Inflation Targeting and Business Cycle Synchronization

Robert P. Flood and Andrew K. Rose*

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Comments Welcome!

Abstract

Inflation targeting seems to have a small but positive effect on the synchronization of business cycles; countries that target inflation seem to have cycles that move slightly more closely with foreign cycles. Thus the advent of inflation targeting does not explain the decoupling of global business cycles, for two reasons. Indeed business cycles have not in fact become less synchronized across countries.

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Contact: Andrew K. Rose
Haas School of Business
University of California
Berkeley, CA USA 94720-1900
Tel: (510) 642-6609
Fax: (510) 642-4700
E-mail: arose@haas.berkeley.edu

* The authors are respectively: Senior Economist, IMF; and B.T. Rocca Jr. Professor of International Trade, NBER research associate and CEPR research fellow. This research was conducted in part while Rose visited INSEAD, the Monetary Authority of Singapore and the National University of Singapore, whom he thanks for hospitality. We have benefited from comments and conversations with Joshua Aizenman, Mike Bordo, Yin-Wong Cheung, Hans Genberg, Sebnem Kalemli-Ozcan, Ayhan Kose, Jim Lothian, Ricardo Reis, Kwanho Shin, Pierre Siklos, Frank Smets, Dietz Vollrath, and conference participants at the ADB, Central Bank of Turkey, ECB, HKIMR, UC Santa Cruz, and Texas Monetary Conference. We also thank Ayhan Kose and Chris Candelaria for data assistance. A current (PDF) version of this paper, sample output, and the key data sets are available at http://faculty.haas.berkeley.edu/arose.

1. Introduction

This paper is concerned with why business cycles are synchronized across countries. We focus particularly on two inter-related phenomena. The first and less important is "decoupling," the idea that business cycles are becoming more independent and less synchronized across countries. The second is inflation targeting (IT), a recent policy that allows the monetary authority to focus on purely domestic inflation. One of the oft-cited advantages of IT is the fact that it provides insulation from foreign shocks. In this paper, we empirically investigate if the advent of inflation targeting can be linked to business cycle synchronization (BCS), and thus decoupling. We find first that the advent of IT seems to result, in both theory and fact, in higher cross-country synchronization of business cycles. Indeed, decoupling does not seem to be present at all in the data.

2. Theory

Brief Summary of the Literature

Mundell first formally explored the logic of the insulation value of floating exchange rates in his famous textbook *International Economics*. While he is best known for his presentation of the small open economy comparison of fixed and flexible exchange rates with perfect capital mobility, Mundell also presents a two-country model in an appendix to chapter 18. He shows that under fixed exchange rates, monetary shocks lead to positive BCS while the effect of real shocks is theoretically ambiguous. By way of contrast, with flexible exchange rates, real shocks are associated with positive spillovers and BCS for very large countries, while a monetary shock leads to opposite effects in the domestic and foreign economies. He states explicitly "It cannot, therefore, be asserted that a country is automatically immunized by its flexible exchange rate from business cycle disturbances originating abroad." His reasoning is that a positive domestic real shock raises the domestic interest rate, attracting foreign capital and appreciating the exchange rate. Similarly, with fixed rates, business cycles cause by real shocks of large countries may or may not be transmitted abroad.

Devereux and Engel (1999, 2003) use dynamic stochastic general equilibrium models to investigate regime choice. However, their models do not easily lend themselves to the questions at hand here for a number of reasons (e.g., the models are restrictive, there are a very limited number of shocks, and the focus is on welfare and thus consumption rather than GDP). Still, such analysis usually retains the celebrated "insulation" effect in that floating exchange rates protect the domestic economy from foreign monetary shocks.

Our goal here is to provide some theoretical guidance on how we expect the monetary regime to affect the degree of business cycle synchronization. We develop a simple model of a small open economy interacting with a large economy (which can also be interpreted to be the rest of the world), assumed to be unaffected by shocks hitting the small economy. We use this to determine how cross-country business cycle coherence depends on the monetary regime.

We begin by considering a model where prices are flexible. We do this entirely because it makes the solutions to the model algebraically trivial, while giving intuitive and pleasing closed-form solutions. However, we obtain "something like" sticky-price results by letting the aggregate supply curve to become flat. In the extreme, it turns out that our results are essentially identical to those obtained with prices set rigidly based on last period's information. In this case, inflation targeting becomes irrelevant to the covariance of interest (the covariance of interest involves only output innovations and sticky prices do not allocate output innovations).

Model

The goods sector of the small open economy consists of two equations. The first is a standard Lucas/Gray supply curve where the deviation of output from trend depends on the price surprise, while the second equation defines demand for domestic output:

$$y_t = \beta(p_t - E_{t-1}p_t) + u_t \tag{1}$$

$$y_t = E_t y_{t+1} - \delta r_t + \theta y_t^* - \kappa(p_t - p_t^* - s_t) + h_t \tag{2}$$

where: y_t is the (natural logarithm of the deviation from trend of) domestic output at time t; y^* is the analogue for foreign output; p is the domestic-currency price of domestic output; u is a productivity shock; E is the expectations operator; and Greek letters denote parameters. The surprise in demand is driven by a number of forces, including the domestic real interest rate, defined as $r_t \equiv i_t - (E_t p_{t+1} - p_t)$ where i is the domestic nominal interest rate. Foreign demand for domestic output is given by θy^*. The nominal exchange rate (defined as the domestic price of foreign exchange) is s, the foreign-currency price of foreign output is p^*, so that $(p-p^*-s)$ is the real exchange rate. The shock to demand for domestic output is h., which we take to be either a taste shock or linearization error.

The goods market for the small economy clears when supply equals demand, or

$$\beta(p_t - E_{t-1}p_t) + u_t = E_t y_{t+1} - \delta r_t + \theta y_t^* - \kappa(p_t - p_t^* - s_t) + h_t . \tag{3}$$

Purchasing power parity holds up to a shock:

$$p_t = p_t^* + s_t + g_t \,. \tag{4}$$

Monetary policy in the small country is specified in terms of a Taylor-style interest rate rule:

$$i_t = A(E_t p_{t+1} - p_t - \bar{\pi}) + B(\beta(p_t - E_{t-1} p_t) + u_t - \bar{y}) + C(s_t - \bar{s}) \,. \tag{5}$$

There is no need to develop a full model of the large economy, since we need only two elements. We assume that: a) de-trended output of the large economy (y_t^*) is white noise, and b) that the foreign price responds linearly to foreign output shocks, so that $p_t^* = \psi y_t^*$ where $\psi>0$.[1]

In our stripped-down model, there are no slowly moving state variables, only shocks. There are four of these: 1) *u*, domestic supply; 2) *h,* domestic demand; 3) *y**, foreign output; and 4) *g,* a shock to PPP. We assume that all four shocks are mutually uncorrelated white noise. We also set $\bar{\pi} = \bar{y} = \bar{s} = 0$.

Solution

As is well known, the expected price level is indeterminate under Taylor-type interest-rate rules. However, the innovation to the price level is determinate, so we interpret the expected price level as being inherited from the past with the model determining the innovation.

To solve the model, we conjecture:

$$p_t = E_{t-1} p_t + \tau_1 u_t + \tau_2 h_t + \tau_3 + \tau_4 g_t \tag{6}$$

with coefficients

$$\tau_1 = \frac{-(1+\delta B)}{(\beta + \delta - \delta A + \delta\beta B + \delta C)}$$

$$\tau_2 = \frac{1}{(\beta + \delta - \delta A + \delta\beta B + \delta C)}$$

$$\tau_3 = \frac{\theta + \delta\psi C}{(\beta + \delta - \delta A + \delta\beta B + \delta C)}$$

$$\tau_4 = \frac{\delta C - \kappa}{(\beta + \delta - \delta A + \delta\beta B + \delta C)}$$

Just as the price level is based on the inherited expectation, so too is the exchange rate. That is, this framework delivers a poor model of price level or exchange rate determination. However, our focus is on business cycle synchronization. Accordingly, we ignore other shocks and equations to focus completely on the covariance between domestic and foreign output.

In general:

$$\mathrm{cov}(y, y^*) = \beta\tau_3\sigma_{y^*}^2 = \frac{\beta(\theta + \delta\psi C)\sigma_{y^*}^2}{(\beta + \delta - \delta A + \delta\beta B + \delta C)} \qquad (7)$$

where $\sigma_{y^*}^2$ is the variance of y^*

Comparing Business Cycle Synchronization with Differing Monetary Regimes

To investigate the role of monetary policy, we now consider four radically different monetary regimes (each chosen to be as extreme and thus clear as possible). We begin with a regime where there is no active policy (hereafter "NAP") by which we mean $A = B = C = 0$. In this case, one can show that $\mathrm{cov}(y, y^*) = \frac{\beta\theta\sigma_{y^*}^2}{(\beta + \delta)}$. In the special case where $\beta \to \infty$, this reduces to $\mathrm{cov}(y, y^*) = \theta\sigma_{y^*}^2$; we interpret this loosely as NAP under the assumption of extreme sticky prices.

Our three other monetary regimes have different assumptions about the parameters in the interest rate rule. In one, the authorities *only* care about stabilizing inflation; in another, the authorities care *only* about stabilizing output; and in the last, *only* stabilizing the exchange rate is relevant (in the extreme case, the weight on this objective goes to infinity which can be interpreted as a perfectly credible exchange-rate fix or monetary union). In each case, we derive the covariance between domestic and foreign output both generally, and under the assumption $\beta \to \infty$, so that prices can be regarded as sticky. We tabulate a summary of the four extreme cases below.

Case	**Parameters**	**Cov(y,y*), flexible prices**	**Cov(y,y*), sticky prices ($\beta \to \infty$)**

No Active Policy (NAP)	A=B=C=0	$\frac{\beta\theta\sigma_{y^*}^2}{(\beta+\delta)}$	$\theta\sigma_{y^*}^2$
Inflation Targeting (IT)	A>0, B=C=0	$\frac{\beta\sigma_{y^*}^2\theta}{(\beta+\delta-\delta A)}$	$\theta\sigma_{y^*}^2$
Output Stabilization (OS)	B>0, A=C=0	$\frac{\beta\theta\sigma_{y^*}^2}{(\beta+\delta\beta B+\delta)}$	$\frac{\theta\sigma_{y^*}^2}{(1+\delta B)}$
Exchange Rate Stabilization (ERS)	C>0, A=B=0	$\frac{\beta(\theta+\delta\psi C)\sigma_{y^*}^2}{(\beta+\delta+\delta C)}$	$(\theta+\delta\psi C)\sigma_{y^*}^2$
Fixed Exchange Rate (FER)	$C\rightarrow\infty$, A=B=0	$\beta\psi\sigma_{y^*}^2$	

We are now in a position to compare the cross-country output covariance as the monetary regime of the small open economy changes.

The most obvious default case is where the authorities pursue no active policy via interest rates (NAP).[2] Consider the alternative, where the interest rate is directed exclusively towards output stabilization (OS). In our extreme version, a monetary authority experiencing a positive foreign output shock pays no attention at all to the price-level consequences of the shock, and raises the domestic interest rate, thereby choking off domestic demand. This minimizes the domestic output response to the foreign output shock, which makes $\text{cov}(y, y^*)$ smaller for the OS regime than for NAP. Thus, with OS, the covariance of domestic and foreign output falls unambiguously compared to NAP. The intuition is simple; $\delta\beta B$ ends up in the denominator because the interest rate is used to dampen the response of domestic output to the domestic price level surprise caused by the foreign output shock.

Inflation targeting delivers a covariance that is unambiguously larger than under NAP, at least so long as $A < \frac{\beta + \delta}{\delta}$. This is because the interest rate moves opposite to what it would do under OS. Under IT, the interest rate moves to stabilize prices, which exacerbates the domestic output response to a foreign output shock. A positive shock to foreign output, for example, raises demand for domestic goods and thus domestic prices . Since the shocks we are studying are transitory, raising the domestic price of the domestic good lowers forward-looking domestic inflation. The domestic monetary policy rule's response is to lower the domestic interest rate, exacerbating thereby the domestic output effect of the foreign output shock. Hence, $\text{cov}(y, y^*)$ for IT is greater than for NAP. Further, in our simple version of sticky prices, output co-movements are identical for inflation targeting and no active macroeconomic policy.

