figure 13: Historical Shock Decompositions, Western Hemisphere (cont.)

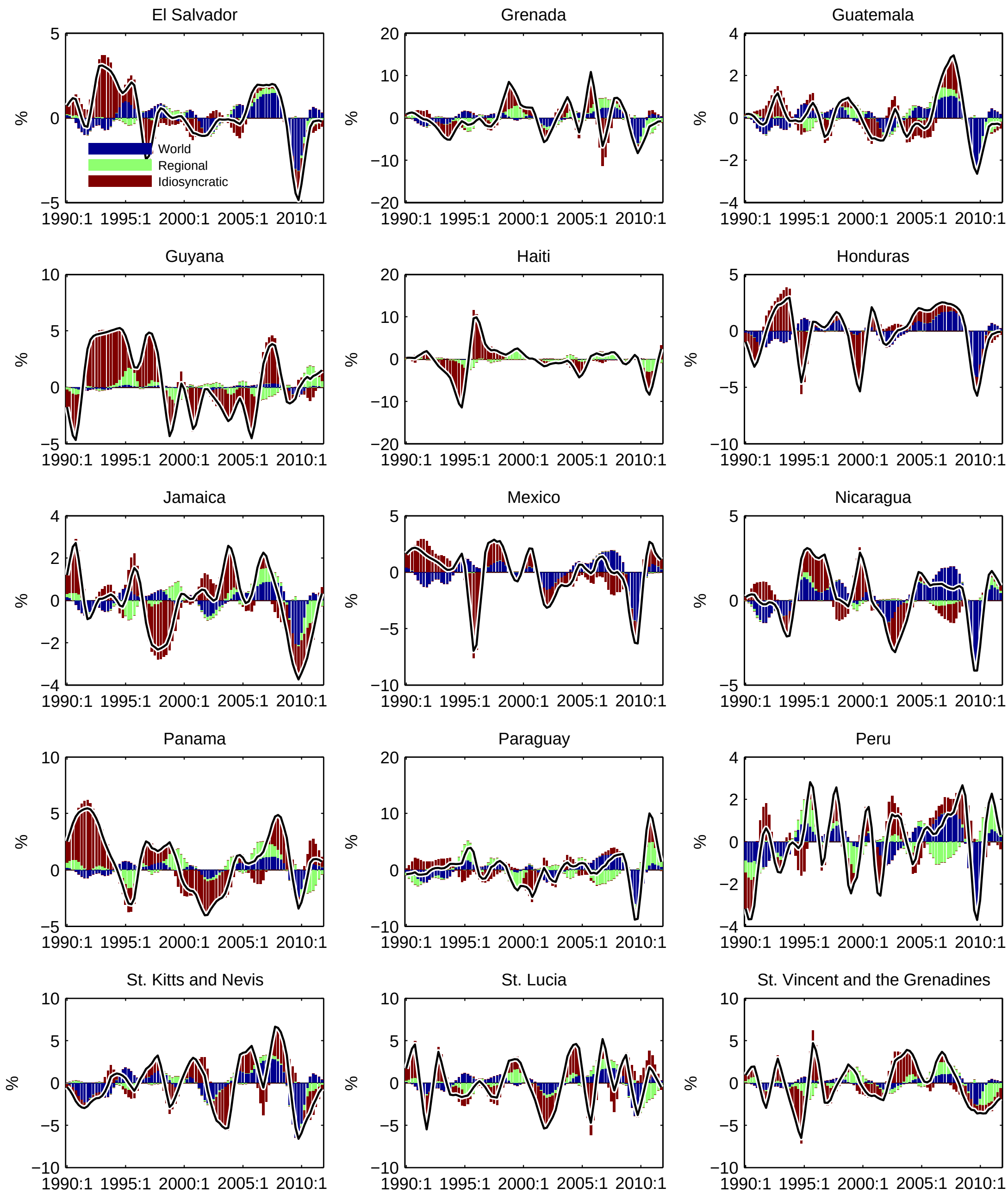

Figure 14: Historical Shock Decompositions, Western Hemisphere (cont.)

