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Abstract

A pressing current issue is the exposure of small open economies to short term and long term changes in global conditions. In this paper we estimate US and Mexican business and financial cycle components and we analyze their cyclical co-movement. We find long term counter-cyclicality and short term pro-cyclicality between US investor sentiment and Mexican leverage growth and the Mexican net financial account. We also find short term and long term counter-cyclicality of the Mexico‘s net financial account with US GDP growth rates and US household sentiment, respectively. This is evidence of exposure of the Mexican economy not only to the US business cycle, but also to the US financial cycle.

JEL classification: C13, C32, E32, E44, F20, F15

Keywords: Cycles; Corporate sentiment; Household sentiment; Economic Integration; State space models

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1 Introduction

The increasing importance of global factors in domestic macroeconomic fluctuations poses problem with regard to the independence of monetary policy in small open economies.[1] These limitations have led to the development of macro-prudential regulatory frameworks (see e.g., Kose, Otrok, and Whiteman, 2003). For instance in Mexico, the macro-prudential policy framework includes counter-cyclical capital buffers, loan-to-value ratios and limits on currency mismatches (see e.g., Upper, 2017). To optimize macro-prudential frameworks, a better understanding of the extent and nature of international exposure is necessary.

The aim of this paper is to quantify the exposure of the Mexican economy to US cyclical factors. In particular, we study Mexican household and non-financial corporate leverage, its net financial account, real GDP growth rates, and the stock market price index returns. We decompose their movements into domestic and US short and long term cyclical components over 1981:Q1–2016:Q1. We also investigate sub-sample effects of the US business cycle on the Mexican stock price index and real GDP growth rates. We do this separately for the early (1981:Q1–1999:Q4) and the late (2000:Q1–2016:Q1) North American Free Trade Agreement (NAFTA) period. Our results suggest strong long term and short term cyclical co-movements between Mexican and US indicators.

Mexico is a small open economy with strong transmission of US shocks due to its real and financial integration with the US markets. Before 1996, domestic volatility swamped the role of US factors in the fluctuations of macroeconomic indicators (see e.g., Swiston and Bayoumi, 2008). The time period after 1995 is described as the Great Moderation of the Mexican business cycle, with less volatility in key macroeconomic indicators (Sosa, 2008). One explanation for this change in dynamics could be an improvement in the monetary policy framework and a stronger fiscal position.

With regard to real integration, in 1994 the NAFTA agreement established a trilateral trade block between Canada, Mexico and the US. As a result, cross-country correlations between macroeconomic aggregates increased. This could be due to similar responses to common shocks, idiosyncratic shocks that happen to be correlated across countries, or spillover effects (Swiston and Bayoumi, 2008). Potential channels for spillovers include trade, wage remittances and capital flows (e.g. see López-Córdova,

[1] These global factors include monetary policies of the Federal Reserve and of other major central banks (e.g., Rey, 2015).

Hernández and Monge-Naranjo, 2003; Kose, Meredith and Towe, 2004; Arora and Vamvakidis, 2005; Sosa, 2008).

With regard to financial integration, rising US risk-free benchmark rates tend to increase emerging market spreads through effects on cost, availability of funds and creditworthiness (Arora and Cerisola, 2001). This causes stability threats since spreads typically first fall and then overshoot (Uribe and Yue, 2006). The effects of US monetary shocks on emerging markets are substantial and explain an important part of fluctuations in macroeconomic variables (Canova, 2005; Mackowiak, 2007). Based on data for more than 50 countries, Rey (2015) provides aggregate level empirical evidence that emerging markets are subject to a global financial cycle in capital flows, asset prices and in credit growth which co-moves with the VIX, a measure of uncertainty and risk aversion of the markets.

This also applies to Mexico. Since 1998, foreign investment in Mexican banks increased financial integration. Before 1998, a foreign bank could not buy a Mexican bank whose market share exceeded 1.5% and the limit on aggregate foreign bank participation was 8% of total market share. In the NAFTA period, changes in the legislation gradually eliminated restrictions on the entry of foreign capital and this led to foreign participation rising from 5.5% of total market share in 1993 to 67.2% in 2000 (Maudos and Solis, 2011).