The effect of a shift from NAP to an exclusive exchange rate target (either ERS or FER) on the covariance of domestic and foreign output is parameter dependent. It is clear that, compared to NAP, we add $\beta\delta\psi C\ \sigma_{y*}^2$ to the numerator and δC to the denominator. The first term, $\delta\psi Cy^*$, stems from the fact that demand is enhanced through the real interest rate when the nominal interest rate is directed to stabilize the exchange rate. But δC is added to the denominator, because prices respond to the fact that the interest rate is used to stabilize the exchange rate. In the most extreme case of a perfectly fixed exchange rate, ($C \to \infty$), the covariance becomes $\beta\psi\sigma_{y*}^2$, whose relation to the covariance under NAP depends on the size of ψ as opposed to $\frac{\theta}{(\beta + \delta)}$. Holding other parameters constant, a move from NAP to FER will increase $\text{cov}(y, y^*)$ if ψ, the elasticity of foreign price with respect to a foreign output shock, is sufficiently large (this is likely to be true for smaller economies which are systematically more open).

If foreign output shocks are primarily demand caused, $\varphi > 0$; if supply shocks are predominant $\varphi < 0$. In a sticky-price model, we think of the shocks as demand shocks so $\varphi > 0$. Notice that $\text{cov}(y, y^*)$ for FER is proportional to β. We interpret very large β as being our model's version of sticky prices. Hence, in our set up, with a Keynesian interpretation at home and abroad (big $\beta, \varphi > 0$) we get the ranking:

$$\text{cov}(y, y^*)(\text{FER}) > \text{cov}(y, y^*)(\text{IT}) > \text{cov}(y, y^*)(\text{NAP}) > \text{cov}(y, y^*)(\text{OS}).$$

To the degree that foreign output shocks originate on the supply side or to the extent that prices are flexible (a real business-cycle interpretation), $\text{cov}(y, y^*)$ for FER can be smaller than for the other regimes.[3]

Summary

Thus, for this model, we conclude that the ranking of cross-country business cycle synchronization is:

$$\text{cov}(y, y^*)(\text{IT}) > \text{cov}(y, y^*)(\text{NAP}) > \text{cov}(y, y^*)(\text{OS}),$$

and the relation of $\text{cov}(y, y^*)$ (FER) to the other regimes is generally parameter-dependent.[4] The cross-country covariance of output is highest when the small open economy targets inflation, and falls as the country moves first to an absence of active policy and then on to stabilize output. The key intuition is that stabilizing output dampens the domestic output response to a foreign output shock; inflating targeting, on the other hand, allows output to move while stabilizing prices so that business cycle synchronization can rise.

We close this section with a number of caveats to be borne in mind when examining the results of this simple theoretical exercise. First, we have assumed zero covariances between our shocks – hence our exclusive focus on the foreign output shock. Second, we have only examined policy extremes (ignoring, for instance, "flexible" inflation targeting where the authorities care about *both* inflation and output). Third, we have assumed variances remain constant across monetary regimes; in principle, policies could change because of changed variances.

3. Data Set and Methodology

We are interested in what determines the coherence of business cycles across countries, especially the effect of monetary regimes like inflation targeting.[5] Accordingly, we choose a data set which spans a large number of countries with different monetary regimes and a number of business cycles at an appropriate frequency.[6]

Since New Zealand began to target inflation in early 1990, twenty-six other countries have adopted formal inflation targeting regimes.[7] We include all IT countries in our sample. To provide a comparison group, we also include all countries that are at least as large as the smallest and as rich as the poorest IT country (so long as they have reasonable data on aggregate output).

IT only began in 1990, and reliable quarterly data ends for most countries in 2007 (the data set was gathered in May 2008); we begin the data set in 1974. This coincides with the beginning of the post-Bretton Woods era, and almost exactly doubles the span of data over time. We choose the quarterly frequency so as to be able to measure business cycle movements with aggregate output series.

We end up with a set of 64 countries which have reliable GDP data, though many are missing observations for some of the sample. The list of countries in the sample is tabulated in Table A1, along with the date of IT adoption (if appropriate). We note in passing that this sample of countries includes a large number of observations for countries that have either fixed exchange rates or relinquished monetary sovereignty in a currency union (the latter are primarily members of EMU but also include Ecuador, a recent dollarizer).

At the core of our measure of business cycle synchronization lies aggregate real output. We take seasonally adjusted GDP data from three different sources: the IMF's *International Financial Statistics* and *World Economic Outlook* data sets, and the OECD. We have checked these data extensively for mistakes.[8] Table A1 also presents the date of the earliest reliable data on output.

Since our focus in this paper is on (the cross-country coherence of) business cycle deviations from trend, it is necessary to detrend the output series. Since there is no universally accepted method, we use four different techniques to create trends. First, we use the well-known Hodrick-Prescott filter.[9] Second, we use the more recent Baxter-King band-pass filter.[10] Third, we construct the fourth difference, thus creating annual growth rates from quarterly data. Finally and perhaps least plausibly, we construct trends by regressing output on linear and quadratic time trends as well as quarterly dummies. We refer to these four methods of detrending as "HP", "BK", "Growth", and "Linear" respectively:

$$\mathbf{y_{i,t}^{HP} \equiv y_{i,t} - \hat{y}_{i,t}^{HP}}$$

$$\mathbf{y_{i,t}^{BK} \equiv y_{i,t} - \hat{y}_{i,t}^{BK}}$$

$$\mathbf{y_{i,t}^{Growth} \equiv y_{i,t} - y_{i,t-4}}$$

$$\mathbf{y_{i,t}^{Linear} \equiv y_{i,t} - (\hat{\alpha} + \hat{\beta}t + \hat{\gamma}t^2 + \widehat{\delta_1}D_{1,t} + \widehat{\delta_2}D_{2,t} + \widehat{\delta_3}D_{3,t})}$$

where: $\mathbf{y_{i,t}}$ is the natural logarithm of real GDP at time t; $\mathbf{\hat{y}_{i,t}^{HP}}$ is its underlying Hodrick-Prescott trend; $\mathbf{\hat{y}_{i,t}^{BK}}$ is its Baxter-King filtered level; and the coefficients for the linear regression are estimated over the whole sample period on time, the square of time, and three quarterly dummy variables $\{D_{j,t}\}$.

Having created business cycle deviations for all our countries, we then compute measures of cross-country coherences of business cycles. We do this by creating conventional sample Pearson correlation coefficients, as is now common practice in the literature (e.g., Baxter and Kouparitsas, 2005, and Imbs, 2006).[11] The correlation coefficients are created using twenty quarterly observations (five years) of data, and are defined as

$$\mathbf{\hat{\rho}_{i,j,\tau}^{d} \equiv \frac{1}{T-1}\sum_{t=1}^{\tau}\left(\frac{y_{i,t}^{d}-\bar{y}_{i,\tau}^{d}}{\sigma_{i,\tau}^{d}}\right)\left(\frac{y_{j,t}^{d}-\bar{y}_{j,\tau}^{d}}{\sigma_{j,\tau}^{d}}\right)}$$

where: $\mathbf{\hat{\rho}_{i,j,\tau}^{d}}$ is the sample correlation coefficient estimated between output for countries i and j over the twenty (T) quarters preceding through time τ; the natural logarithm for real GDP (y) has been detrended with method d (d=HP, BK, Linear, and Growth); and $\mathbf{\bar{y}}$ and σ denote the corresponding sample mean and standard deviation respectively. This statistic, computed between a pair of countries over time, constitutes our key measure of business cycle synchronization (BCS). Note that this measure is not constrained to be constant across time for a dyad, consistent with the findings of Kose, Otrok and Prasad (2008) who find considerable time-variation in business cycle synchronization.[12]

"Decoupling" is sometimes considered to refer to the linkages between a particular developing country and a composite of industrial countries (not simple random pairs of countries). Accordingly, we construct analogous measures for both the G-3 (Germany, Japan, and the USA) and G-7 (the G-3 plus Canada, France, Italy, and the UK), as well as comparable measures of BCS between countries and the G-3/G-7.[13]

We are interested in understanding the determinants of business cycle synchronization, especially the role of the monetary regime. Accordingly, we add dummy variables to the data set, for whether either or both of the countries engaged in inflation targeting. We also include comparable dummies for countries that were in a monetary union such as EMU or a fixed exchange rate regime.[14]

It is sometimes necessary to control for other potential determinants of BCS, above and beyond any possible effect of the monetary regime. Here, we draw on the recent work by Baxter and Kouparitsas (2005) who examine a host of potential determinants of BCS. They conclude that only four variables have a robust effect on BCS: a) the degree of bilateral trade between a pair of countries; b) a dummy variable for both countries being industrialized countries; c) a dummy when both countries are developing countries; and d) a variable measuring the distance between the two countries. Accordingly, we add data for all four of these variables.[15]

We also add one final variable, not considered by Baxter and Kouparitsas; the degree of financial integration between a pair of countries. Imbs (2006) uses the recently developed Coordinated Portfolio Investment Survey (CPIS) data set, and finds that a country-pair with closer financial ties tend to have more synchronized business cycles. He uses the first cross-section of CPIS data (for 2001), and measures financial integration in a manner analogous to the Baxter- Kouparitsas trade measure. We follow his lead, but include data for the 2002 through 2006 data sets as well as that for 2001.[16]

4. Decoupling

Figure 1 presents a first look at the BCS measures. It contains time series plots of the mean value of BCS, averaged across all feasible country-pairs at a point in time. There are four graphs, corresponding to the four different detrending techniques (Hodrick-Prescott, Baxter-King, deterministic linear/quadratic regression, and growth rate). In each case, the average value of the BCS correlation coefficient, and a confidence interval of +/-2 standard deviations (of the mean) are portrayed.[17]

The single most striking thing about the trends portrayed in Figure 1 is that … there are no obvious trends. The average level of BCS varies some over time, but it is typically around a level of .25 or so. There is, however, no evidence that the average correlation coefficient is significantly lower (in either economic or statistical terms) towards the end of the sample. That is, there is little *prima facie* evidence of "decoupling." If anything, there is a slight tendency for business cycles to be slightly *more* correlated across countries in 2007 compared to, say, 2000.[18] This is consistent with the (more narrowly based) findings of Doyle and Faust (2002) and Stock and Watson (2003), neither of whom find significant changes in business cycle synchronization between the G-7 countries.[19]

Figure 1 considers bilateral measures of BCS; all possible pairs of countries are considered (there are over 2000 of these). Figure 2 is an analogue which considers BCS between a given country and an index for the business cycle of the G-7 industrial countries. In this more multilateral sense, there is still no evidence that business cycles are becoming more isolated from each other.[20]

Some think of "decoupling" as referring to a shrinking relationship between the business cycles of industrial and developing countries. Accordingly, Figure 3 is an analogue to Figure 1 that only considers pairs of countries in which one country is industrial and the other is developing. Again, no dramatic declines in the degree of business cycle synchronization are apparent; instead, the correlations seem to fluctuate around an approximately constant mean. The same description characterizes Figure 4, which is an analogue to Figure 2 that considers only BCS between developing countries and the G-7 aggregate.[21]

5. Inflation Targeting

What about the impact of inflation targeting on BCS? The easiest way to start is to consider countries that have been targeting inflation for a considerable period of time. Figure 5 is a set of four time-series plots (again, one for each method of detrending) which portray BCS between New Zealand and the G-7. The introduction of inflation targeting is marked with a vertical line, and the average levels of BCS before and after its introduction are also depicted.[22] Somewhat surprisingly, there is no evidence that New Zealand's business cycle has become systematically less synchronized with that of the main industrial countries since IT was introduced. If anything, there has been a slight increase in BCS, though it is insignificant compared with the considerable volatility in BCS over time.

Figure 6 is an analogue but portrays Sweden, another small industrial country that switched to inflation targeting early on. The plots show that Swedish business cycles, like those of New Zealand, have not become systematically delinked from those of the G-7. If anything the opposite seems to be true, though again the variation over time in BCS is more striking than any trend. Figures 7 and 8 are analogues to other early converts to IT, Canada and the UK. Since both are members of the G-7, we portray the correlation between their business cycles and those of the G-3, not the G-7.[23] Canadian business cycles have become less synchronized with those of the G-3 on average, though the size of this effect is still not very large compared with the variation in BCS. The evidence for the UK is much more mixed, with essentially no significant changes in BCS since it adopted IT.