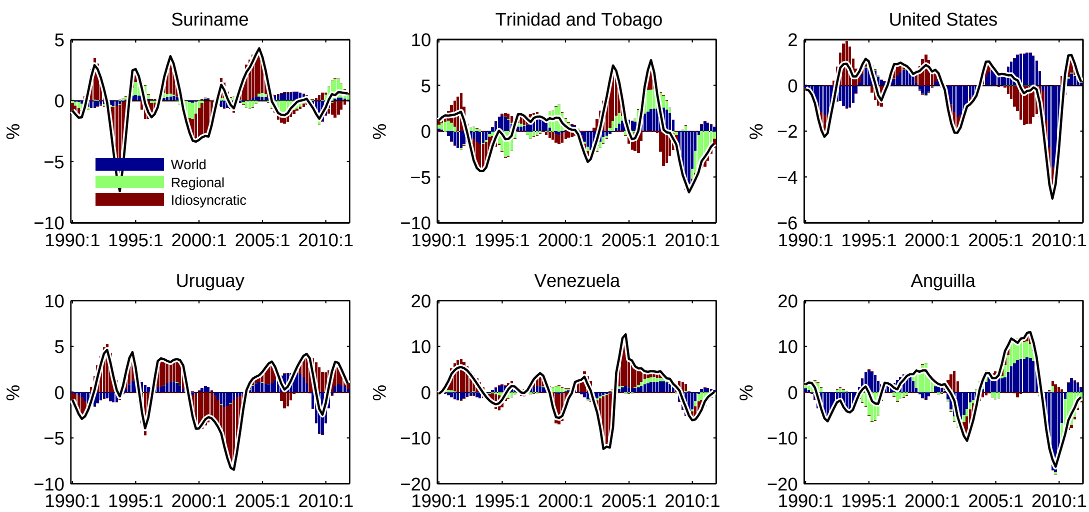

Figure 15: Historical Shock Decompositions, Sub-Saharan Africa

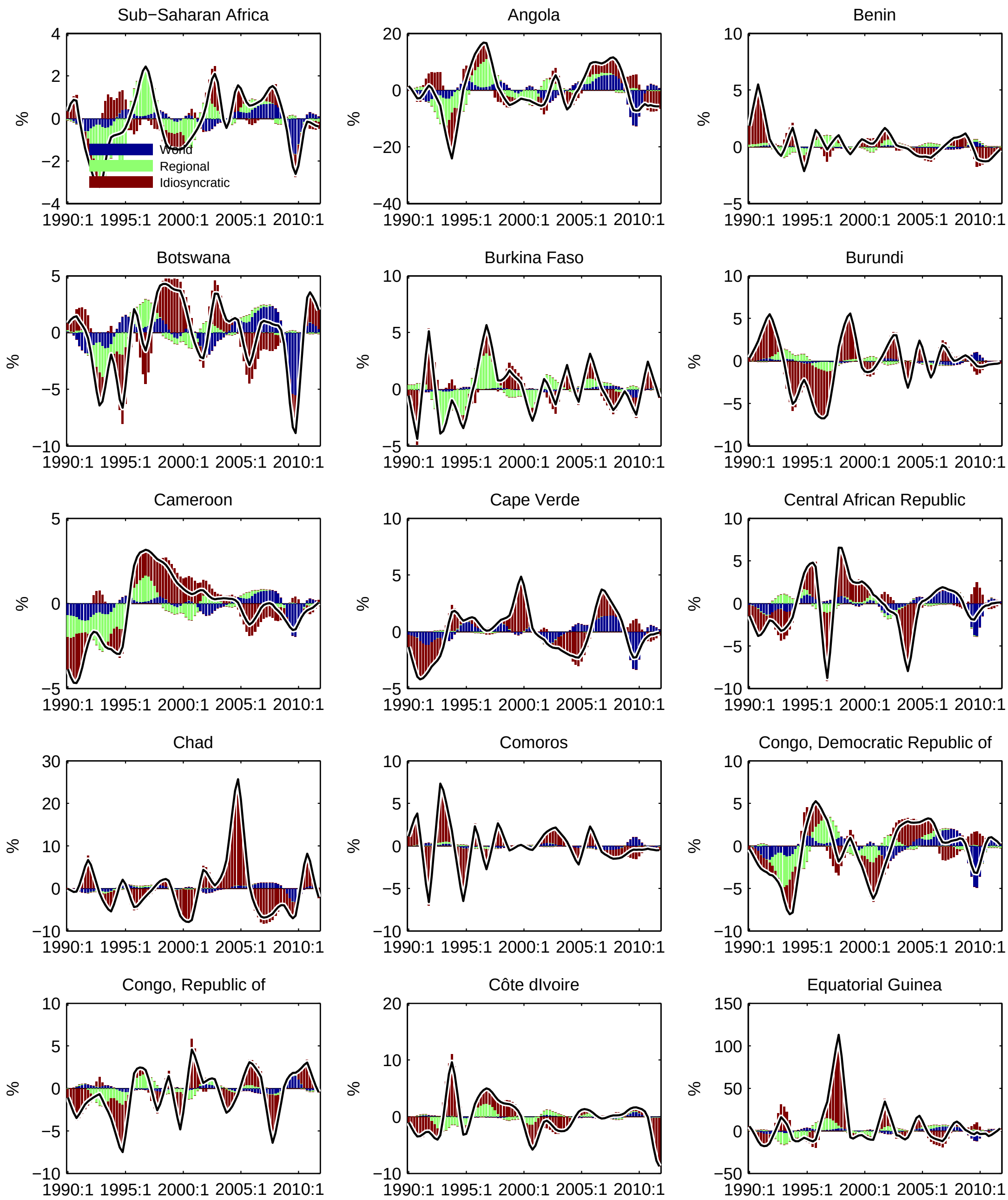

Figure 16: Historical Shock Decompositions, Sub-Saharan Africa (cont.)

