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ORIGINAL ARTICLE

Business cycle synchronization: is it affected by inflation targeting credibility?

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Abstract

We empirically study the impact of inflation targeting credibility on business cycle synchronization with G-7 economies. To do this, we use a sample of 15 inflation targeting countries to develop and calculate a reputation-based credibility measure for long- and short-term memory. By using dynamic multipliers through a panel vector autoregressive model, our main findings indicate that greater credibility allows for greater anchoring of inflation expectations by economic agents. This would lead to a greater effectiveness of monetary policy in stabilizing the evolution of prices, allowing the output gap to be more sensitive to external aggregate demand shocks. Therefore, countries with inflation targeting regimes must develop and maintain credibility for their monetary policy if they want to encourage greater interactions with the rest of the world.

Keywords Business cycle synchronization · Credibility · Globalization · Inflation targeting · Panel VAR

JEL Classification F42 · E52

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1 Introduction

Globalization, through its effects on both the real and the financial sectors, has increased the interaction between business cycle phases of different economies. This phenomenon is known as business cycle coupling or synchronization. Due to its importance in coordinating economic policies between countries (commercial, technological, financial, and monetary policies), business cycle synchronization (BCS, henceforth) has received considerable attention during the last decade, with an increasing amount of research but few conclusive results (Pesce 2017).

Theoretical foundations in BSC highlight trade intensity, for both inter-industry trade and intra-industry trade,[1] as a factor that affects the degree of synchronization between two economies (Frankel and Rose 1998). Moreover, the degree of production structure symmetry and levels of financial linkages between countries are additional factors explaining the synchronization of business cycle phases (Imbs 2004; Calderón et al. 2007; Schiavo 2008).

Macroeconomic policies can also have an effect on the level of BCS. Economic authorities define policy framework to achieve objectives associated with fiscal, trade, and exchange rates and monetary aspects. Among the latter, central banks primarily attempt to stabilize the evolution of aggregate price levels. Inflation targeting (IT, henceforth) has become a leading strategy for inflation stabilization. Since the 1990s, when the first countries began to use IT, the number of nations implementing this regime has increased drastically, especially in emerging economies (Schmidt-Hebbel and Carrasco 2016).

The existing evidence on the impact of IT on BCS has suggested that IT promotes synchronization among economies—although the evidence is neither abundant nor conclusive. Arguments in favor of a positive effect of IT on BCS state that by adopting IT central banks can set interest rates in order to stabilize inflation, resulting in a domestic output that is more sensitive to external shocks (Flood and Rose 2010). In the same vein, Inoue et al. (2012) present evidence that IT encourages BCS for some Asian countries.

Nowadays, there are an increasing number of countries that have adopted and maintained IT. Using IT, central banks have been able to make and prove their commitment to price-level stabilization, which has helped the strategy gain more credibility. Credibility is understood as the degree of expectations that agents have about whether inflation converges to target levels within the deadlines announced by policy makers (De Mendonça and E Souza 2009). Therefore, it is possible to conclude that IT's effectiveness is driven by its degree of credibility.

In this paper, we focus on the impact of central bank credibility on BCS. To do this, we measure credibility based on the reputation of central banks. More specifically, we look at whether greater credibility allows for a better anchoring of inflation

[1] In relation to Heckscher–Ohlin's theory, Calderón et al. (2007) state that a pattern of inter-industrial trade is one that is generated by different industries (different kinds of products) and favors specialization. In contrast, intra-industry trade is one that assumes a given country imports and exports goods and/or services of the same nature, simultaneously.

expectations toward inflation targets. In this way, increasing credibility would promote a coupling effect of business cycles phases as a positive externality of monetary policy in IT countries. We postulate that interest rate is a mechanism by which IT can impact BSC. A positive transitory shock that increases price levels also decreases expectation for future inflation. Therefore, policymakers decrease interest rate in order to maintain inflation expectations around the target level. In such an environment, interest rate reduction intensifies the effect on domestic output caused by a positive external shock. Thus, correlation between domestic and external outputs increases under IT regimes (see a deeper discussion about this issue in Flood and Rose 2010).

The objective of this paper is to study the impact of central banks' degree of credibility on BCS. Our main contribution is focusing on the degree of credibility instead of focusing on IT, per se, as a factor affecting BCS. We also provide evidence on the explicit impact of IT credibility on BCS—evidence which is certainly not abundant. For instance, Flood and Rose (2010) show theoretically that IT promotes BCS by assuming perfect credibility. Empirically, mixed evidence for Asian economies is found by Inoue et al. (2012), whose alternative findings could have been driven by varying degrees of credibility on implemented policies.

We used a sample of 15 countries that have adopted IT for a long period of time and have been successful in their convergence to their inflation targets. This sample includes both developed and emerging economies for the quarterly period 1985:Q1 to 2015:Q4 for real, seasonally adjusted GDP data. We focus on the synchronization of these economies with G-7 countries, which represent an appropriate proxy for world economic activity (Colomo 2015).[2]

By computing a reputation-based credibility measure (following De Mendonça and E Souza 2009) and using a panel vector autoregressive model (PVAR, henceforth), we obtain dynamic multipliers to analyze the effect of the degree of credibility on BCS. Our main findings indicate that a greater degree of credibility allows for a greater anchoring of agent's expectations and, thus, an increased effectiveness of monetary policy in stabilizing prices.