The evidence of Figures 5-8 is relatively narrow, including data for only four IT countries and their relationships vis-à-vis the major industrial countries. Figure 9 broadens the sample considerably, and provides evidence for a large number of country-pairs around the time of IT entry. All dyads are portrayed when a single country in the pair enters an IT regime. The graphs begin seven and a half years before entry and end ten years after entry into IT, data allowing. The mean value of the correlation coefficient is shown, along with a confidence interval extending +/- two standard deviations on either side.[24]

The event studies of Figure 9 shows little evidence that inflation targeting is systematically associated with a *decline* in business cycle synchronization across countries. While there is considerable variation over time in BCS, it still seems to be somewhat *higher* in the years after one of the countries has adopted IT. Differences across detrending techniques tend to be small. Figure 10 is an analogue that portrays the relationships between countries entering IT and the G-7 business cycle; it also shows a slight increase in BCS following the adoption of inflation target.

For the purpose of comparison, Figures 11 and 12 are event studies that consider two alternative monetary regimes of interest, fixed exchange rates and EMU.[25] Countries fixing exchange rates against each other seem to have systematically more synchronized business cycles within five or ten years after the event. For three of the four different detrending techniques, the same seems to be true of entry into EMU (results are weaker, but not negative, for the case of linear detrending). Since theory commonly leads one to expect that a common monetary policy should be associated with more synchronized business cycles, these intuitive findings encourage one to think that the data has power enough to speak.

Thus our overview of the data ends on a double note of puzzlement. First, it seems that there is little evidence that business cycles have actually become less synchronized across countries of late; decoupling is hard to see in the actual data. Second, entry by a country into an inflation targeting regime does not seem to be associated with a decline in business cycle synchronization; if anything, BCS seems to rise.

6. Regression Analysis

The event studies discussed above are intrinsically bivariate in that they do not control for other potential reason why BCS might have varied across countries and/or time. Further, they use a limited amount of data. In this section, we attempt to remedy both problems, using standard regression techniques.

We run regressions of the form:

$$\hat{\rho}^{d}_{i,j,\tau} = \beta_1 IT(1)_{i,j,\tau} + \beta_2 IT(2)_{i,j,\tau} + \gamma_{Fix,1} Fix(1)_{i,j,\tau} + \gamma_{Fix,2} Fix(2)_{i,j,\tau} + \gamma_{MU,1} MU(1)_{i,j,\tau}$$

$$+\gamma_{MU,2} MU(2)_{i,j,\tau} + \theta_T Trade_{i,j,\tau} + \theta_D Dist_{i,j} + \theta_I Ind_{i,j} + \theta_L LDC_{i,j} + \{\delta_{i,j}\} + \{\delta_\tau\} + \epsilon^{d}_{i,j,\tau}$$

where: IT(1) and IT(2) are dummy variables that are unity if one or both of the countries are inflation targeters during the period; Fix and MU represent comparable dummies for fixed exchange rates and monetary unions respectively; Trade denotes the Baxter-Kouparitsas measure of bilateral trade shared by the countries; Dist denotes the natural logarithm of great-circle distance between the countries; Ind and LDC are dummy variables for both countries being industrial or developing countries respectively; $\{\gamma\}$ and $\{\theta\}$ are nuisance coefficients, $\{\delta\}$ are fixed-effects for either country-pair dyads or time periods; and ε represents the host of other factors affecting BCS which are omitted from (and hopefully orthogonal to) the equation.[26] The coefficients of interest are $\{\beta\}$. The theoretical reasons discussed above indicate that IT should reduce business cycle synchronization, i.e., $\beta<0$.

Estimate for the key coefficients are reported in Table 1. There are two panels; the top panel excludes the Baxter-Kouparitsas control variables (so that $\{\theta\}=0$), while the bottom panel includes these controls.[27] For the sake of comparison, we also tabulate $\gamma_{Fix,2}$ and $\gamma_{MU,2}$, the effects of countries sharing a fixed exchange rate regime or currency. Robust standard errors are reported in parentheses; coefficients that are significantly different from zero at the .05 (.01) level are marked with one (two) asterisk(s).

We estimate the model using two variants of least squares. To the left of the table, we report results estimated with time effects (setting $\{\delta_{i,j}\} = 0$, retaining a comprehensive set of time effects to account for shocks that are common across countries. On the right we include both time and a comprehensive set of time-invariant dyadic effects that will pick up any effect that is common to a pair of countries. To avoid serial correlation induced by overlapping observations, we estimate this equation with quarterly data sampled every twentieth observation.[28]

The estimates of the impact of inflation targeting on business cycle synchronization in Table 1 are weak, in the sense that most estimates are economically small and statistically indistinguishable from zero. Of the 32 coefficients (= 4 detrending techniques x 2 sets of fixed effects x with/without controls x one/both countries in IT), only two are significantly negative at the 5% significance level (none are significantly negative at the 1% level). On the other hand, three quarters of the coefficients have positive point estimates, and five of them are significantly so at the 5% level (one of these at the 1% level). The results do not seem to depend very much on which detrending technique is used, and whether dyadic fixed effects and/or extra controls are included.

By way of comparison, we expect positive coefficients for the effects of both fixed exchange rates and monetary union on BCS, and we mostly find them. Eleven of the 32 coefficients are significantly positive at the 1% level and a further five at the 5% level. Only two of the coefficients are negative, neither significantly so. So the data set seems able to reveal the effect of the monetary regime, if they are there.[29]

Table 2 is an analogue to Table 1, but deals with linkages between countries and the G-7 instead of between pairs of countries. Results are similarly weak; targeting inflation does not seem to have any detectable effect on BCS.[30]

7. Estimating Treatment Effects via Matching

The regression analysis of Tables 1 and 2 can be criticized on a number of grounds. Most importantly, countries do not choose their monetary regimes randomly. Rather, they choose to link their exchange rates or currencies through monetary regimes deliberately, perhaps in order to synchronize their business cycles further. Similarly, countries that choose to target inflation might do so intentionally in order to isolate themselves from foreign shocks that they might otherwise import. In such cases, it would be inappropriate to treat the monetary regime as exogenous. Countries that choose to target inflation may not be a random sample of all countries. Rather, they may possess special features which the regression analysis does not adequately model. This may be of particular importance if the relationship between the monetary regime and BCS is not linear. Further, there may be breaks in the process linking business cycles across both countries and time, as emphasized by Doyle and Faust (2005).

For these reasons, we now use a matching technique to estimate the linkage between the monetary regime and business cycle synchronization. The essential idea is to use a strategy akin to that commonly used in medicine of conducting a controlled randomized experiment. We use a common technique, matching together individual "treatment" observations (each consisting of a country-pair at a point in time that include an inflation targeting country) to "control" observations that are similar but do not include an inflation targeter. Vega and Winkelried (2005) perform a similar analysis on inflation targeters, but oriented towards the behavior of domestic inflation dynamics.

To implement our technique, we need to match each treatment observation to a control observation (or set of control group observations). We do this by using the propensity score of Rosenbaum and Rubin (1983), the conditional probability of assignment to a treatment given a vector of observed covariates. Conditional on these variables, BCS is expected to be similar for treatment and control observations, ignoring any possible effect of the monetary regime. Since we construct $\hat{\rho}^{d}_{i,j,\tau}$ from a twenty periods of quarterly data, we only use one observation of $\hat{\rho}^{d}_{i,j,\tau}$ every five years. For the covariates of the propensity score, we choose the four variables shown by Baxter and Kouparitsas to have a robust effect on BCS: bilateral trade, distance, and dummies for pairs of industrialized and developing countries.[31] As a sensitivity check, we also augment this model by using a measure of financial integration. We begin with the popular "nearest neighbor" matching technique, comparing each treatment observation to its five closest neighbors from the control group.

Table 3 contains matching estimates, one for each of the four different detrending techniques. We begin considering as "treatment" observations any pair of countries where one country is an inflation targeter; the other country can have any monetary regime (other than IT). As controls, we consider all observations since 1990 that are not inflation targeters.[32] We are left with 1,041 treatment observations and 5,038 controls.

The default estimates are tabulated at the left-hand side of the table. All four of the point estimates are not only positive, but significantly so at the 1% significance level. The exact size of the effect varies a little depending on the precise method used to detrend the data, but the cross-country correlation of business cycles seems to rise by around .1. Since the average value of $\hat{\rho}^{d}_{i,j,\tau}$ for this sample is around .15, an increase of .1 represents an economically significant *increase* in business cycle synchronization.

Do these results depend very sensitively on the exact methodology? Perhaps, for instance, the results depend on the exact definition of treatment and controls groups. We explore this idea in the remaining columns of Table 3, which consider seven alternative sets of treatment and/or control groups. Of course, as one varies either the treatment or control group, one is comparing different groups and thus implicitly asking different questions.

The first robustness check compares business cycle synchronization between countries with IT to that of the entire G-7. This dramatically reduces the sample size and thus increases the standard errors considerably. However, none the point estimates are dramatically changed; all stay positive, and one remains statistically significant.

While inflation targeting is a well-defined monetary regime, the absence of inflation targeting is not. It is thus natural and interesting to compare IT with well-defined alternatives such as fixed exchange rates or monetary unions. Accordingly, we vary the control group in a number of different ways, considering first: a) country-pairs that maintain either fixed exchange rates or are in a currency union vis-à-vis each other; and b) country-pairs that fix exchange rates against one another. These groups are of special interest, since IT can theoretically be expected to deliver monetary sovereignty when compared directly to either fixing or currency union. However, in practice IT is associated with only statistically insignificant differences in BCS compared with either group; any differences also tend to be economically small.

We next consider for our control group pairs of countries that maintain either fixed exchange rate policies or participate in monetary unions, but not vis-à-vis each other (so that, e.g., Hong Kong-France would qualify in 2005). However, this does not lead to substantively different results from those of the default; IT has a significantly positive effect on cross-country business cycle coherence. The same is true when we exclude countries from the control group countries that either fix exchange rates or are in currency union.

Finally, for our treatment group we consider pairs of countries where one targets inflation and the other participates in either a fixed exchange rate regime or a monetary union. We compare these to a control group where both countries share a monetary policy either directly through a currency or indirectly through a fixed exchange rate regime. Yet even here, all four of the coefficients are positive, three of them significantly so.[33]

Table 4 checks the sensitivity of the default results further by examining a number of different estimators. At the extreme left, we re-tabulate the default nearest neighbor results, estimated with five control matches per treatment observation. We then provide results for five different estimation techniques. First, we reduce the number of control group observations matched from five to one. Next, we augment the propensity score model by adding a measure of cross-country financial integration to the other four variables. Finally, we move away from the nearest neighbor technique and perform our matching using three different estimators: a) stratification matching; b) kernel matching; and c) radius matching (further details on these techniques are available from Becker and Ichino, 2002).[34] Appendix Table A3 presents the analogue to Table 3, but matching covariances as measures of BCS instead of correlation coefficients.[35] However, none of these results substantially change the estimated treatment effects; all are positive and both economically and statistically significant, averaging around .1. It seems that the treatment effects delivered by matching techniques are even more puzzling than the regression results, showing that inflation targeting actually seems to increase the synchronization of business cycles.

8. Conclusion

In this paper, we investigated the degree of cross-country synchronization of business cycles, primarily from an empirical perspective. A simple examination of the data reveals that business cycles have not in fact becoming less synchronized of late; there is little evidence of "decoupling" in the data. Rather, business cycles seem to have become increasingly similar across countries. This tendency is well exemplified by the dramatic downturn in the global economy that began in 2008, and has affected essentially all economies of any size.

The rising international synchronization of business cycles has coincided with the growing tendency of central banks to establish inflation targeting (IT) regimes. At first blush, one might imagine that IT should be associated with lower business cycle synchronization, since the monetary authority might seem to acquire the ability to insulate itself from foreign shocks with a strategy of focusing on purely domestic phenomena such as inflation. However, we have used a simple model to show theoretically that IT can be easily be associated with greater business cycle synchronization, a notion that is born out in the data. That is, the domestic monetary sovereignty provided by a regime of an inflation target and flexible exchange rate may still result in considerable international business cycle synchronization. The key idea is that business cycle synchronization can rise or fall depending on what precisely the monetary authority does. If stabilizing output is the objective of the central bank, the domestic output response to a foreign output shock is dampened. Inflating targeting, on the other hand, allows output to move while stabilizing prices so that business cycle synchronization can end up higher.