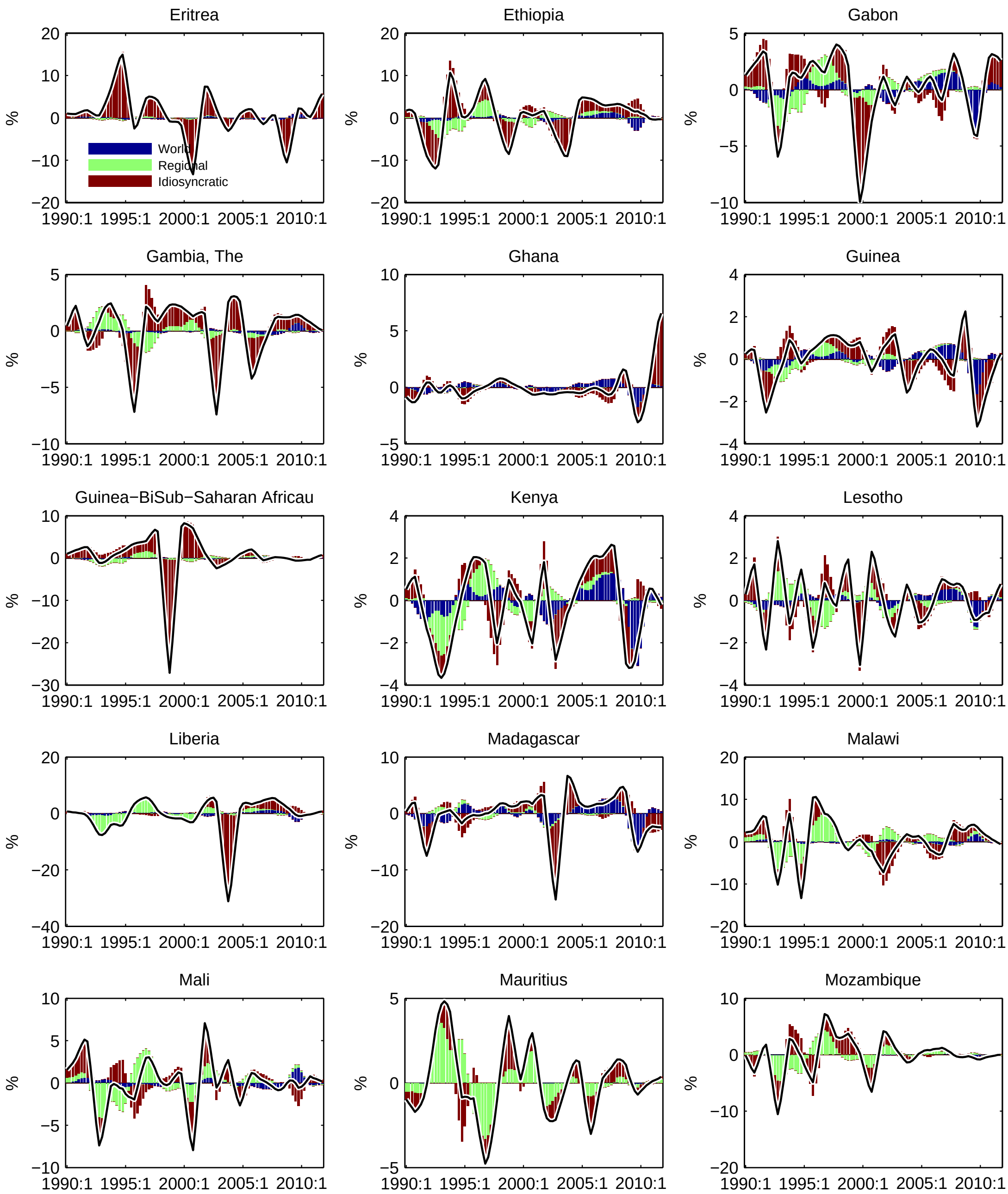

Figure 17: Historical Shock Decompositions, Sub-Saharan Africa (cont.)