The Mexican stock market was also closed to foreign investment until 1981. Thereafter only one Mexican American depositary receipt (ADR) was traded (see e.g., Bekaert and Harvey, 1995). In 1989 the Mexican stock market opened to foreign investors with the exception of key sectors. Clark and Berko (1997) surmise that the broadening in the investor base increases risk sharing and liquidity, decreases expected returns and increases emerging market stock prices and covariance with the US markets.[2]

The current paper does not examine any specific transmission mechanism of US shocks to the Mexican economy, but investigates their aggregate effect. Conceptually similar work to the present paper is by Kose, Meredith and Towe (2004). They use a dynamic latent factor model with regional and country-specific factors to analyze Mexican output, consumption and investment series over the period 1980–2002. The present paper studies Mexico's household leverage, non-financial corporate leverage, GDP and stock price index growth and its net financial account flows. We analyze their short and long term cyclical co-movements with US household and investor sentiment

[2]A stock with a restricted investor base pays premium which is an increasing function of stock's conditional variance, the narrowness of investors base and investors risk aversion.

indicators. short term cyclical co-movements have business cycle length and long term co-movements have financial cycle length.Traditionally business cycles have a period of two to eight years whereas financial cycles duration is more than eight years and have an average duration of around 16 years (see Drehmann, Borio and Tstasaronis, 2012; Galati, Koopman, Hindrayanto and Vlekke, 2016; de Winter, Koopman, Hindrayanto and Chouhan, 2017).

The distinction between the two types of cycles is relevant since Mexico's short term and long term links to the US may differ in nature. We analyze how the cyclical co-movement between US GDP and Mexican GDP and stock price index growth rates changed from 1981:Q1–1999:Q1 to 2000:Q1–2016:Q1. We refer to the latter period as the late NAFTA subsample. Our subsample choice is motivated by the fact that from 2000 onwards Mexico had opened its banking sector and equity market to foreign participation, and achieved monetary stability.

We find that the Mexican net financial account and Mexican leverage growth move pro-cyclically to US investor sentiment in the short-run, as expected, but counter-cyclically in the long -run. One explanation is that in the long run relation, an upswing in the US financial cycle is associated with more defaults in Mexico and sale of assets to foreigners (see e.g., Morais, Pedro and Ruiz, 2015). We estimate that in the long run, US household sentiment is counter-cyclical to the Mexican net financial account. This implies a net outflow of foreign currency from Mexican to the US economy when US households expand their balance sheets. We observe short-run counter-cyclicality between US GDP growth and Mexican non-financial corporate leverage and short term pro-cyclicality between US GDP growth and Mexican stock price index returns. We reason that positive foreign demand shocks can increase a firm's equity through increased profits thus reduce its overall leverage and increase its net value (see e.g., Fernandez and Gulan, 2015). We estimate that US business cycle effects became more important for the Mexican economy in the late NAFTA period. In the short-run, US GDP moves pro-cyclically to Mexican stock price index returns and to real GDP growth. This is not surprising, given that many Mexican companies are oriented towards the US market.

The rest of this paper is organized as follows: Section 2 describes our key macroeconomic indicators, Section 3 presents some stylized facts to motivate modeling choices, Section 4 describes the model. The estimation procedure is described in Section 5. In Section 6 the findings presented and discussed and Section 7 concludes.

2 Data

Our dataset contains Mexican and US quarterly macroeconomic indicators over the period 1981:Q1–2016:Q1. Along financial and business cycle frequencies, we analyze cyclical co-movements between Mexican and US indicators.

The financial cycle reflects credit conditions, perceptions of value and risk. Traditionally, it is described with information in asset prices and credit variables (see e.g., Borio, 2014; Drehmann, Borio and Tstasaronis, 2012). Positive future cash-flow outlooks or sentiments increase asset prises and leverage. In this paper, we distinguish between investor and household sentiment. While household sentiment depends on income and (expected) demand for real estate, investor sentiment depends upon future profit expectations translated into capital asset prices and the conditions under which short and long term finance are available (see e.g. Minsky, 1978). In earlier work we found that indicators for household and corporate sentiments relate well to US financial stress and crisis moments (Rozite, Bezemer and Jacobs, 2016).