This paper is organized as follows: Sect. 2 presents the methodological approach, and Sect. 3 shows data used in this paper. Section 4 discusses our main results, and Sect. 5 concludes the paper.

2 Methodology

To quantify the degree of IT credibility for each country, we use the index proposed by De Mendonça and E Souza (2009). They argue that reputation is essentially a backward-looking variable, and hence, an IT regime gains credibility based on the past reputation of policy makers (De Mendonça 2007). Our reputation-based

[2] According to Colomo (2015), the GDP of G-7 economies accounted for more than 60% of the world's GDP. G-7 countries are: Germany, Canada, the USA, France, Italy, Japan, and the UK.

credibility measure allows us to compute two credibility indexes: long- and short-term memory. The central bank's reputation of country i during period t is defined by

$$R_{it} = \begin{cases} 1 & if\ \pi^*_{it\,\mathrm{Min}} \leq \pi_{it} \leq \pi^*_{it\,\mathrm{Max}} \\ 1 - \frac{1}{0.2-\pi^*_{it\,\mathrm{Max}}}\left[\pi_{it} - \pi^*_{it\,\mathrm{Max}}\right] & if\ \pi^*_{it\,\mathrm{Max}} \leq \pi_{it} \leq 0.2 \\ 1 - \frac{1}{-\pi^*_{it\,\mathrm{Min}}}\left[\pi_{it} - \pi^*_{it\,\mathrm{Min}}\right] & if\ 0 \leq \pi_{it} \leq \pi^*_{it\,\mathrm{Min}} \\ 0 & if\ \pi_{it} \geq 0.2 \text{ or } \pi_{it} \leq 0 \end{cases} \tag{1}$$

where π_{it} is the current inflation. $\pi^*_{it\,\mathrm{Min}}$ and $\pi^*_{it\,\mathrm{Max}}$ represent the lower and upper limits of the IT bands established by the central bank, respectively. Thus, a central bank has total reputation when current inflation is within the target range and loses reputation when inflation is outside that range. Following De Mendonça and E Souza (2009), we have assumed a 20% threshold for defining reputation loss.[3] From this measure of reputation, we calculate two reputation-based credibility indexes: long- and short-term memory. We measure reputation based on a weighted average of past reputations, giving more weight to more recent periods. This approach gives us a long-term memory (LTM) measure, i.e.,

$$\mathrm{CI}_{\mathrm{LTM}} = \left\{ \frac{\sum_{j=1}^{n} (R_j \cdot p_j)}{\sum_{j=1}^{n} p_j} \right\}, \tag{2}$$

where $p_j = \frac{k_j}{n}$ is the weight given to reputation during period j, which corresponds to the ratio between k_j and n total periods. k_j is a natural number that decreases on t; it begins with one for the first period of IT implementation and increases by one unit for each subsequent period.

Next, we develop a reputation-based credibility index focusing on agents' short-term memory (STM) by calculating a moving average over six lags[4] (one semester memory), i.e.,

$$\mathrm{CI}_{\mathrm{STM}} = \left\{ \frac{R_t + R_{t-1} + \cdots + R_{t-6-1}}{6} \right\}. \tag{3}$$

To measure synchronization, we use the Hodrick and Prescott filter (1980) defined by $y^{\mathrm{HP}}_{it} \equiv y_{it} - \hat{y}^{\mathrm{HP}}_{it}$, where y_{it} is the natural logarithm of real GDP during period t and $\hat{y}^{\mathrm{HP}}_{it}$ is its trend level. After obtaining the GDP's cyclical component, we calculate the degree of BCS between the sample countries and the G-7 economies. To do this, we obtain a Pearson's coefficient of sample correlation using 12, 16, and 20 previous observations of past data (including the contemporary period). Thus,

[3] De Mendonça and E Souza (2009) claim that inflation rates above 20% produce a loss of regulatory control by the monetary authority.

[4] We used three and twelve lags without significant changes in our main findings.

our BCS measure, $\hat{\rho}^{d}_{it}$, represents the correlation coefficient between country i and G-7 economies during period t for d past observations.

Because of the macropanel structure of data, we use a PVAR model to estimate dynamic multipliers.[5] Although these multipliers are analogous to impulse response functions, they are generated by an exogenous variable. The PVAR model used to investigate the effect of credibility on BCS is defined as follows:

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \cdots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + X_{it}B + \mu_i + \varepsilon_{it} \tag{4}$$

where Y_{it} and X_{it} are vectors of endogenous and exogenous variables, respectively. Matrices $A_1, A_2, \ldots A_{p-1}, A_p$ and B contain the parameters to be estimated. μ_i is a vector of country fixed effects, ε_{it} is a vector of error terms, and p is the maximum lag order for vector of dependent variables.

We control for the main factors that can explain BCS between countries. Firstly, greater intra-industry trade relationships between countries allow their trade balances to be more closely related, leading to a greater association of their business cycle phases. In contrast, this effect could be negative if intensity is generated mainly through inter-industrial trade, which encourages specialization and decoupling. Our measure of trade intensity for country i with G-7 economies, T_{it}, is computed as the ratio of trade flows between two economies and the sum of country i's total trade flows with the rest of the world, that is,

$$T_{it} = \frac{X^{i}_{G7,t} + M^{i}_{G7,t}}{X^{i}_{W,t} + M^{i}_{W,t}}, \tag{5}$$

where $X^{i}_{G7,t}$ and $X^{i}_{W,t}$ represent the flow of exports during period t from country i to G-7 economies and the rest of the world, respectively. Similarly, $M^{i}_{G7,t}$ and $M^{i}_{W,t}$ represent the flows of imports, respectively. The expression of Eq. (5) can be interpreted as the share of country i's trade flows with G-7 economies compared to its trade flows with the rest of the world.[6]

Secondly, BCS's behavior between countries differs significantly when pairs of developed countries are analyzed and compared to situations where developed economies are paired with emerging countries.[7] To capture this effect, we create a variable based on the Human Development Index[8] (HDI):

$$D_{it} = \begin{cases} 1 & \text{if HDI} \geq 0.800 \\ 0 & \text{otherwise} \end{cases}. \tag{6}$$

[5] The PVAR model was estimated using the Abrigo and Love (2016) package.