It has long been noted that IT was introduced around the same time as the "Great Moderation" began. Was this simply a fortuitous coincidence, or did the new monetary regime play and promote a causal role? This is a long-standing and unresolved debate, one that has mostly been pursued by comparing domestic inflation and growth experiences across countries (e.g., Ball and Sheridan, 2003). The fact that IT is associated in theory with business-cycle synchronization higher than that of other policy regimes (such as passive regimes or output stabilization-regimes) is (to us) an unexpected implication of our modeling extreme IT.   The synchronization can even be higher than in fixed exchange rate regimes, depending on the nature of foreign output-shock transmission to prices and the degree of price stickiness. That the implication is born out empirically with higher real cross-country business cycle synchronization nudges us closer to the view that IT may well be influencing BCS.

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Table 1a: Regression Analysis: Monetary Regimes and Business Cycle Synchronization

	One IT	Both IT	Fixed ER	Monetary Union	One IT	Both IT	Fixed ER	Monetary Union
HP Detrending	.03 (.02)	.05* (.02)	.27** (.05)	.41** (.03)	.03 (.02)	-.04 (.03)	.14** (.05)	.08 (.05)
BK Detrending	.02 (.04)	.06 (.04)	.21 (.12)	.59** (.01)	.03 (.04)	.02 (.06)	.04 (.07)	.11* (.05)
Linear Detrending	.05* (.02)	.07 (.04)	.34** (.07)	.55 (.22)	.14** (.03)	.01 (.05)	.24** (.07)	.18** (.06)
Growth Detrending	.03 (.02)	.01 (.05)	.20* (.07)	.23** (.01)	.00 (.03)	-.10* (.04)	.10* (.05)	-.02 (.05)
Fixed Effects	Time	Time	Time	Time	Time, Dyads	Time, Dyads	Time, Dyads	Time, Dyads

Table 1b: Adding Controls

	One IT	Both IT	Fixed ER	Monetary Union	One IT	Both IT	Fixed ER	Monetary Union
HP Detrending	.03 (.02)	.05 (.02)	.22** (.05)	.29** (.03)	.03 (.02)	-.03 (.03)	.14** (.05)	.11* (.05)
BK Detrending	.04 (.02)	.07 (.03)	.09 (.10)	.40** (.03)	.03 (.04)	.02 (.06)	.01 (.09)	.15** (.05)
Linear Detrending	.06** (.01)	.07 (.04)	.28** (.05)	.41 (.18)	.14** (.03)	.02 (.05)	.26** (.07)	.22** (.06)
Growth Detrending	.02 (.02)	.01 (.05)	.12 (.06)	.06* (.02)	.01 (.03)	-.10* (.04)	.07 (.05)	-.03 (.06)
Fixed Effects	Time	Time	Time	Time	Time, Dyads	Time, Dyads	Time, Dyads	Time, Dyads

Least squares estimation: regressand is bilateral correlation coefficient for de-trended GDP between countries, computed with twenty observations. Robust standard errors in parentheses; coefficients significantly different from 0 at .05(.01) marked with one (two) asterisk(s).
Quinquennial data, computed from quarterly observations between 197Q4 and 2007Q4 for up to 64 countries (with gaps).
Controls included but not reported include: one country with fixed exchange rate; and one country in monetary union. Panel B adds controls: bilateral trade, log distance, and dummies for both industrial/developing countries.

Table 2a: Determinants of Synchronization with G7

One Country in:	IT	Fix	MU	IT	Fix	MU
HP Detrending	.11 (.07)	.03 (.05)	.15 (.19)	-.02 (.11)	.03 (.10)	-.04 (.14)
BK Detrending	.16 (.09)	.05 (.10)	.44** (.02)	.00 (.13)	.23* (.11)	.27* (.12)
Linear Detrending	.14 (.07)	.13 (.12)	.37 (.19)	.08 (.13)	.20 (.10)	.27* (.12)
Growth Detrending	.04 (.09)	.04 (.05)	.21* (.08)	-.09 (.10)	.10 (.10)	-.03 (.14)
Fixed Effects	Time	Time	Time	Time, Dyads	Time, Dyads	Time, Dyads

Table 2b: Adding Controls

One Country in:	IT	Fix	MU	IT	Fix	MU
HP Detrending	.07 (.05)	.01 (.03)	.02 (.15)	.01 (.11)	.07 (.10)	-.03 (.14)
BK Detrending	.12 (.07)	.03 (.10)	.20** (.04)	.05 (.13)	.27* (.11)	.29* (.14)
Linear Detrending	.09 (.06)	.13 (.10)	.20 (.12)	.13 (.12)	.26** (.10)	.28* (.12)
Growth Detrending	.00 (.07)	.02 (.04)	-.00 (.06)	-.07 (.11)	.13 (.10)	-.03 (.14)
Fixed Effects	Time	Time	Time	Time, Dyads	Time, Dyads	Time, Dyads

Least squares estimation: regressand is bilateral correlation coefficient for de-trended GDP between countries, computed with twenty observations. Robust standard errors in parentheses; coefficients significantly different from 0 at .05(.01) marked with one (two) asterisk(s).
Quinquennial data, computed from quarterly observations between 197Q4 and 2007Q4 for up to 64 countries (with gaps).
Controls included but not reported include: one country with fixed exchange rate; and one country in monetary union. Panel B adds controls: bilateral trade and dummy for both industrial countries.

Table 3: Matching Estimates of Effect of Monetary Regime on Cycle Synchronization

Monetary Regimes, Treatment Pair (number)	IT, any (1041)	IT, any (30)	IT, any (1041)	IT, any (1041)	IT, any (1041)	IT, any (1041)	IT, Fix/MU (276)
Monetary Regimes, Control Pair (number)	Any (5038)	G-7 (532)	Fix or MU (469)	Fix (267)	Fix or MU* (3185)	No fix or MU (1853)	Fix or MU (478)
HP Detrending	.08** (.01)	.08 (.07)	-.03 (.05)	-.08 (.06)	.09** (.02)	.06** (.02)	.08* (.04)
BK Detrending	.14** (.03)	.11 (.10)	.03 (.07)	-.04 (.08)	.15** (.03)	.12** (.03)	.17** (.06)
Linear Detrending	.10** (.02)	.07 (.09)	.02 (.07)	-.02 (.08)	.12** (.02)	.08** (.02)	.01 (.06)
Growth Detrending	.13** (.02)	.14* (.06)	.03 (.05)	-.06 (.06)	.15** (.02)	.11** (.02)	.11** (.04)

Coefficients reported are sample average of treatment effect; standard errors in parentheses. Coefficients significantly different from 0 at .05(.01) marked with one (two) asterisk(s).
Propensity score model for used for matching includes: bilateral trade, log distance, and dummies for both industrial/developing countries.
Estimates from nearest neighbor matching, with five matches per treatment.
Quinquennial data, computed from quarterly observations between 1990Q1 and 2007Q4 for up to 64 countries (with gaps).
* indicates both countries must be in fixed exchange rate regime or monetary but not necessarily vis-à-vis each other.

Table 4: Different Matching Estimators

Estimator	**Nearest Neighbor** (5 matches)	**Nearest Neighbor** (1 match)	**Nearest Neighbor** (5 matches)	**Strati-fication**	**Kernel**	**Radius**
HP Detrending	.08** (.01)	.08** (.02)	.07** (.02)	.06** (.01)	.07** (.02)	.08** (.01)
BK Detrending	.14** (.03)	.12** (.03)	.16** (.04)	.08** (.02)	.10** (.02)	.12** (.02)
Linear Detrending	.10** (.02)	.10** (.03)	.12** (.03)	.11** (.02)	.11** (.02)	.12** (.02)
Growth Detrending	.13** (.02)	.13** (.02)	.17** (.02)	.13** (.01)	.13** (.01)	.13** (.01)
Propensity Score Model	Standard	Standard	Augmented	Standard	Standard	Standard
Effect on	Average	Average	Average	Treated	Treated	Treated

Coefficients reported are sample treatment effects on average/treated; standard errors in parentheses. Coefficients significantly different from 0 at .05(.01) marked with one (two) asterisk(s). Standard errors for stratification and kernel estimated with (50) bootstrap replications.
Standard model for propensity score used for matching includes: bilateral trade, log distance, and dummies for both industrial/developing countries. Augmented propensity score model adds financial integration.
Treatment dyad includes one IT country and one non-IT country; control dyads include any non-IT countries. Quinquennial data, computed from quarterly observations between 1990Q1 and 2007Q4 for up to 64 countries (with gaps).

Table A1: Sample of Countries

	IT	Data
Argentina		1994
Australia	1993	1974
Austria		1974
Belarus		1996
Belgium		1974
Brazil	1999	1995
Bulgaria		2002
Canada	1991	1974
Chile	1991	1984
China		1998
Colombia	1999	1998
Costa Rica		2004
Croatia		1997
Cyprus		1999
Czech Republic	1998	1998
Denmark		1974
Ecuador		1995
Estonia		1997
Finland	1993	1974
France		1974
Georgia		2000
Germany		1974
Greece		1974
Hong Kong, China		1977
Hungary	2001	1999
Iceland	2001	2001
Indonesia	2005	1997
Iran		1999
Ireland		1974
Israel	1992	1984
Italy		1974
Jamaica		2000
Japan		1974
Korea	1998	1974
Latvia		1996
Lithuania		1997
Luxembourg		1999
Macao, China		2002
Malta		1974
Mauritius		2003
Mexico	1999	1997
Morocco		2002
Netherlands		1974
New Zealand	1990	1974
Norway	2001	1974
Peru	2002	1983
Philippines	2002	1985
Poland	1998	1999
Portugal		1974
Romania	2005	2002
Russia		1995
Singapore		1987
Slovakia	2005	1997
Slovenia		1996
South Africa	2000	1994
Spain	1995	1974
Sweden	1993	1974
Switzerland	2000	1974
Thailand	2000	1997
Tunisia		2004
Turkey	2006	1991
USA		1974
United Kingdom	1992	1974
Venezuela		2001

Dates indicate year of entry into inflation targeting, and year of earliest reliable output data.

Table A2: Adding Financial Integration to Business Cycle Synchronization Determination

	One IT	Both IT	Fixed ER	Monetary Union	One IT	Both IT	Fixed ER	Monetary Union
HP Detrending	.07* (.01)	.02 (.02)	.25 (.07)	.29* (.01)	.19** (.06)	.06 (.07)	-.39** (.05)	n/a
BK Detrending	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Linear Detrending	.11* (.004)	.05 (.04)	.26 (.02)	.39 (.17)	.40** (.06)	.19 (.12)	-.22** (.06)	n/a
Growth Detrending	.02 (.05)	-.02 (.09)	.07 (.03)	.05 (.04)	.23** (.07)	-.01 (.13)	-.14 (.15)	n/a
Fixed Effects	Time	Time	Time	Time	Time, Dyads	Time, Dyads	Time, Dyads	Time, Dyads

Least squares estimation: regressand is bilateral correlation coefficient for de-trended GDP between countries, computed with twenty observations. Robust standard errors in parentheses; coefficients significantly different from 0 at .05(.01) marked with one (two) asterisk(s).
Quinquennial data, computed from quarterly observations between 197Q4 and 2007Q4 for up to 64 countries (with gaps).
Controls included but not reported include: one country with fixed exchange rate; and one country in monetary union. Panel B adds controls: bilateral financial integration; bilateral trade, log distance, and dummies for both industrial/developing countries.