While there are several candidate indicators describing market sentiments ($\text{FI}_{G,t}$), relatively few contain financial cycle frequency components. Our indicator for US household sentiment is the quarter on quarter logarithmic growth rate of US household leverage ($\text{HHLEV}_{G,t}$). Household leverage is defined as credit to households scaled by wages and salaries. To construct the series, we collect information on US credit market instruments for households and non-profit organizations (liabilities) and information on wages and salaries reported in nominal terms and expressed in the local currency units from the Federal Reserve Bank of St. Louis. For the investor sentiment indicator, we use a measure developed in Baker and Wurgler (2006) ($\text{SENT}_{\text{U},t}$). Their index is based on the first principal component of five (standardized) sentiment proxies: the closed-end fund discount which is the average difference between the net asset values of closed-end stock fund shares and their market prices; value-weighted dividend premium; the average first-day returns on IPOs; IPO volume and equity share in new issues. The sentiment index is not orthogonal to macroeconomic conditions, hence it also is a business cycle indicator. Our second indicator for the US business cycle is the real US GDP growth rate ($\text{GDP}_{\text{U},t}$).

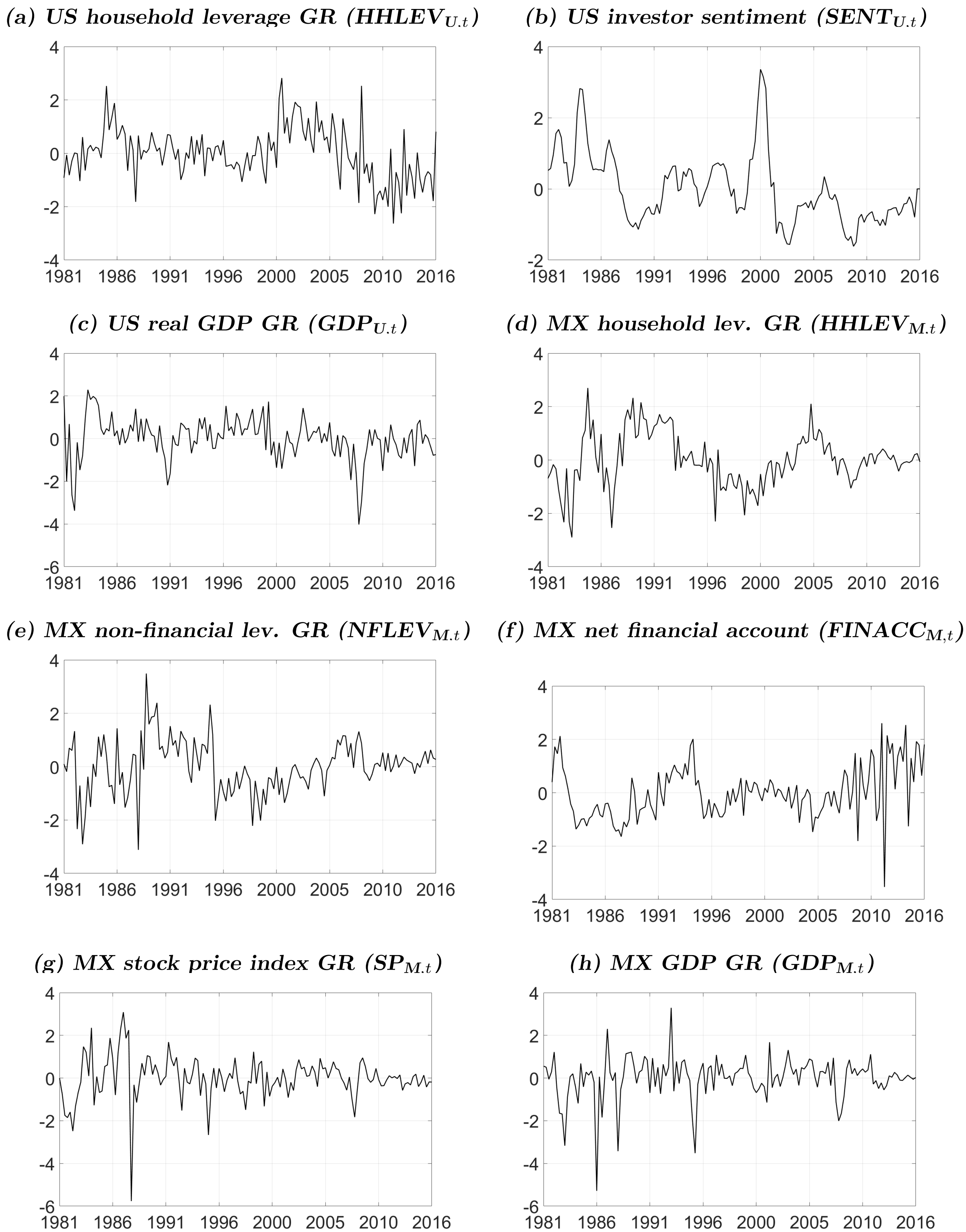
The selection of Mexican financial and real activity indicators is constrained by data availability. From Banco de México we obtain the consumer price index (CPI) with reference year 2010; GDP in local currency units in nominal terms; loans to non-financial enterprises; consumption and mortgage loans to households in nominal terms and the Mexican stock price index with reference year 2010.[3] From the Federal Reserve Bank of St. Louis we collect Mexican net financial account data including changes in official reserves in US dollars not seasonally adjusted. The net financial account shows claims or liabilities on financial assets held by non-residents. These financial assets include direct investment, portfolio investment and reserve assets. All Mexican financial and real activity indicators are seasonally adjusted prior to modeling using the X-13 ARIMA-SEATS procedure in `Eviews`. This is done to keep the model parsimonious. Mexican household leverage is computed as total loans to households scaled with nominal GDP, of which quarter on quarter logarithmic growth rates are computed ($\text{HHLEV}_{\text{M},t}$). Similarly we construct non-financial corporate leverage growth rates ($\text{NFLEV}_{\text{M},t}$).[4] The Mexican stock price index and nominal GDP are adjusted for inflation using the CPI, and converted to quarter on quarter logarithmic growth rates ($\text{SP}_{\text{M},t}$, $\text{GDP}_{\text{M},t}$). The Mexican net financial account in current US dollars is scaled by the US GDP deflator ($\text{FINACC}_{\text{M},t}$). To check the timing of peaks and troughs in the Mexican indicators, we collect the OECD recession indicator for Mexico. The US and Mexican indicators do not contain unit roots and are standardized (see Appendix C for further details).