[6] Different measures of trade intensity consider the total trade flows of the second country in the denominator. We do not add this flow for G-7 economies since the focus of this study is country i and also because G-7 economies are larger economy compared to the countries in the sample. Thus, trade flows from the G-7 would cause values of this ratio to be quite small, which could distort the interpretation of our results.

[7] This phenomenon is explained by asymmetry in production structures.

[8] This index is available in annual frequency, but it was transformed to quarterly frequency through linear interpolations.

We use a threshold of 0.8 because a country is considered "developed" when its HDI is very high, i.e., equal to or greater than 0.8. Therefore, our development variable, D_{it}, is a dummy variable that takes a value of 1 if country i during period t fulfills the necessary conditions for a very high level of human development, and 0 otherwise.[9]

Thirdly, it is possible that BCS can change structurally in situations of negative economic growth, especially if the situation triggers an economic recession (Inoue et al. 2012). We expect an increased coupling of business cycle phases during periods of negative economic growth. Therefore, we capture a world economic downturn by:

$$REC_t^{G7} = \begin{cases} 0 & \text{if } g_t^{G7} \geq 0 \\ g_t^{G7} & \text{if } g_t^{G7} < 0 \end{cases} \tag{7}$$

where g_t^{G7} is the real GDP growth rate of G-7 economies during period t. In this case, REC_t^{G7} captures temporary effects of G-7 economic recessions on synchronization from scenarios transmitted as aggregate demand shocks to the countries in our sample.

Finally, we control for exchange rate regime. Svensson (2000) shows that a flexible IT has less effect on macro variables like GDP as compared to strict IT since inflation targets are fixed over longer time horizons. A shock in domestic inflation that increases nominal and real interest rates (i.e., appreciation of the exchange rate) causes a more moderate impact on output gap; thus, inflation converges to its target at a more gradual pace. Similarly, a demand shock encourages restrictive monetary policies that stabilize output gap. Therefore, a flexible IT implies a more gradual return to target compared to strict IT. In the context of this paper, a flexible exchange rate acts as a shock absorber, reducing BCS. For this reason, we create a dummy variable FIX_{it} that takes the value 1 if country i in period t had a fixed exchange regime in place, and 0 otherwise.[10] Under the aforementioned context, we expect a positive effect of fixed exchange rate regimes on BSC (Flood and Rose 2010).

As a result, we define $Y_{it} = \left(T_{it}, \hat{\rho}_{it}^{d}\right)$ and $X_{it} = \left(D_{it}, REC_t^{G7}, \mathrm{FIX}_{it}, \mathrm{CI}_{it}\right)$ for our model in Eq. (4). These variables are differentiated according to their order of integration, with the exception of dichotomous variables. We also applied a logarithmic transformation to our measures of trade intensity, synchronization, and credibility. Based on Granger (1969) causality tests, we observe some evidence that synchronization and trade intensity variables are affected by each other, while our reputation-based credibility index, development, and recession variables are not caused by synchronization and trade intensity variables. This evidence is in line with Frankel and Rose (1998), who hypothesize an endogeneity problem between the degree of coupling cycles and trade intensity; increases in the synchronization of business cycle

[9] The advantage of our definition is that it provides time variability to our level development variable.

[10] Data on exchange rate regimes were obtained from Reinhart and Rogoff (2009). Fixed exchange rate regimes include coarse classification codes 1 and 2. Dataset are available at: http://www.carmenreinhart.com/data/browse-by-topic/.

phases encourage trade agreements and, therefore, greater intensity among their current account balances.

An important issue is that fixed effects of the model in Eq. (4) are correlated with *X*-variables due to lags in *Y*-variables. To deal with this problem, we remove fixed effects by performing an orthogonal transformation using mean deviations of those effects' future values, as proposed by Arellano and Bover (1995). This technique allows us to use the lags of *X*-variables as instruments for estimating coefficients using the generalized method of moments (GMM). Since we have an unbalanced panel, it is possible to improve the efficiency of GMM by following Holtz-Eakin et al. (1988), who propose adding instruments using observed realizations and substituting missing values with zeros (based on the assumption of non-correlation of the set of instruments with error terms).