Table A3: Matching Estimates of Effect of Monetary Regime on Covariances instead of Correlation Coefficients

Monetary Regimes, Treatment Pair (number)	IT, any (1041)	IT, any (1041)	IT, any (1041)	IT, any (1041)	IT, any (1041)	IT, Fix/MU (276)
Monetary Regimes, Control Pair (number)	Any (5038)	Fix or MU (469)	Fix (267)	Fix or MU* (3185)	No fix or MU (1853)	Fix or MU (478)
HP Detrending	-.00000 (.00001)	-.00001 (.00001)	-.00002 (.00001)	.00001 (.00001)	-.00002 (.00001)	.00001 (.00001)
BK Detrending	.00003** (.00001)	.00001 (.00001)	.00000 (.00001)	.00003** (.00001)	.00003** (.00001)	.00002 (.00001)
Linear Detrending	.00008** (.00002	-.00002 (.00003)	-.00004 (.00004)	.00006** (.00002)	.00009** (.00003	-.00003 (.00003)
Growth Detrending	.53** (.19)	.23 (.24)	-.10 (.29)	,58** (.15)	.45 (.23)	.24 (.15)

Coefficients reported are sample average of treatment effect; standard errors in parentheses. Coefficients significantly different from 0 at .05(.01) marked with one (two) asterisk(s).
Propensity score model for used for matching includes: bilateral trade, log distance, dummies for both industrial/developing countries, and product of output standard deviations for both countries.
Estimates from nearest neighbor matching, with five matches per treatment.
Quinquennial data, computed from quarterly observations between 1990Q1 and 2007Q4 for up to 64 countries (with gaps).
* indicates both countries must be in fixed exchange rate regime or monetary but not necessarily vis-à-vis each other.