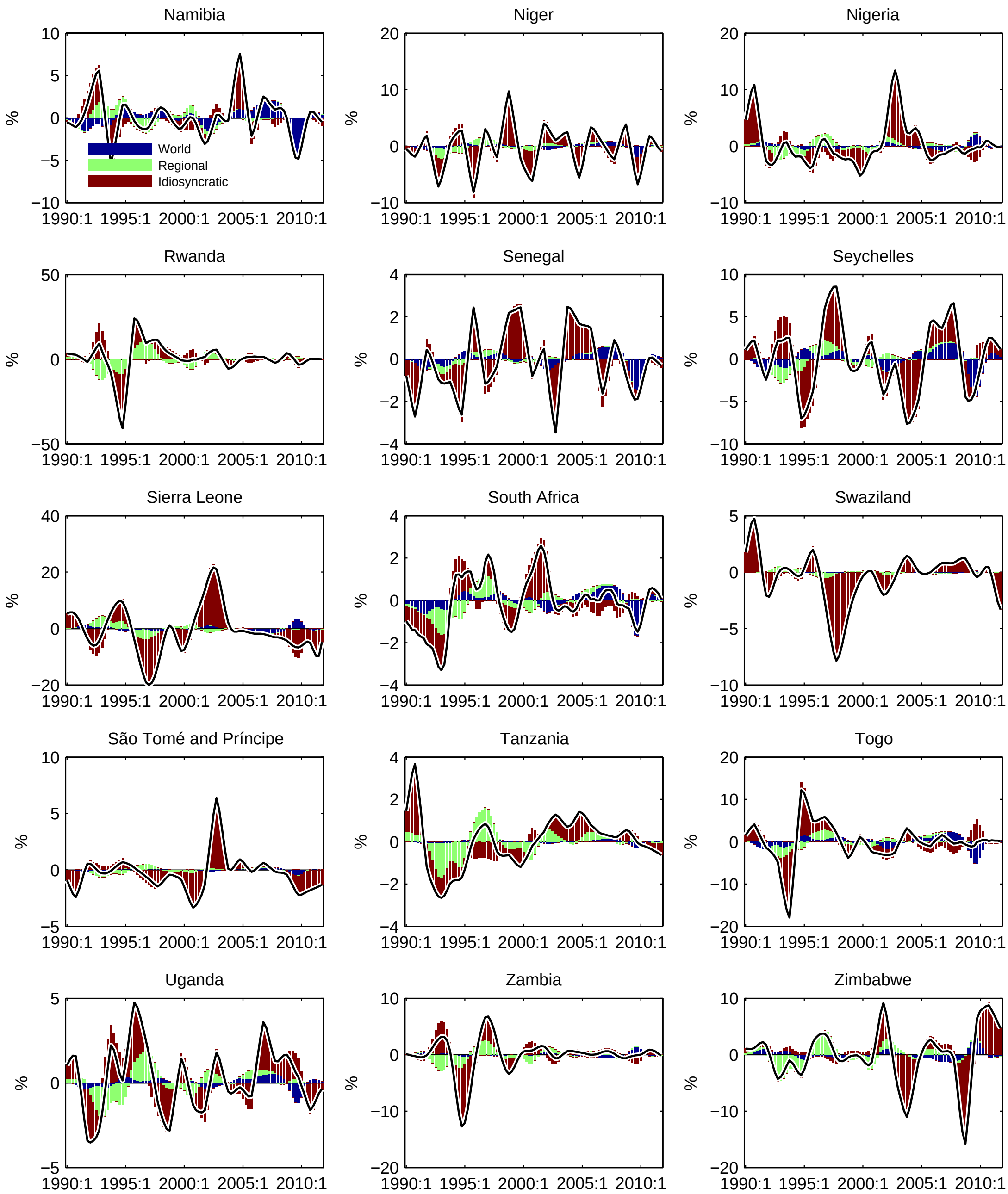

Figure 18: Historical Shock Decompositions, Middle East and North Africa