3 Data

We use a sample of 15 countries that implemented an IT regime between 1985:Q1 and 2015:Q4. GDP series are in quarterly frequency, seasonally adjusted, and measured in 2010 millions of US dollars adjusted by purchasing power parity. Data on real GDP were obtained from the OECD Quarterly National Accounts. We used the Hodrick and Prescott (1980) method to eliminate trend patterns, as widely seen in the literature.[11] Our choice of 15 sample countries was based on data availability for economies that had implemented IT regimes for over 10 years and had been effective in stabilizing inflation (Details on these countries are given in "Appendix A"). The formal initial period of IT implementation was based on Schmidt-Hebbel and Carrasco (2016).[12]

Reputation measures are computed using monthly data for annual inflation rates, taking the official price index reference into account. In most cases, the official reference is the Consumer Price Index (CPI) (Details on calculating inflation rates and IT regimes are presented in "Appendix B"). If a country had a sporadic target for a certain quarter, we followed Brunila and Lahdenpera (1995) by including a fictitious band of one percentage point. Our sample contains a few countries that did not present inflation bands in some periods. Since agents expect a gradual adjustment of actual inflation to their target levels, we performed a linear interpolation for such cases. Our reputation-based credibility measure is computed using monthly data, so we calculate quarterly averages to make them comparable with BCS series.

Data for trade intensity were obtained from the Direction of Trade Statistics (DOTS), International Monetary Fund. We use quarterly data on FOB export and CIF import flows, both measured in US dollars, from 1990 to 2015.[13] All these

[11] We use a smoothing parameter of 1600 for quarterly frequency data.

[12] There is no consensus in the literature regarding formal dates of implementation of IT regimes for each country.

[13] We define trade flows of G-7 economies as the sum of flows from each country in this economic block separately, previously seasonally adjusted.

Table 1 Evolution of average annual inflation of IT countries. *Source*: Own elaboration

Country	Start IT	1992–1995	1996–1999	2000–2003	2004–2007	2008–2011	2012–2015
AUS	2.40		1.90	2.80	2.73	3.09	2.04
KOR	1.67				2.50	3.53	1.36
ISL	4.42			4.49	4.60	8.11	3.13
ISR	8.45		6.07	2.16	0.89	3.52	0.77
NOR	4.92			2.44	1.25	2.38	1.74
NZL	6.76	1.92	1.14	2.39	2.73	3.05	0.92
SWE	2.53	2.53	0.33	1.88	1.10	1.77	0.16
BRA	4.47		6.69	8.82	5.18	5.41	6.51
CHL	24.75	12.00	5.49	3.18	2.97	3.76	3.38
COL	9.33		9.38	7.67	5.20	4.23	3.27
HUN	10.50			5.71	5.54	4.78	1.78
IDN	7.84				10.52	6.29	5.87
MEX	7.80			5.18	3.99	4.40	3.60
POL	9.93		7.52	4.41	2.27	3.71	0.94
TUR	7.93				9.19	7.94	8.24

series are seasonally adjusted using the Census X-12 method. An important issue to consider is that export flows from one country to another are not necessarily equal to import flows from the same pair of countries. We dealt with this issue by considering the data reported by the country with the highest income level as more reliable. Data for HDI index were obtained from the United Nations Development Program (UNDP).[14]

4 Stylized facts

Table 1 clearly shows the process of gradual convergence of inflation rates in response to the implementation of IT for countries in our sample. Some prominent cases are Chile and Hungary, which reduced their average inflation rates from more than two digits to their target levels. We can also observe that many countries experienced a rise in their inflation rates during the 2008–2011 period, i.e., the subprime crisis. Although countries in our sample show a general convergence of inflation rates, they present periods with different degrees of IT effectiveness. These different degrees of effectiveness are essential for the purpose of this paper.

To analyze the dynamics of BCS and reputation-based credibility series overtime, we calculate the average values for these figures among all countries for each time period. Graphs of these series are presented in Fig. 1. We can see that both BCS and reputation-based credibility series have a fairly common pattern for a large part of the period under consideration. Another common characteristic is that during the first

[14] Database reference: http://hdr.undp.org/en/data.

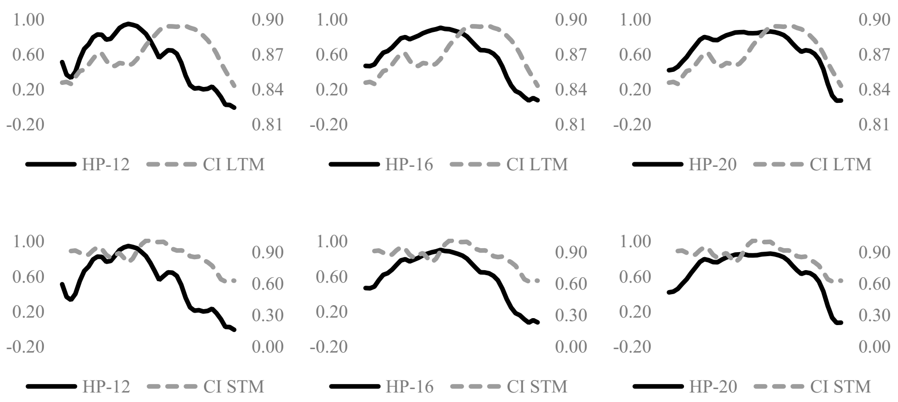

Fig. 1 BCS and IT credibility series in levels, 2006–2015. *Source*: Own elaboration

years, almost all series tended to increase, followed by a decreasing trend in later years. For the synchronization measures, changes in trend seemed to occur during economic crises, while those changes occurred more during subsequent years for the long-term reputation-based credibility measures. Short-term reputation-based credibility measures, in contrast, did not present changes in trend.