Figure 1 shows developments of the indicators. For cross-country comparison, we investigate our data in levels. From the Bank of International Settlement, we obtain US and Mexican credit statistics. Just before 2008, US household debt reached close to 100% of GDP but by the end of 2016 it had decreased to 80%. In comparison, Mexican household debt steadily increased since the early 2000s, reaching around 16% of GDP in 2016. Since the early 2000s and until the end of the sample, Mexican non-financial corporate debt rose from 42% to 75% of GDP. In comparison, non-financial corporate debt in the US mostly increased throughout the sample, reaching 250% of GDP in 2016. Since the early 2000s, Mexican stock market capitalization increased from 15% to 34% of GDP at the end of the sample. In 2000s, US stock market capitalization reached its peak of 146% of GDP, dropping to 93% in 2008 and then recovering to 140% of GDP by the end of sample. The Mexican net financial account fluctuates around zero in the past 10 years. Relative to Mexican GDP, the most important indicator is Mexican

[3]Unfortunately data on Mexico's real estate price index are available only from 2005. Hence this variable is omitted from our analysis.

[4]In the data there is a sharp decrease in the credit levels from 1995 and onwards due to the governmental rescue programs. During the rescue programs loans were transfered to a mutual fund. It is not possible to correct for this occurrence since there is no available information on separate positions regarding the amount of household and non-financial corporate credit transfers.

Figure 1: Standardized Mexican and US macroeconomic and financial indicators



Notes: Data are seasonally adjusted. The abbreviation "GR" denotes growth rates.

non-financial corporate leverage followed by the stock market index, household leverage and finally its net financial account.