Figure 1

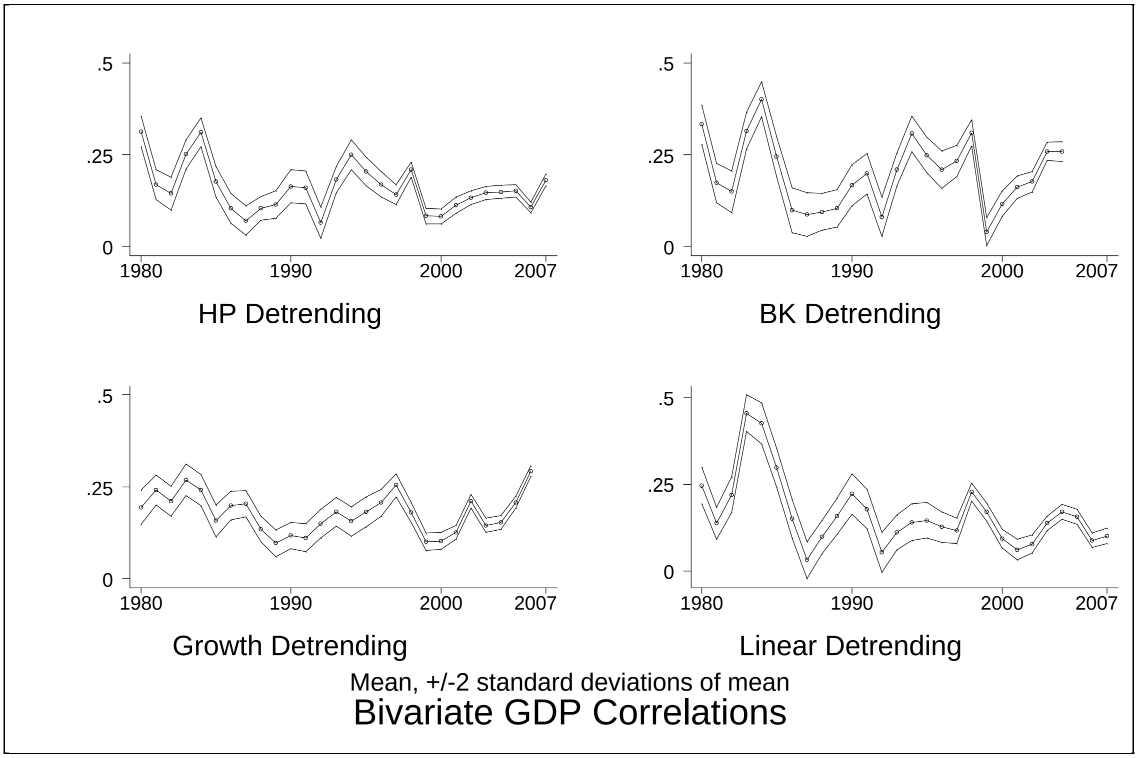


Figure 2

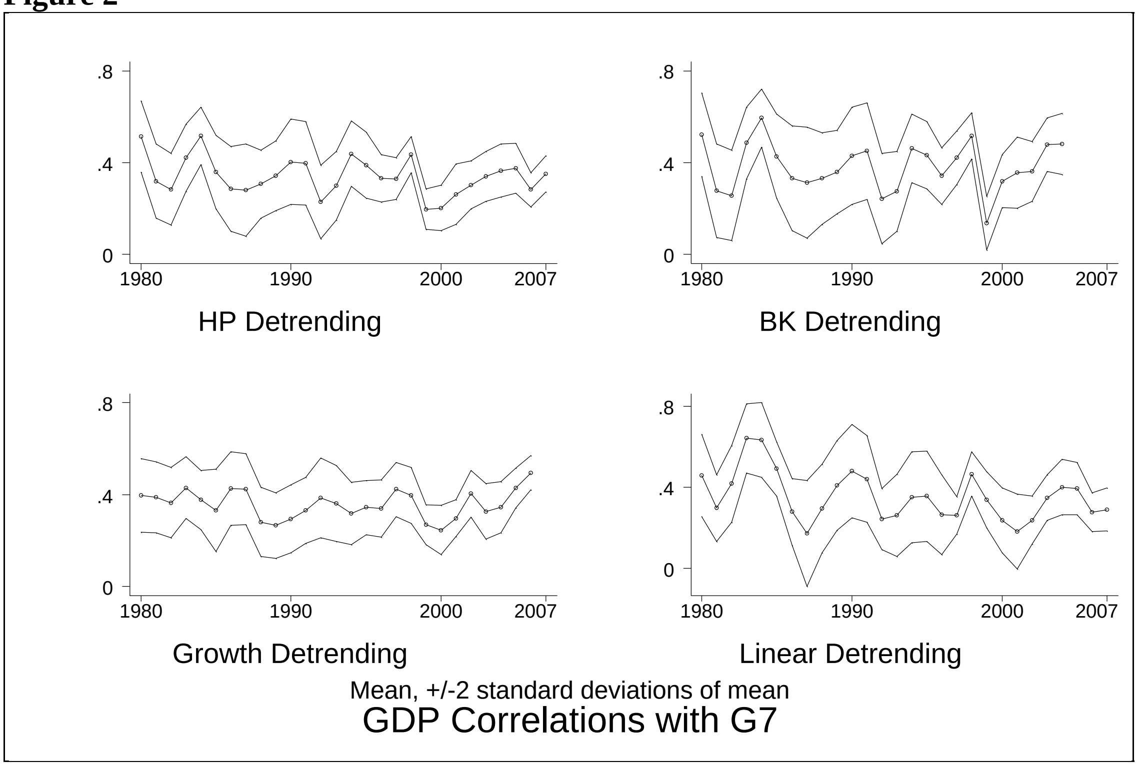


Figure 3

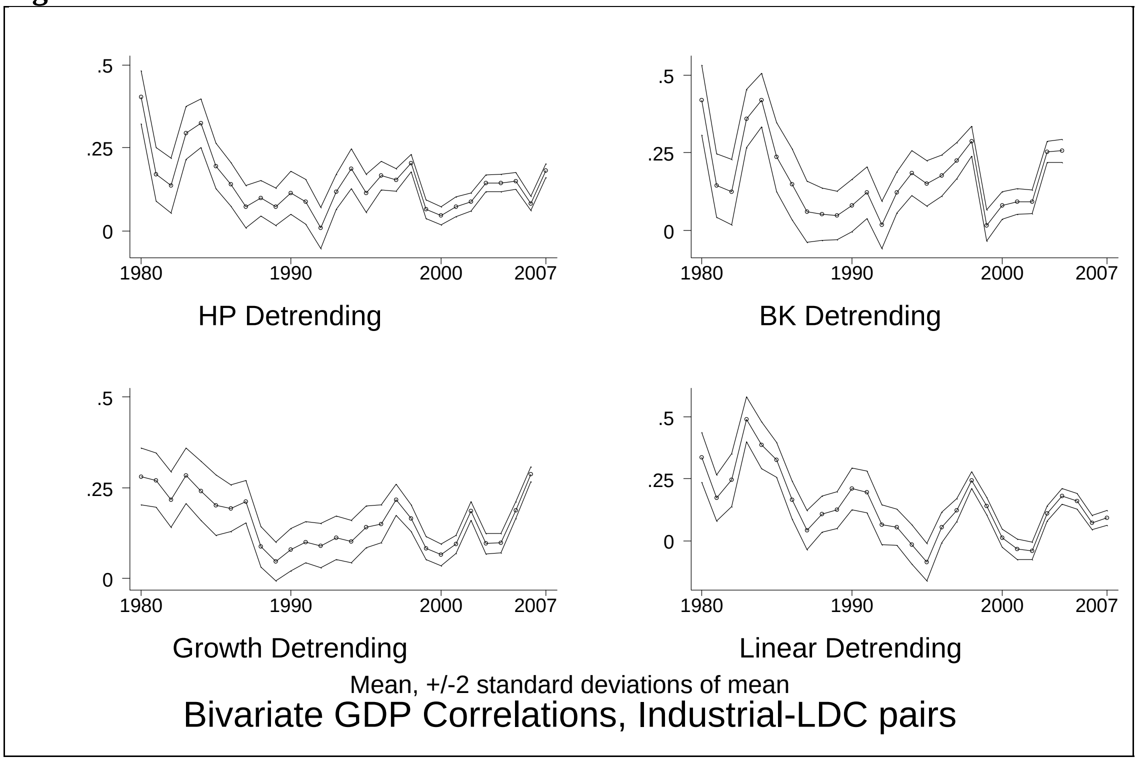


Figure 4

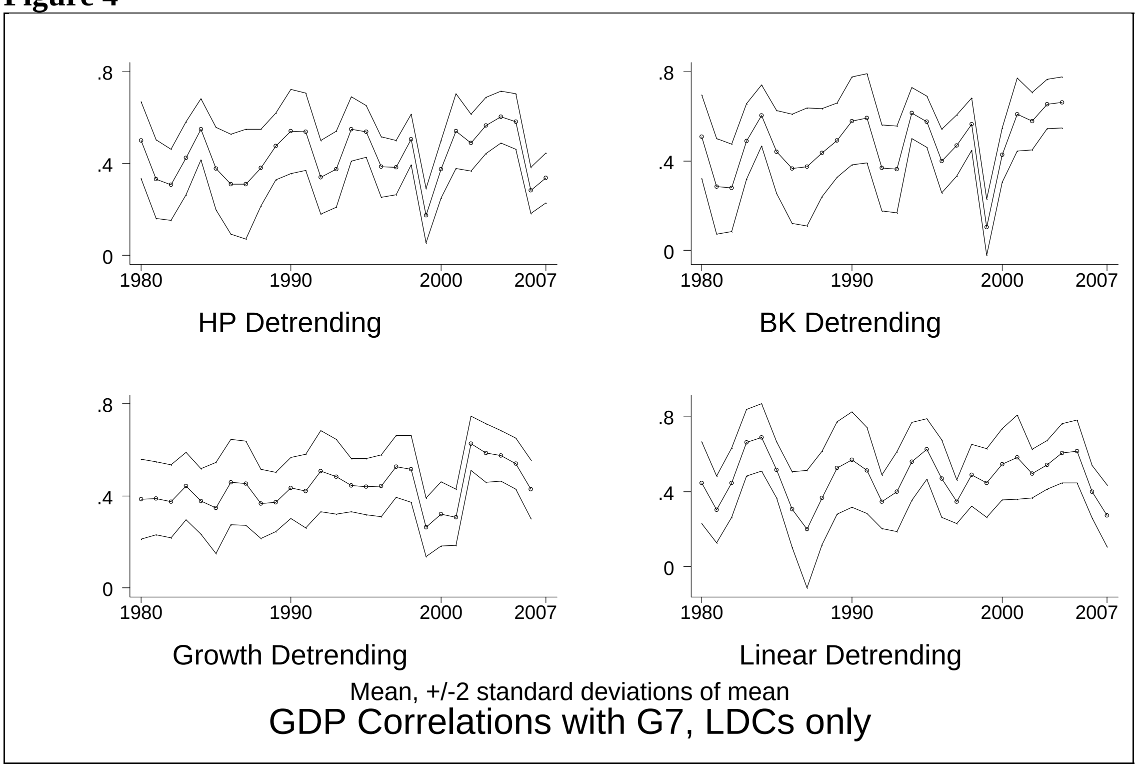
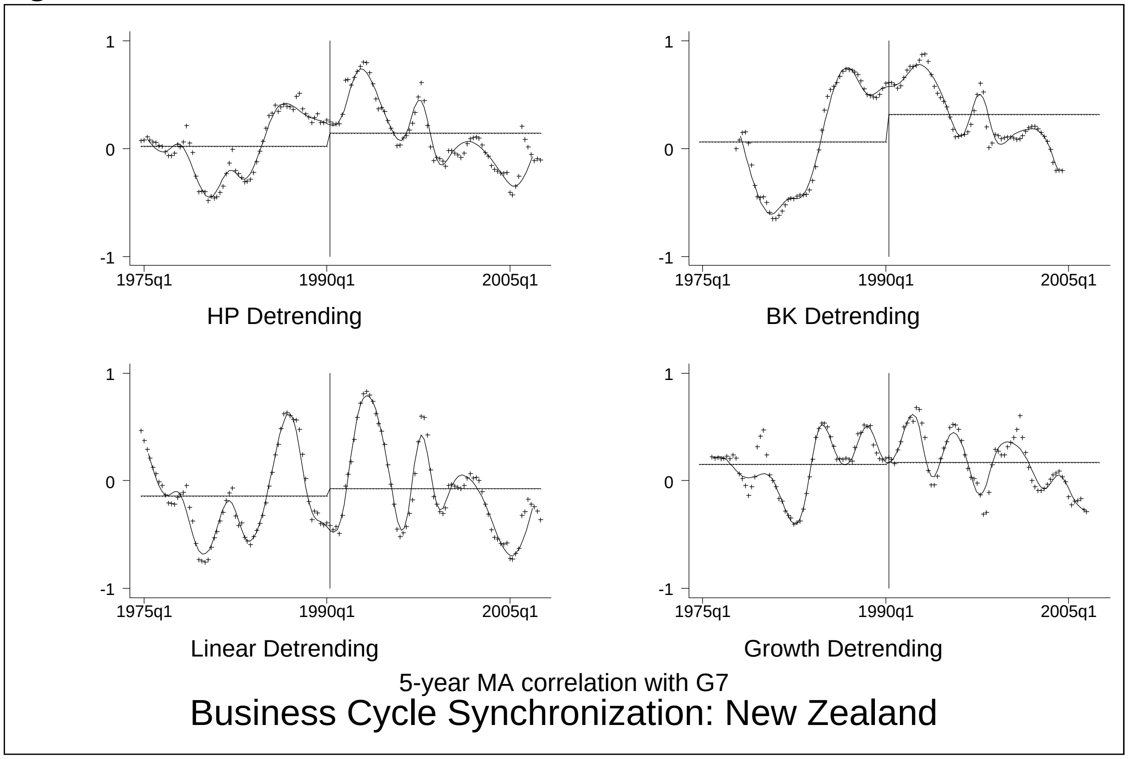


Figure 5



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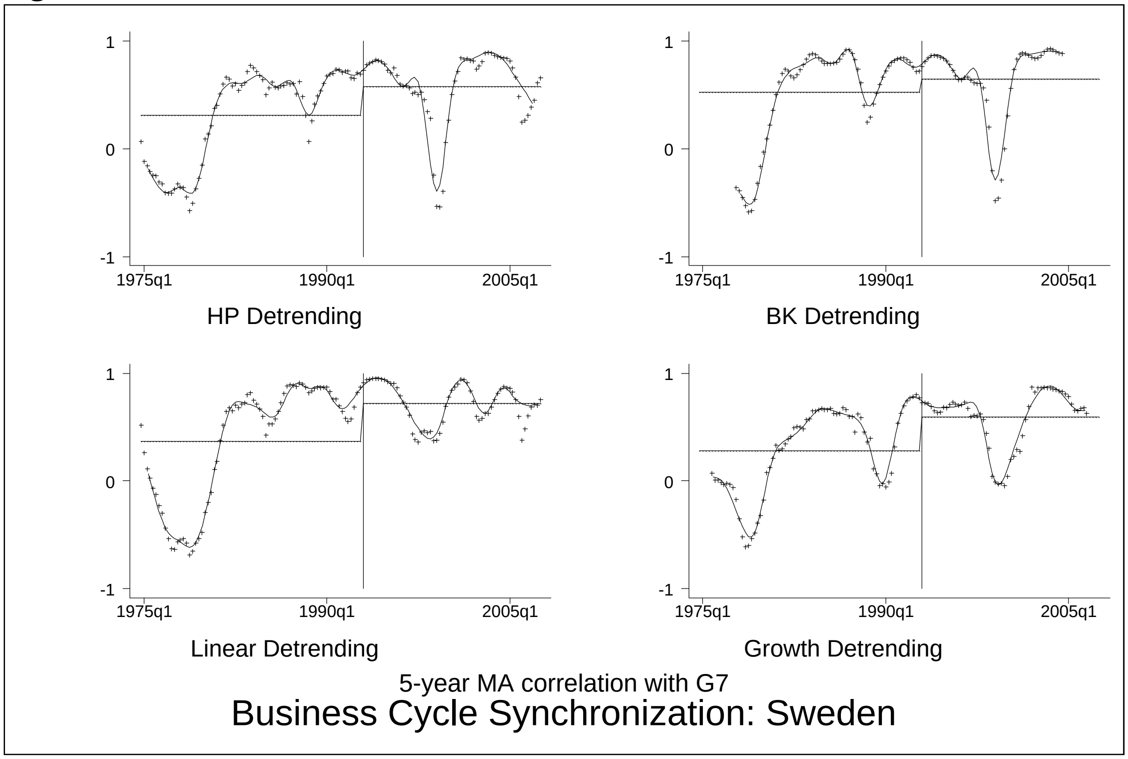