We also compute growth rates of these series, as presented in Fig. 2. Again, we can observe common patterns in the evolution of these series for a large extent of the sample period. Increases (decreases) in reputation-based credibility are consistent with increases (decreases) in the degree of BCS. To confirm these findings, we calculate correlation coefficients between these variables (both the level and growth rates), which are shown in Table 2. For all cases, we find positive correlations with relatively high values, most of them significant at the conventional levels. This evidence allows us to conclude that there is a positive and significant correlation between mean values of BCS with G-7 economies and credibility indexes for the sample of IT countries from 2006 to 2015.

5 Results from the PVAR model

To identify the order of integration for the series under analysis, we perform the stationarity test proposed by Im et al. (2003). This test assumes heterogeneous variances for the residuals of each single unit root test—an appropriate test for unbalanced panels. The results indicating that reputation-based credibility measures are integrated of order one are presented in Table 3. Synchronization series are stationary in levels when 12 quarters are used to calculate them. The rest of synchronization series, however, require a regular difference for stationarity. Finally, trade intensity series are stationary in levels. We follow Andrews and Lu (2001) and choose lag order for our model in Eq. (4) according to the Schwarz (1978) information criteria;

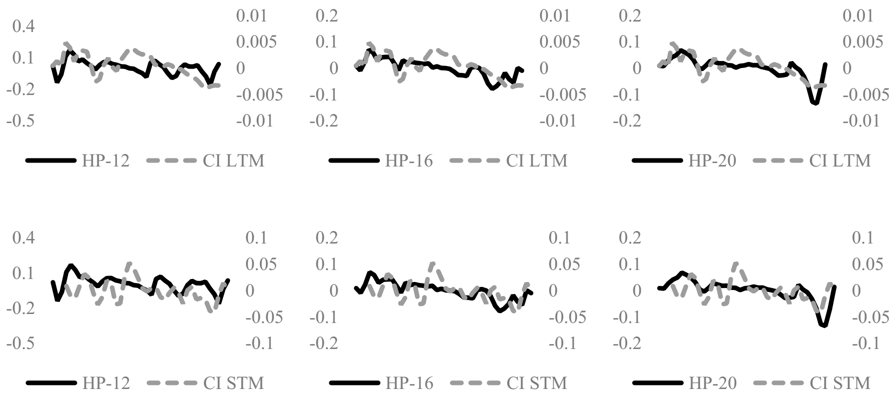

Fig. 2 BCS and IT credibility series in the first logarithmic difference, 2006–2015. *Source*: Own elaboration

Table 2 Correlations between credibility and synchronization measures. *Source*: Own elaboration

	HP-12	HP-16	HP-20
Panel A: variables in levels			
CI_{WR}	0.01	0.24	0.55***
CI_{MAR}	0.65***	0.83***	0.85***
Panel B: variables in the first logarithmic difference			
CI_{WR}	0.38**	0.63***	0.70***
CI_{MAR}	0.16	0.37**	0.38**

***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively

all models require two lags (see Table 4). A set of transformed endogenous variables with four lags is used as a set of instruments.[15]

Results of the PVAR estimation are presented in Table 5. Contemporary effects of credibility growth on the change of BCS are positive and significant in most cases. To analyze the robustness of these findings, we use synchronization measures based on two alternative filter methods. We consider the Christiano and Fitzgerald (2003) random walk band-pass filter and the Butterworth (1930) square wave high-pass filter. These estimates support the main results discussed in this paper, i.e., positive and significant.[16] Regarding our control variables, we find evidence of a negative relation between synchronization and commercial intensity changes. This finding suggests a greater effect of inter-industrial trade than intra-industrial trade, explained by differences between productive structures of the countries in our sample. Moreover, there is a negative and significant effect of economic development on BCS. Furthermore, regarding the effect of a negative growth shock in G-7

[15] The use of additional instruments did not affect our main findings.

[16] Results can be obtained from the authors upon request.

Table 3 Im, Pesaran and Shin (2003) unit root test. *Source*: Own elaboration

Variables	*z*-statistic	
	Level	First difference
BSC measures		
HP12	2.3219***	16.7346***
HP16	0.5290	13.8071***
HP20	1.5555	13.0516***
Reputation-based credibility measures		
CI_{LTM}	1.0450	12.1019***
CI_{STM}	0.6471	11.1847***
Trade intensity		
T	8.2121***	30.8261***

***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively

Table 4 PVAR model specifications. *Source*: Own elaboration

No.	Lags	Endogenous variables	Exogenous variables
1	2	$T,\ \hat{\rho}^{\mathrm{HP}}\ (\tau = 12)$	D, REC, FIX, ΔCI_{LTM}
2	2	$T,\ \hat{\rho}^{\mathrm{HP}}\ (\tau = 12)$	D, REC, FIX, ΔCI_{STM}
3	2	$T,\ \Delta\hat{\rho}^{\mathrm{HP}}\ (\tau = 16)$	D, REC, FIX, ΔCI_{LTM}
4	2	$T,\ \Delta\hat{\rho}^{\mathrm{HP}}\ (\tau = 16)$	D, REC, FIX, ΔCI_{STM}
5	2	$T,\ \Delta\hat{\rho}^{\mathrm{HP}}\ (\tau = 20)$	D, REC, FIX, ΔCI_{LTM}
6	2	$T,\ \Delta\hat{\rho}^{\mathrm{HP}}\ (\tau = 20)$	D, REC, FIX, ΔCI_{STM}

countries, we find that synchronization tends to be higher as aggregate demand disturbances are transmitted more quickly. Finally, the effect of the presence of a fixed exchange rate regime on BSC is positive and significant in most cases. Also, note that all PVAR models estimated meet the stability condition since all their eigenvalues are within the unit circle, and the six specifications are estimated controlling for heteroskedasticity using robust standard errors.