For our model input, we transform non-stationary indicators into stationary growth rates. The common practice is to use observations in levels and to model stationary components alongside non-stationary trends using for example model based filters. The obtained cycles are then called growth cycles. We deviate from this practice for several reasons. First, modeling stochastic trends is not of direct interest in our case since we are interested in growth rate cycles primarily. Layton and Moore (1989) note that a growth rate cycle is an alternative to growth cycles. Growth rate cycles in comparison are more volatile which makes identification of turning points more difficult.[5] Second, the econometric model-based approaches to detrending frequently are prompt to calibration choices and can generate spurious cycles (e.g. Harvey and Jaeger, 1993). Since empirically it is difficult to isolate a stochastic trend due to its weak signal to noise ratio, estimations are facilitated by calibrating the stochastic trend parameters.[6] Third, we difference our data because the process we observe might have higher frequency components than a sampling frequency. Hence an effect known as aliasing occurs in which high frequency components erroneously get translated to low frequencies, which may be confused for actual trends.

Instead of modeling stochastic trends, one can use non-parametric detrending methods such as Hodrick and Prescott (1980), the band-pass filters of Baxter and King (1999) and Christiano and Fitzgerald (2003) which require prior assumptions on the length of the cycle. As a result of these prior assumptions, estimation problems may be encountered. For example, low frequency cycles outside the pre-specified band can be classified as part of the long term trend (see e.g., Comin and Gertler, 2006; Cogley and Nason, 1995; Igan, Kabundi, Simone, Pinheiro and Tamirisa, 2009; Galati, Koopman Hindrayanto and Vlekke, 2016). These considerations determine our choice to calculate quarter-on-quarter growth rates of non-stationary data.

3 Stylized Facts

Several mechanisms can cause co-movements between Mexican and US financial and real activity indicators. First, many US producers outsource part of their production

[5]Turning points are identified using smoothed growth rates.

[6]These choices are based on the objective to obtain smoothness and some persistence of the long term trend.

process to Mexico. Hence there should be a positive relation between Mexico's GDP and non-financial corporate leverage growth on one hand and US GDP on the other. Second, we expect a positive relation between Mexican non-financial corporate leverage and stock price growth and US investor sentiment. US investors are more likely to invest in Mexico when their sentiment is positive. For the same reason, we expect an increase in demand for Mexican financial assets. Thus the Mexican net financial account is expected to be pro-cyclical to US sentiment indicators. Third, since Mexico generates a significant part of its wage income from the tourism industry we expect a positive relation between US household leverage growth on one hand and Mexican GDP and household leverage growth on the other hand.

As preliminary check of co-movements, we compute rank correlations between standardized Mexican and US financial indicators. We choose rank correlations since they assess monotonic rather than only linear relationships. We note that Kose, Meredith and Towe (2004) caution against relying on correlations to make strong inference on co-movements. Correlations capture only the contemporaneous co-movement and account for co-movement only in a single variable. In addition correlations average over high and low frequency co-movements. With these caveats, Table 1 shows correlations for the full sample period and sub-samples.

There are no clear patterns which link US and Mexican financial and real indicators. In the full sample and the two sub-samples, Mexican household and non-financial leverage ratios have the strongest correlation. US household leverage growth rates are correlated with Mexican non-financial leverage in the full and the late NAFTA sample period. There is however no correlation with Mexican household leverage in either subsample or in the full sample period. The Mexican net financial account is negatively correlated to US household leverage growth rates.

Examining the 1981–1999 and the 2000–2016 subsamples we find no general indication that correlations between US and Mexico increased for real or financial indicators. One exception is the correlation between US GDP growth and Mexican stock price index returns. The US investor sentiment index correlates with Mexican leverage indicators in the full and 1981–1999 sample periods but is consistently uncorrelated with Mexican GDP. Lastly, Mexican and US real GDPs are correlated only in the late NAFTA period.

Table 2 shows the timing of peaks and troughs in the indicators. These are obtained using the BBQ turning point detection algorithm, which requires a few input parameters: a window length around a peak or trough, a minimum phase length and a minimum cycle length (see Harding and Pagan, 2002). For our sample we set the

Table 1: Kendall rank correlations for Mexican and US economic activity indicators.