Figure 7

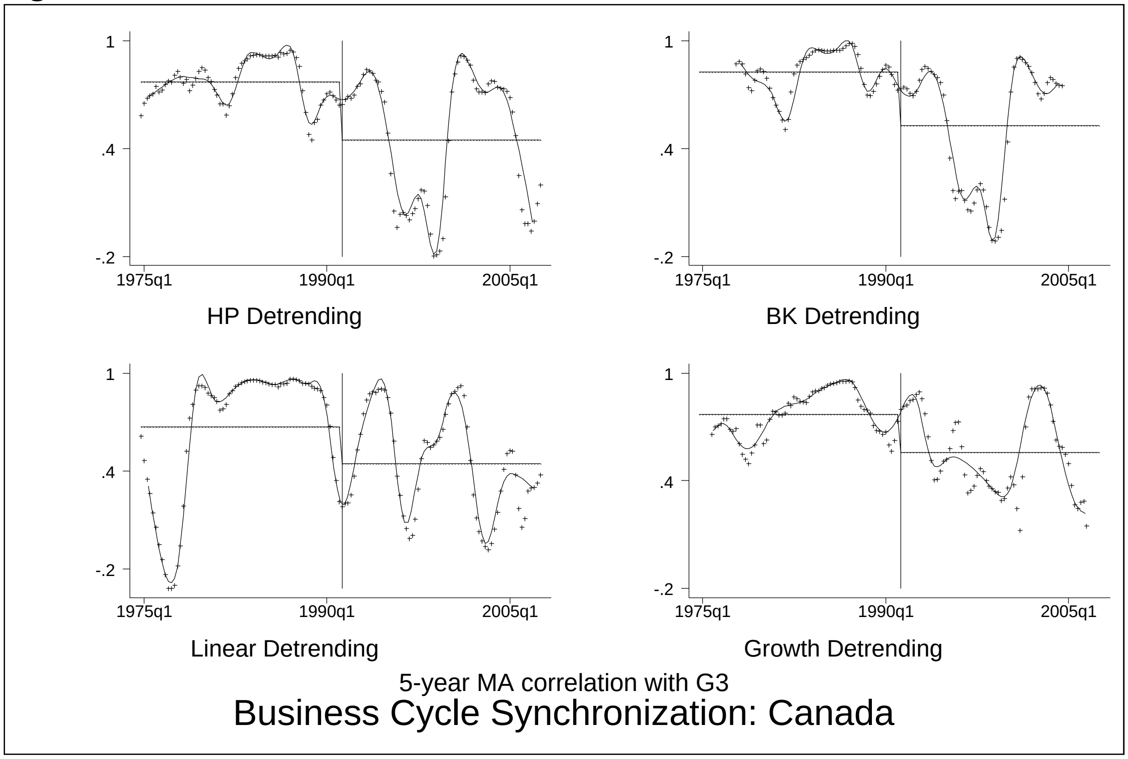


Figure 8

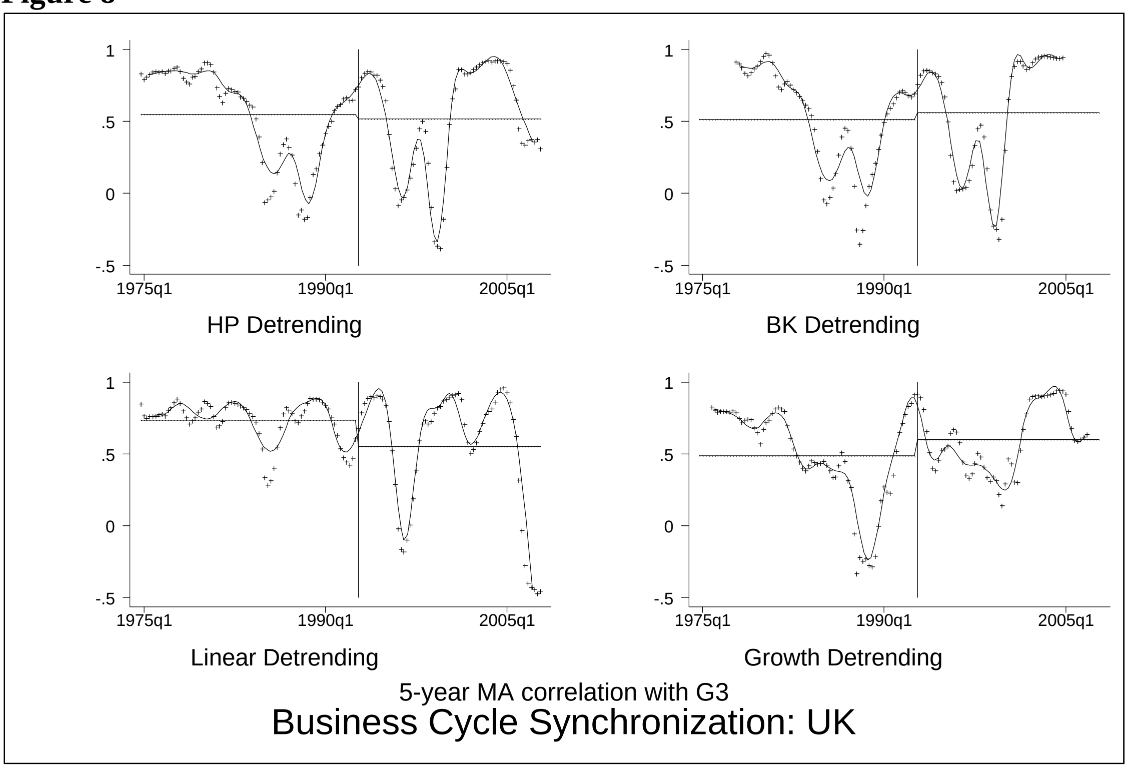


Figure 9

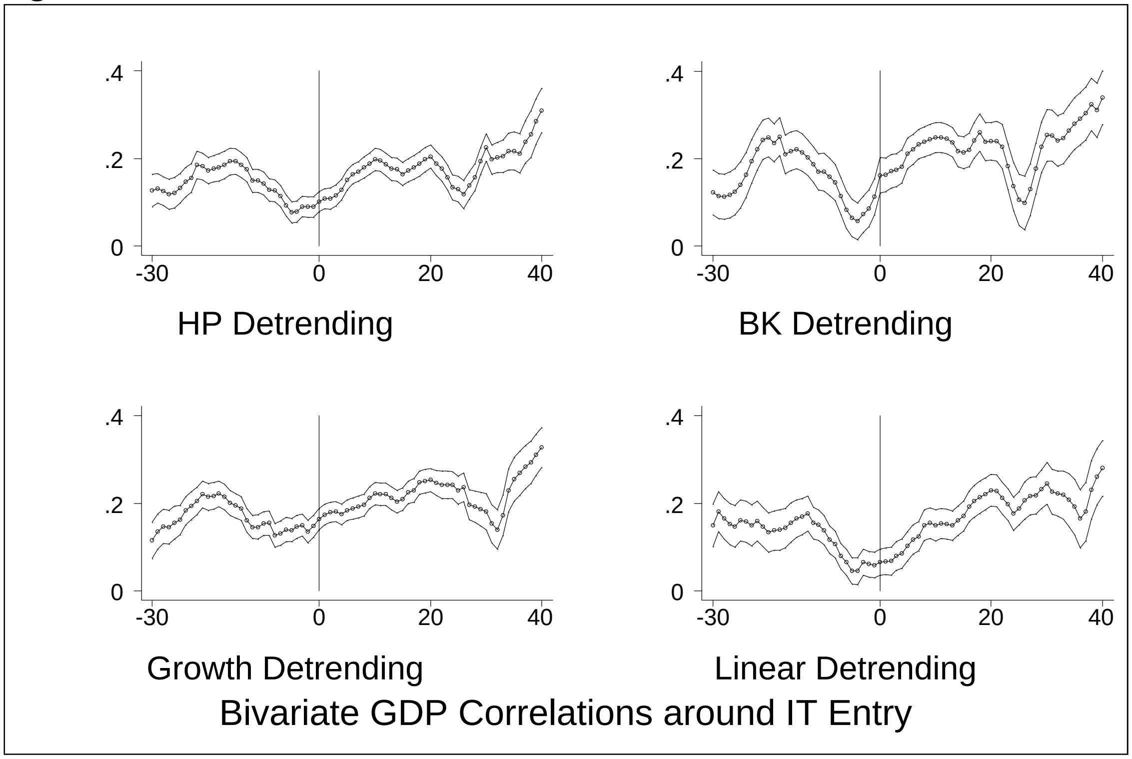


Figure 10

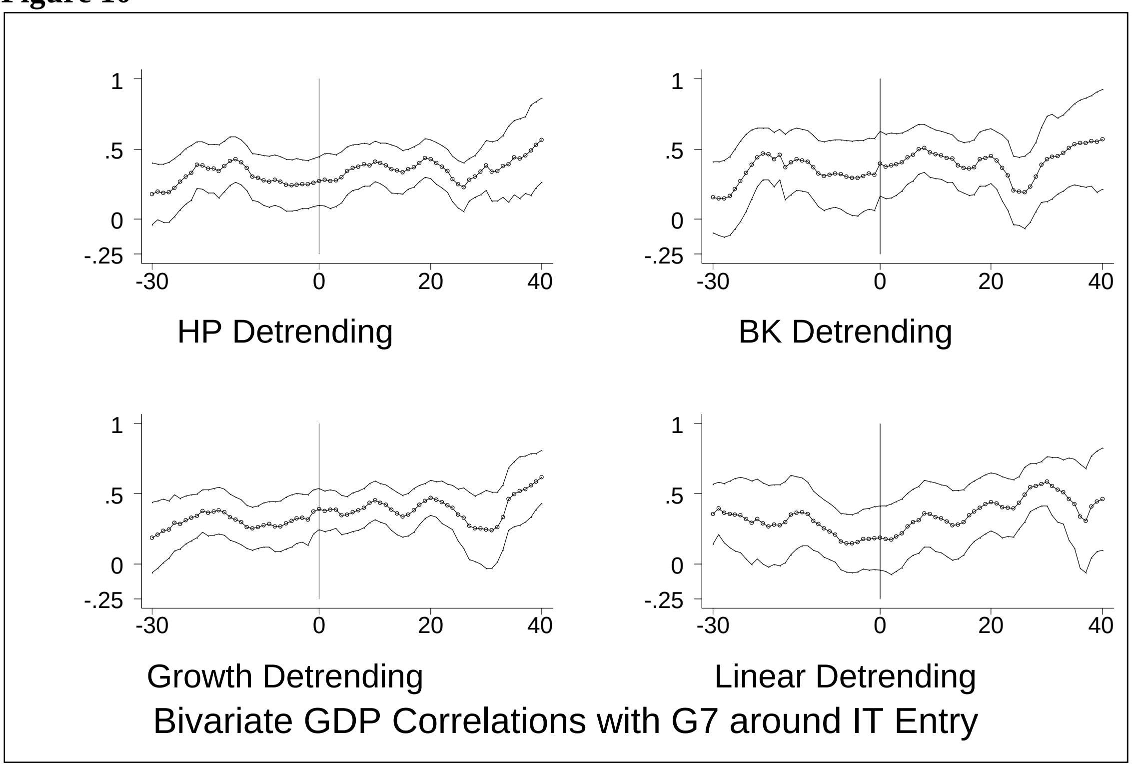
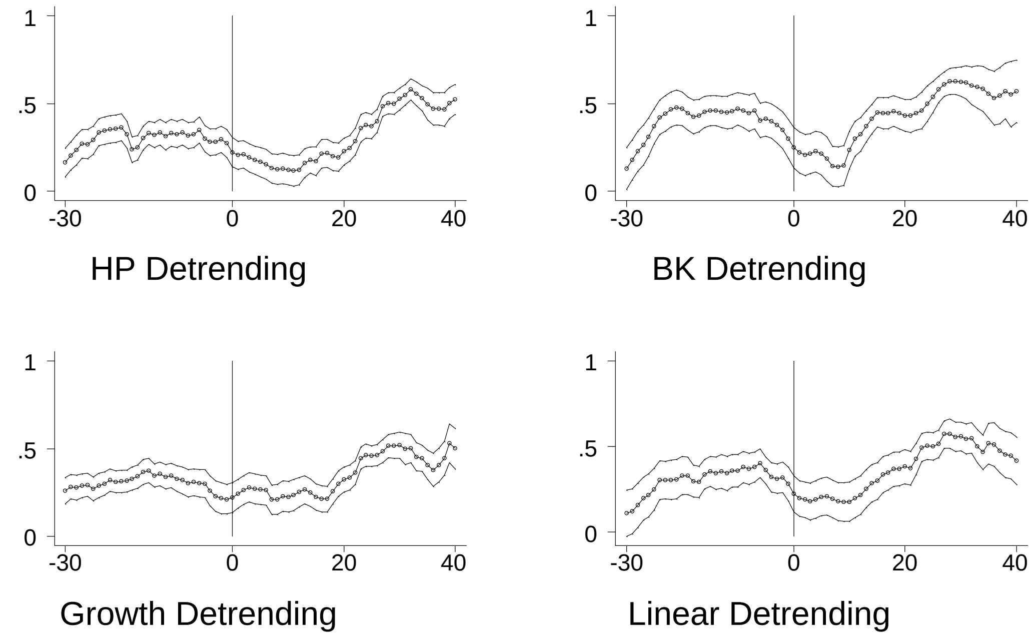
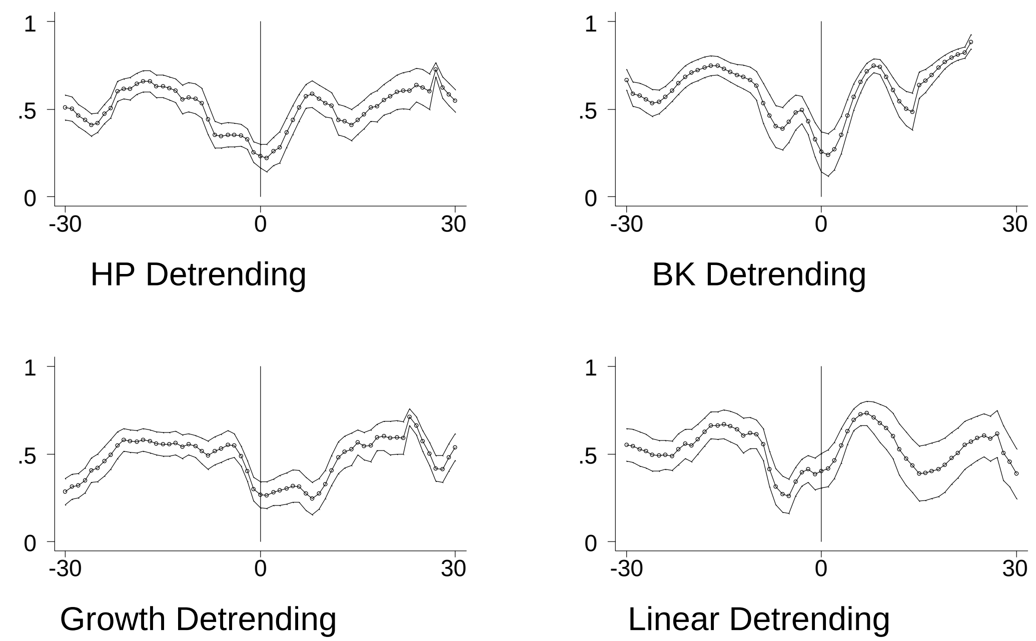


Figure 11



Bivariate GDP Correlations around Entry into Fixed Exchange Rate

Figure 12



Bivariate GDP Correlations around EMU Entry

Figure A1

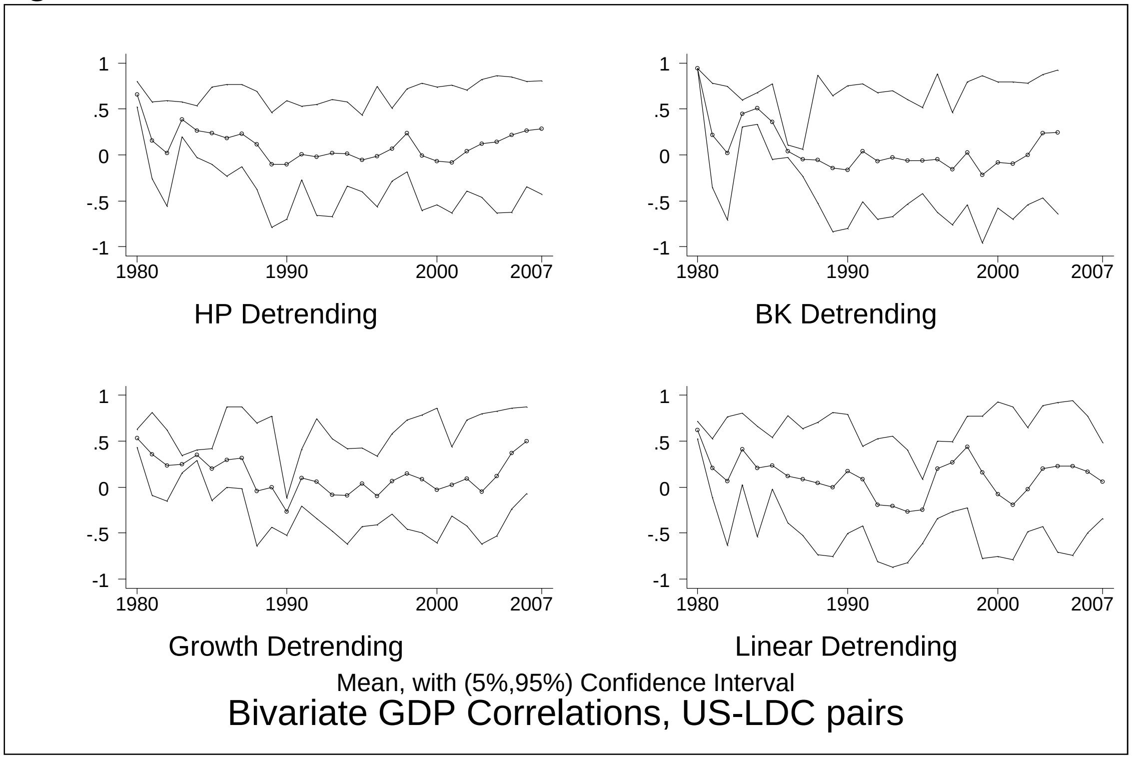
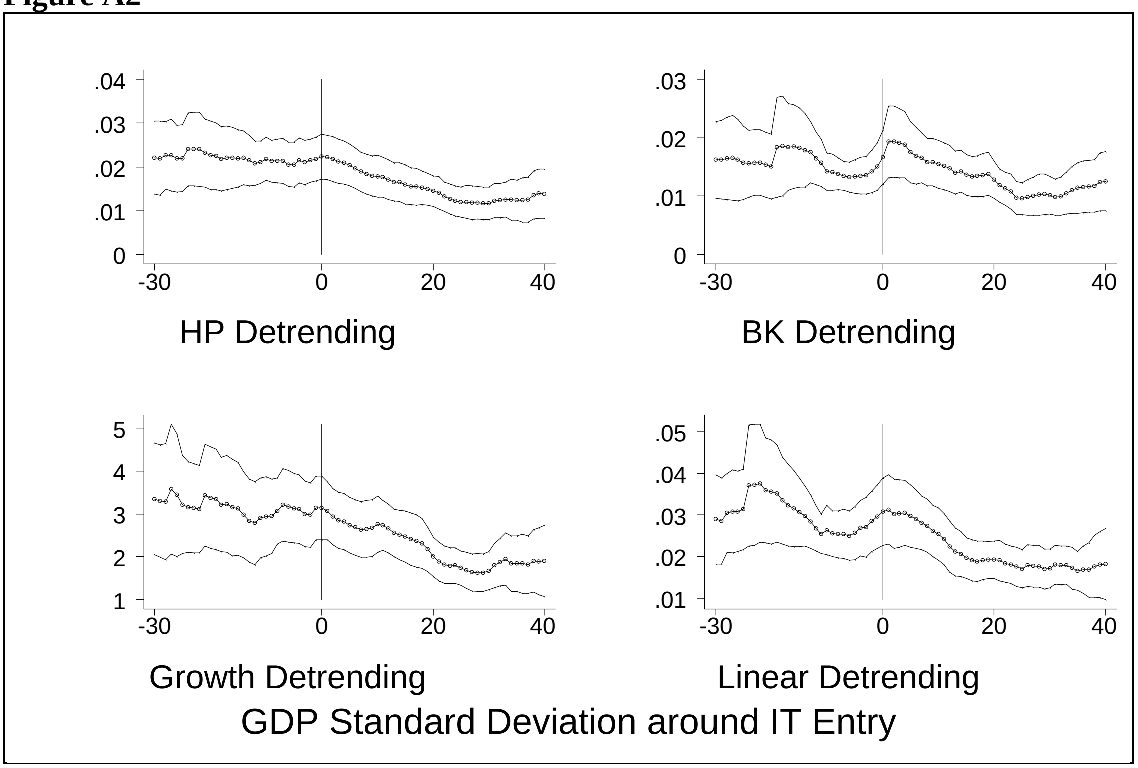