Despite the aforementioned findings, evidence is analyzed not only for contemporary effects, but also for the total effect of credibility on BCS over time. We estimate dynamic multiplier functions of reputation-based credibility on the degree of BCS with G-7 economies (see Fig. 3). We use Cholesky's decomposition and Monte Carlo simulation techniques with 500 iterations for estimating 90% confidence intervals.

Figure 3 shows BCS's responses to a shock in the degree of reputation-based credibility. All effects are significant at conventional levels, with a greater magnitude in the case of long-term memory credibility compared to that of short-term memory. Expanding agents' memory seems to intensify the effect on BCS. Our results also show an average contemporary effect of a long-term memory credibility shock that is five times greater than the short-term one. It would seem that credibility shocks are more drastic when agents consider the entire history of the central banks' IT regime rather than just the recent history. From another perspective, shocks tend to

Table 5 PVAR estimation results. *Source*: Own elaboration

Y-variable	*X*-variable	Lag	(1)	(2)	(3)	(4)	(5)	(6)
T	*T*	1	0.5595	0.5629	0.5451	0.5425	0.5582	0.5566
			(10.76)***	(10.62)***	(10.64)***	(10.48)***	(10.57)***	(10.41)***
		2	0.4011	0.3990	0.4029	0.4025	0.4035	0.4035
			(8.09)***	(7.96)***	(8.24)***	(8.19)***	(7.93)***	(7.84)***
	BCS	1	−0.0045	−0.0043	−0.0036	−0.0045	−0.0116	−0.0114
			(−1.60)	(−1.54)	(−0.49)	(−0.60)	(−1.61)	(−1.51)***
		2	0.0005	0.0007	−0.0008	−0.0006	−0.0127	−0.0095
			(0.20)	(0.27)	(−0.13)	(−0.10)	(−1.67)*	(−1.14)
	D		0.0016	0.0024	0.0055	0.0052	0.0004	0.0015
			(0.36)	(0.51)	(1.22)	(1.14)	(0.07)	(0.29)
	REC		−0.0893	−0.0840	−0.0377	−0.0355	−0.0630	−0.0581
			(−1.68)*	(−1.57)	(−0.72)	(−0.68)	(−1.23)	(−1.14)
	FIX		−0.0043	−0.0049	−0.0053	−0.0053	−0.0030	−0.0041
			(−1.59)	(−1.79)*	(−1.95)*	(−1.92)*	(−1.20)	(−1.60)
	CI		−0.0236	0.0031	−0.0088	0.0047	−0.0305	0.0008
			(−0.91)	(0.56)	(−0.34)	(0.80)	(−1.39)	(0.16)
BSC	*T*	1	−0.3870	−0.4411	−0.5230	−0.4920	−0.0776	−0.0534
			(−1.24)	(−1.37)	(−2.68)***	(−2.53)**	(−0.41)	(−0.27)
		2	0.3136	0.4269	0.6255	0.6170	0.1340	0.1118
			(1.15)	(1.41)	(3.54)***	(3.49)***	(0.80)	(0.65)
	BSC	1	1.4608	1.4550	0.6711	0.6710	0.7353	0.8121
			(15.40)***	(15.11)***	(10.30)***	(10.22)***	(8.46)***	(9.80)***
		2	−0.5512	−0.5497	−0.1563	−0.1561	−0.1155	−0.1631
			(−6.83)***	(−6.71)***	(−3.63)***	(−3.54)***	(−1.54)	(−2.63)***
	D		−0.1737	−0.1740	−0.0742	−0.0711	−0.0569	−0.0472
			(−2.91)***	(−2.89)***	(−2.51)**	(−2.41)**	(−1.77)*	(−1.47)
	REC		−1.4281	−1.4740	−0.3709	−0.3035	−0.4110	−0.3838
			(−3.37)***	(−3.42)**	(−1.29)	(−1.05)	(−2.26)**	(−2.08)**
	FIX		0.0603	0.0649	0.0194	0.0210	0.0239	0.0284
			(2.24)**	(2.38)**	(0.88)	(0.95)	(1.65)*	(1.87)*
	CI		0.2457	0.1166	0.3189	0.0640	0.7155	0.0593
			(0.93)	(2.12)**	(1.91)*	(1.43)	(2.55)**	(1.98)**
VAR–Granger causality Wald test								
T	BCS		(9.072)**	(7.303)**	(0.467)	(0.440)	(8.469)**	(5.484)**
BCS	*T*		(1.634)	(2.190)	(12.725)***	(12.496)***	(0.893)	(0.699)
Eigenvalue stability condition			Yes	Yes	Yes	Yes	Yes	Yes
Observations			969	949	948	932	928	912

***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively. *t*-student and Chi-squared statistics are in parenthesis for significance of estimated coefficients and VAR–Granger causality tests, respectively

be considered more permanent than transitory with long-term memory since credibility is less stable with short-term memory.