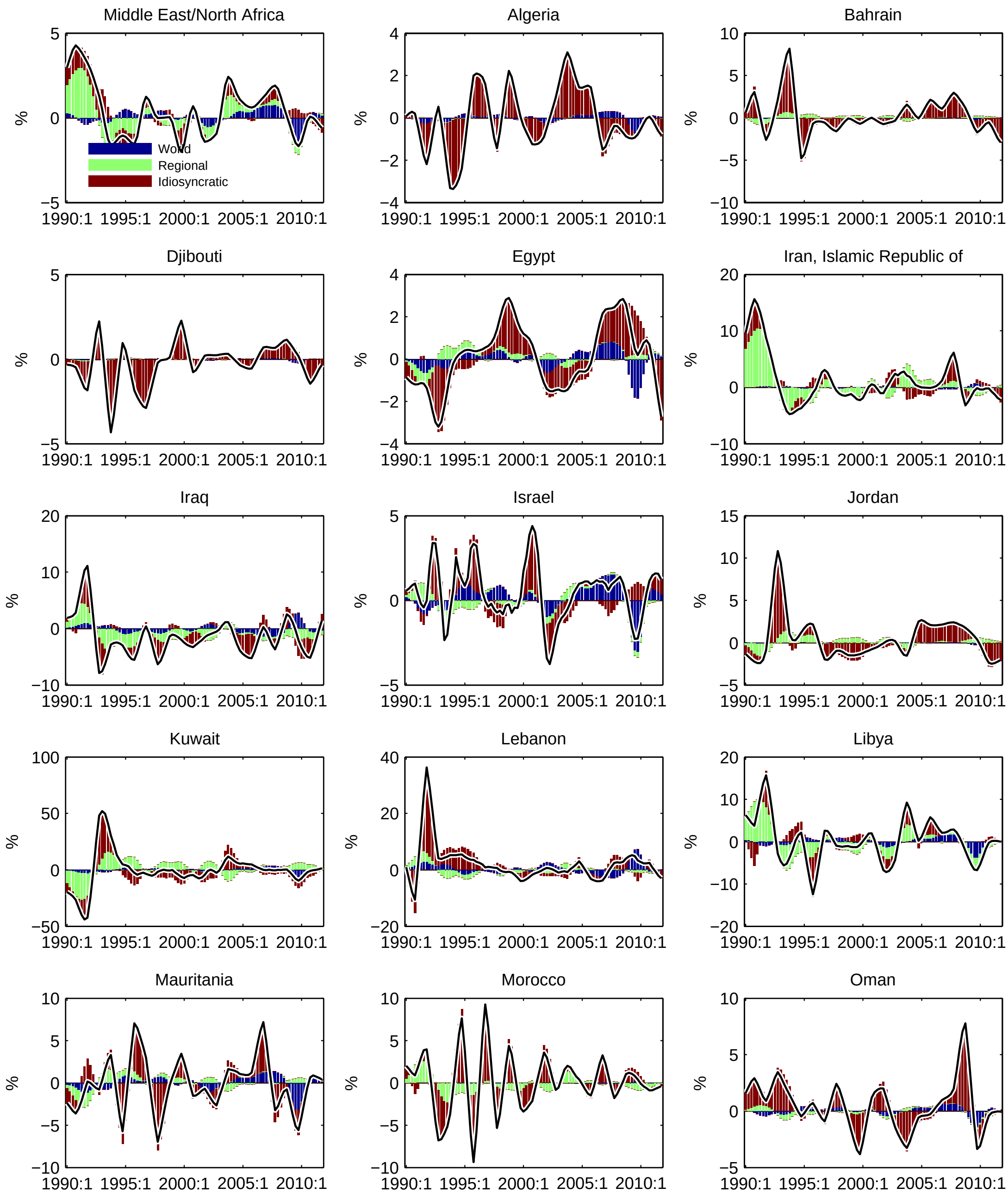

Figure 19: Historical Shock Decompositions, Middle East and North Africa (cont.)