Figure A2



Endnotes

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[1] We note that there is no UIP equation. Indeed, we do not even bother with the foreign interest rate. The interpretation is either that capital is immobile internationally or that the risk premium is whatever is needed on a period-by-period basis to keep capital from moving.

[2] Our NAP regime corresponds perhaps most closely to what Friedman had in mind in his celebrated (1953) case for floating exchange rates. Friedman states (p 200): "In effect, flexible exchange rates are a means of combining interdependence among countries through trade with a maximum of internal monetary independence; they are a means of permitting each country to seek for monetary stability according to its own lights, without either imposing its mistakes on its neighbors or having their mistakes imposed on it."

[3] Our result can be compared with the results of Céspedes, Chang and Velasco (2004), who begin their paper "Any economics undergraduate worthy of a B learns this key policy implication of the Mundell-Fleming model: if any economy is predominantly hit by foreign real shocks, flexible exchange rates dominate fixed rates."

[4] Our implication requires $\frac{\beta+\delta}{\delta} > A.$ For quarterly data, the literature puts A in the range $2 \geq A > 0.$ In our sticky-price interpretation $\beta \gg 0,$ which gives our result for reasonable $\delta.$

[5] Cecchetti and Ehrmann (1999) address the question of whether inflation targeting has affected output volatility.

[6] Our questions have been little addressed empirically in the literature. To the best of our knowledge, the most clear predecessor is Kose, Otrok and Prasad (2008), who use a factor model to analyze the interdependence of business cycles. They cover more countries than we do here, but at the annual frequency. Our empirical model is consistent with most their findings, but is focused differently, since our emphasis is on linking business cycle synchronization to economic determinants, rather than characterizing BCS *per se*. Bordo and Helbling (2003) use similar techniques on a much longer-run span of data. All these approaches are reduced-form in nature; yet another way to proceed would be to pursue a more structural approach by imposing more structure and examining the reactions to e.g., common productivity shocks. This would require plausibly identifying exogenous shocks for a multitude of countries; we leave such work to more ambitious authors. Finally, we note that one could also follow Alesina et al (2003) and ask comparable questions concerning nominal phenomena, such as the cross-country co-movement in inflation.

[7] We follow the definition of Mishkin (2004), who lists five components to an inflation targeting regime:

a) The public announcement of medium-term numerical targets for inflation,
b) An institutional commitment to price stability as the primary goal of monetary policy,
c) An information-inclusive strategy to set policy instruments,
d) Increased transparency of the monetary policy strategy, and
e) Increased accountability of central bank for attaining its inflation objectives.

For more discussion of this and the dates when inflation targeting began, see Rose (2007); here, we simply stress that there is no requirement that the central bank be either independent or successful in hitting its inflation target. We also note in passing that Serbia may soon become a formal inflation targeter.

[8] We were unsuccessful in our attempt to construct feasible series for employment and unemployment. We also note in passing that some series had to be seasonally adjusted, which we performed via the X-12 filter.

[9] We use a smoothing parameter of 1600, as is standard for quarterly data.

[10] We focus on cycles of between 6 and 32 quarters in length, and follow the Baxter-King recommendation of using, and therefore losing 12 quarters of data for leads/lags.

[11] Gouveia and Correia (2008) provide further references to BCS determination in the context of EMU.

[12] Alternative measures of synchronization are explored by Alesina et al (2003) and Kalemli-Ozcan et al (2009). One can imagine other measures, especially if business cycles in some countries systematically lead or lag those of others, in which case a contemporaneous correlation might not be optimal.

[13] We construct weights for the G-3 and G-7 by comparing sample-averages for real PPP-adjusted GDP for the countries from the Penn World Table 6.2. For the G-3, this results in weights of: .1551266 (Germany), .2179533 (Japan) and .6269201 (US). For the G-7, the weights are: .0398185 (Canada); .0791699 (France); .1135938 (Germany); .071953 (Italy); .1598016 (Japan); .0759468 (UK); and .4597164 (USA).

[14] We use the updated Reinhart-Rogoff "coarse" measure of fixed exchange rate regimes; details and the data set are available at http://www.wam.umd.edu/~creinhar/Papers.html. The coarse measure includes: a) no separate legal tender; b) pre-announced peg or currency board arrangement; c) pre-announced horizontal band that is narrower than or equal to +/-2%; and d) de facto peg.

[15] We follow Baxter and Kouparitsas (and others such as Frankel and Rose, 1998) and use their preferred "BT1" measure, thus defining bilateral trade between a pair of countries (i and j) as the sum of all four bilateral trade flows (exports from i to j, imports into j from i, exports from j to i, and imports into i from j), divided by the corresponding multilateral sums (i's exports, j's exports, i's imports and j's imports). Annual bilateral trade data on FOB exports and CIF exports is drawn from the IMF's *Direction of Trade* data set; values are the same for all quarter in a given year (the same is true of our measure of financial integration). We follow the IMF in defining a country as industrial if its IFS country code is less than 200. We also use the natural logarithm of bilateral distance, where a country's location in longitude and latitude is given by the CIA's *World Factbook* location.
We note in passing that Baxter and Kouparitsas used data at two points of time (1970 and 1995), so that we are extrapolating their cross-sectional results to the panel context we consider. We also note that Baxter and Kouparitsas did not consider fixed exchange rate, inflation targeting, or EMU regimes. They did not find a robust effect of developing country currency unions on BCS.
[16] Kalemli-Ozacan et. Al. (2009) use a confidential panel data set that covers bilateral bank lending positions over the past three decades of industrial country activity.
[17] Since the correlation coefficients are computed with twenty observations each, they are highly dependent over time.
[18] "Decoupling" is not typically defined carefully, but is usually considered to refer to divergences in short-term aggregate fluctuations across countries. For instance, in their May 23, 2007 Global Economics Report *Global Decoupling: A Marathon, not a Sprint* Merrill Lynch seems to refer (on p1) to a chart entitled "Chart 1: Yes, decoupling" with divergent growth between the US and the rest of the world since 2004. On p2 of the same report, they refer to this divergence taking place in 2000, though their Chart 2 focuses on divergence beginning in early 2006. Perhaps most revealingly, on p20 Merrill Lynch writes "the arguments and evidence in favor of decoupling appear stronger than ever. We still think a US slowdown - even a mild US recession -would have a modest impact on Asian growth." It is hard to think of decoupling as referring to longer-term growth, since substantial differences in growth rates across countries are the norm.
[19] In our sample, there is a very small negative correlation between (country x quarter) observations of business-cycle volatility and the incidence of inflation targeting; the average (across the different detrenders) is around -.04.
[20] Figure 2 includes the observations of the individual G-7 countries with the G-7 aggregate. No conclusions change if these observations are dropped.
[21] Appendix Figure A1 is an analogue to Figure 4 which considers BCS of the developing countries against the United States instead of the G-7. The conclusion is the same; there is little sign of any strong decline in BCS between the developing world and the USA.
[22] The correlation coefficients are individually marked and connected with a non-parametric data smoother.
[23] Conclusions however would be essentially unchanged if we used the G-7 instead of the G-3.
[24] The correlation coefficients are highly dependent, both across time (for a given dyad) and across dyads (at a given point in time), so the standard errors should be taken with a large grain of salt.
[25] In contrast to the events portrayed in Figures 9 and 10, the events of Figures 11 and 12 are intrinsically dyadic; in the latter *both* countries must begin to fix exchange rates vis-à-vis each other or enter EMU simultaneously to count as an event, whereas in the former precisely one of the two countries in the dyad must adopt IT to count as an event.
[26] Note that Fix(2) is only unity if both countries are fixed vis-à-vis each other; similarly, MU(2) is unity if both countries are in the same currency union. Thus, e.g., MU(2)=0 in 2002 for Ecuador and France; both were in currency unions at the time though they did not share a common currency.
[27] Only time-varying effects can be estimated when dyadic fixed effects are included in the regressions.
[28] The exact choice of which quarter is included does not seem to affect any conclusions.
[29] Table A2 adds financial integration to the list of controls, as suggested by Imbs (2006). This additional regressor reduces the sample size considerably, but does not induce substantively negative IT effects. Only five of the twelve coefficients are significantly different from zero, and all are positive.
[30] It is unsurprising that the monetary union coefficient is often positive, since both Ecuador and the EMU countries share currencies with other members of the G-7.
[31] One can test the suitability of the propensity score model in part by determining whether it delivers "balanced" characteristics independent of treatment/control status, so that the treatment/control status is random for a given value of the propensity score. In practice, the propensity score model consisting of the four Baxter-Kouparitsas

essentially never satisfies the balancing property. Adding interactions and second-order terms to the model does not allow the balancing property to be satisfied. This throws serious doubt on the matching estimates.

[32] In addition, for computation reasons, we restrict control group observations to first-quarter observations. For the default measure, we are also forced for computational reasons to draw our control group observations from even years. However, the latter restriction is not necessary when we consider more restricted control groups, which thus also include odd years.

[33] The sample is much smaller when we restrict attention to just fixed exchange rate regimes instead of either fixes or monetary union. In this case, none of the effects is significantly different from zero, though three of the four are positive.

[34] The latter three estimates are of the treatment effect on the treated, not the average treatment effect.

[35] We add the product of the countries' standard deviations to the propensity score model. We do this because there is evidence that output volatility has declined following the advent of inflation targeting; graphical evidence is supplied in the form of an event study in Appendix Figure A2 which examines the standard deviation of detrended output around the time of entry into Inflation targeting. The decline in output volatility may be simply a reflection of the fact that volatility fell everywhere in the late part of the sample during the "Great Moderation." The fact that the covariances between countries rise when one (or both) target inflation are consistent with the hypothesis that the Great Moderation was good policy and not simply good luck.