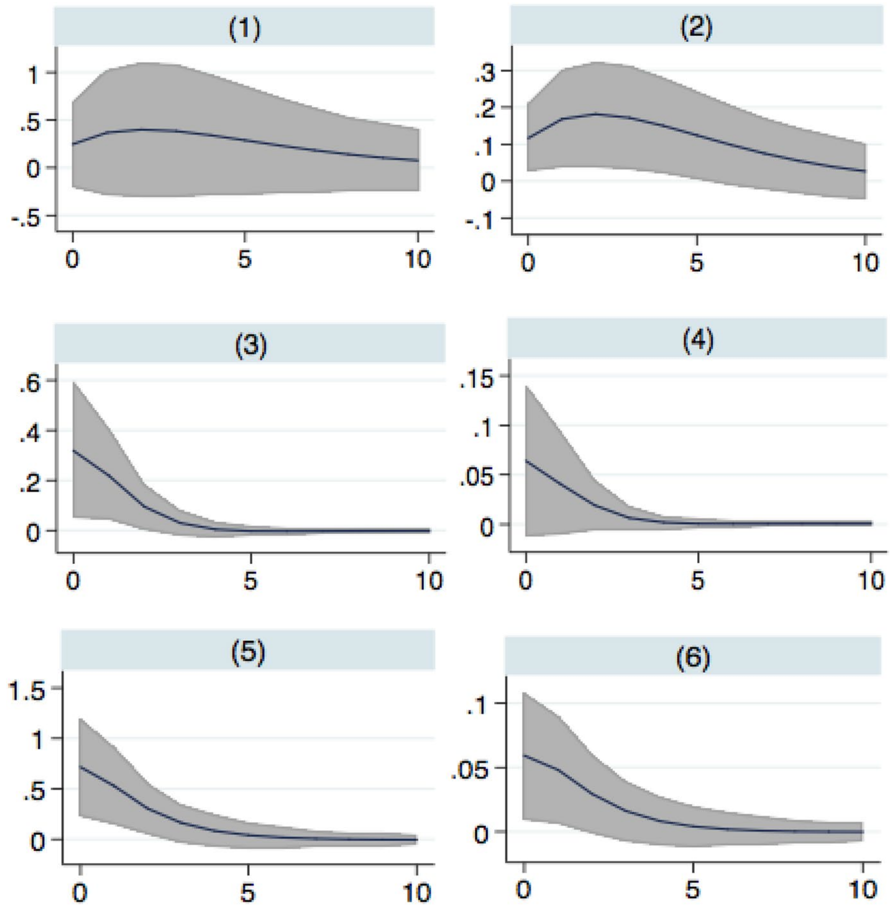

Fig. 3 Dynamic multipliers of the effect of credibility shock on business cycle synchronization. *Source*: Own elaboration

Finally, we can also observe that the duration of responses to the shocks is between three and five quarters. Our findings imply that a decline in reputation-based credibility would cause a reduction in BCS growth; thus, synchronization response is reduced, at most, to five quarters.[17] These results expand the existing empirical evidence on BCS determinants. Previous authors and the available evidence had focused on the mere implementation of IT regime and its impact on BCS instead of the degree of credibility. Our findings, on the other hand, suggest that a fall in credibility will impact agents' expectations, affecting the effectiveness of central banks' announcements. With lower IT credibility, output lowers its sensitivity to external shocks on aggregate demand, leaving the output gap less sensitive to replicate patterns of external business cycles.

[17] While the graphs show the impact of positive credibility growing shock, it is more reasonable to explain the effect of a negative shock, that is, a credibility reduction of central bank.

6 Conclusions

In this paper, we presented new empirical evidence on the effect of reputation-based credibility on BCS with G-7 economies. To do this, we built two measures of credibility, long- and short-term memory, for a sample of 15 countries with IT regimes. By estimating a PVAR model, we obtained dynamic multipliers, indicating a significant effect of the degree of reputation-based credibility on BCS. Our results show that not only the adoption of IT allows for greater synchronization, but also the degree of credibility of IT announcements is relevant and significant for cycle coupling. This means that a higher degree of credibility allows for a greater anchoring of inflation expectations, a better stabilization of price levels, and an output gap that is more sensitive to the external shocks of aggregate demand. In addition, our findings indicate that the effect on synchronization is greater if agents adopt a long-term memory in determining the credibility of inflation expectations.

Countries with IT regimes must develop and maintain credibility for their monetary policy if they want to achieve greater interactions with the rest of the world. This is especially important for emerging countries that aim to have stronger links with developed economies. Without enough credibility, these economies could experience cycle decoupling, leading to disharmonization between economic and commercial agreements.

Finally, this analysis can be extended to compare the impact of different monetary regimes and credibility levels on BCS by using theoretical and empirical models, taking into account the measure of credibility introduced in this paper. Our empirical model could also be assessed with a different framework of expectations formation for inflation, transitioning from backward-looking expectations to forward looking ones.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval Also, authors testify that this paper complies with the ethical rules of the journal. Authors declare that the work described has not been published before; that it is not under consideration for publication anything else; that its publication has been approved by all co-authors and by the responsible authorities at the institute where this work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

Appendix A

See Table 6.

Table 6 List of countries and data availability. *Source*: Own elaboration

Code	Country	Data	IT
AUS	Australia	1985:Q1	1993:Q1
BRA	Brazil	1996:Q1	1999:Q3
CHL	Chile	1995:Q1	1991:Q1
COL	Colombia	2000:Q1	1999:Q4
HUN	Hungary	1995:Q1	2001:Q3
IDN	Indonesia	1990:Q1	2005:Q3
ISL	Iceland	1985:Q1	2001:Q2
ISR	Israel	1995:Q1	1997:Q3
KOR	South Korea	1985:Q1	1998:Q2
MEX	Mexico	1985:Q1	2001:Q1
NOR	Norway	1985:Q1	2001:Q2
NZL	New Zealand	1985:Q1	1990:Q2
POL	Poland	1995:Q1	1998:Q4
SWE	Sweden	1985:Q1	1995:Q1
TUR	Turkey	1985:Q1	2006:Q1

Appendix B

See Tables 7, 8 and 9.

Table 7 Detail of sample of IT countries. *Source*: Own elaboration based on information from central banks and statistical institutes of the countries in our sample

Country	Full implementation date	Target inflation	Target type	Price index
Australia	First quarter of 1993	Since 1993: 2–3%	Continuous band	CPI, excluding charges prior to the September quarter 1998 adjusted tax charges interest 1999–2000
Brazil	July 1999	1999: 8% (±2%) 2000: 6% (±2%) 2001: 4% (±2%) 2002: 3.5% (±2%) 2003: 8.5% 2005: 5.1% (+1.9/−3.1%) Since 2006: 4.5% (±2%)	Continuous band, with the exception of 2003, which had a continuous point target	IPCA (National CPI)
Chile	January 1991	1991: 15–20% 1992: 13–16% 1993: 10–12% 1994: 9–11% 1995: 8% 1996: 6.5% 1997: 5.5% 1998: 4.5% 1999: 4.3% 2000: 3.5% Since 2001: 3% (±1%)	Discrete bands for December of each year from 1991 to 1994. Discrete point target until 2000. Since 2001 a continuous target band rules	Total CPI

Table 7 (continued)

Country	Full implementation date	Target inflation	Target type	Price index
Colombia	September 1999	1999: 15%	Point target from 1999 to 2002. Continuous band since 2003	Total CPI
		2000: 10%		
		2001: 8%		
		2002: 6%		
		2003–2004: 5.5% (±0.5%)		
		2005: 5% (±0.5%)		
		2006: 4.5% (±0.5%)		
		2007–2008: 4% (±0.5%)		
		2009: 5% (±0.5%)		
		Since 2010: 3% (±1%)		

Table 8 Detail of sample of IT countries (continuation). *Source*: Own elaboration based on information from central banks and statistical institutes of the countries in our sample

Country	Full implementation date	Target inflation	Target type	Price index
Hungary	June 2001	2001: 7% 2002: 4.5% 2003–2004: 3.5% 2005: 4% 2006: 3.5% 2007–2015 (Feb.): 3% Since March 2015: 3% (±1%)	From 2001 to 2006: Discrete point target. In 2007, the target is continuous. Since March 2015, continuous target band	Total CPI
Indonesia	July 2005	2005: 6% (±1%) 2006: 8% (±1%) 2007: 6% (±1%) 2008: 5% (±1%) 2009: 4.5% (±1%) 2010–2011: 5% (±1%) 2012–2014: 4.5% (±1%) 2015: 4% (±1%)	Continuous target band	Total CPI
Iceland	April 2001	Since 2001: 2.5% (±1.5%)	Continuous target band	Total CPI
Israel	June 1997	1997–1998: 7–10% 1999: 4% 2000: 3–4% 2001: 2.5–3.5% 2002: 2–3% Since 2003: 1–3%	From 1997 to 1998: Band of discrete targets. In 1999: Discrete point target. From 2000 to 2002: Discrete bands. Since 2003: Continuous bands	Total CPI

Table 8 (continued)

Country	Full implementation date	Target inflation	Target type	Price index
South Korea	April 1998	1998: 9% (± 1%) 1999: 3% (± 1%) 2000: 2.5% (± 1%) 2001–2003: 3% (± 1%) 2004–2006: 2.5–3.5% 2007–2009: 3% (± 0.5%) 2010–2012: 3% (± 1%) 2013–2015: 9% (± 0.5%)	Continuous target band	Since 2000: Core CPI. Until then and since 2007: Total CPI. Core IPC excludes petroleum products and agricultural production (excluding grains)
Mexico	January 2001	2001: 6.5% 2002: 4.5% Since 2003: 3% (± 1%)	Until 2002: Discrete point target. Since 2003: Continuous target band	Total CPI

Table 9 Detail of sample of IT countries (final). *Source*: Own elaboration based on information from central banks and statistical institutes of the countries in our sample

Country	Full implementation date	Target inflation	Target type	Price index
New Zealand	March 1990	1990: 3–5%	Discrete target bands. Since 2002: continuous bands	Total CPI
		1991: 2.5–4.5%		
		1992: 1.5–3.5%		
		1993–1996: 0–2%		
		1997–2002: 0–3%		
		Since Sep. 2002: 1–3%		
Norway	March 2001	Since 2001: 2.5% approximately	Continuous point target	CPI-ATE (used before 2003). In later periods: Total CPI
Poland	October 1998	1999: 8–8.5%	From 1999 to 2003: Discrete Bands. Since 2004: Continuous bands	Total CPI
		2000: 5.4–6.8%		
		2001: 6–8%		
		2002: 4–6%		
		2003: 2–4%		
		2004: 2.5% (1%)		
Sweden	January 1995	Since 1995: 2% (1%)	Continuous band	Total CPI
Turkey	January 2006	2006: 5%	Discrete target bands at the end of each year	Total CPI
		2007: 4%		
		2008: 4%		
		2009: 7.5%		
		2010: 6.5%		
		2011: 5.5%		
		Since 2012: 5%		

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