	$HHLEV_{U,t}$	$SENT_{U,t}$	$GDP_{U,t}$	$HHLEV_{M,t}$	$NFLEV_{M,t}$	$GDP_{M,t}$	$SP_{M,t}$	
				1981–2016				
$HHLEV_{U,t}$	1							
$SENT_{U,t}$	0.066	1						
$GDP_{U,t}$	0.011	0.118^b	1					
$HHLEV_{M,t}$	0.030	-0.188^c	0.007	1				
$NFLEV_{M,t}$	−0.082	-0.131^b	−0.089	0.458^c	1			
$FINACC_{M,t}$	-0.166^c	−0.068	-0.171^c	−0.012	0.116^b	1		
$GDP_{M,t}$	−0.009	−0.0635	0.060	0.018	0.020	−0.009	1	
$SP_{M,t}$	0.124^b	−0.061	0.183^c	0.070	−0.079	-0.160^c	0.126^b	1
				1981–1999				
$HHLEV_{U,t}$	1							
$SENT_{U,t}$	−0.038	1						
$GDP_{U,t}$	-0.148^a	0.090	1					
$HHLEV_{M,t}$	0.080	-0.255^c	−0.06	1				
$NFLEV_{M,t}$	−0.024	-0.170^b	−0.03	0.455^c	1			
$FINACC_{M,t}$	-0.145^a	−0.056	-0.128^a	0.056	0.152^a	1		
$GDP_{M,t}$	−0.013	−0.059	−0.044	0.010	0.132^a	0.105	1	
$SP_{M,t}$	0.230^c	−0.058	0.132^a	0.015	−0.037	-0.208^c	0.08	1
				2000–2016				
$HHLEV_{U,t}$	1							
$SENT_{U,t}$	0.108	1						
$GDP_{U,t}$	0.107	−0.058	1					
$HHLEV_{M,t}$	−0.029	0.052	0.072	1				
$NFLEV_{M,t}$	-0.162^b	0.061	-0.174^b	0.377^c	1			
$FINACC_{M,t}$	-0.202^c	0.004	−0.124	−0.092	0.042	1		
$GDP_{M,t}$	−0.033	−0.050	0.218^c	−0.002	-0.146^a	-0.144^a	1	
$SP_{M,t}$	0.058	−0.072	0.255^c	0.133	-0.179^b	−0.110	0.217^c	1

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$, $SENT_{U,t}$ is US investor sentiment, $HHLEV_{U,t}$ is US household leverage growth rate (GR), $GDP_{U,t}$ is US GDP GR, $HHLEV_{M,t}$ is Mexican household leverage GR, $NFLEV_{M,t}$ is Mexican non-financial corporate leverage GR, $FINACC_{M,t}$ is the Mexican net financial account, $GDP_{M,t}$ is Mexican GDP GR, $SP_{M,t}$ is Mexican stock price index GR. All indicators are standardized.

window length at 12 quarters, the minimum phase length at 2 quarters and a minimum cycle length at 12 quarters.

The results show that troughs of US and Mexican financial indicators coincide during the Black Monday market crash in 1987 and during the Great Financial crisis episode. Troughs of Mexican stock market returns and real GDP coincide during the Tequila

Table 2: The turning points of US and Mexican indicators.

Indicator	Peaks				Troughs			
$\text{HHLEV}_{\text{U},t}$	1985-1	1994-1	2001-3	2013-1	1987-4	2000-1	2012-1	
$\text{SENT}_{\text{U},t}$	1984-1	1993-1	2001-1	2007-1	1989-3	1998-4	2003-4	2009-4
$\text{GDP}_{\text{U},t}$	1987-4	2000-2	2003-3		1990-4	2001-3	2008-4	
$\text{HHLEV}_{\text{M},t}$	1984-4	1989-1	2005-4	2012-3	1987-1	1996-4	2009-3	
$\text{NFLEV}_{\text{M},t}$	1988-4	2008-4			1988-1	1998-4	2009-4	
$\text{FINACC}_{\text{M},t}$	1994-2	1998-4	2012-1		1987-3	1995-2	2009-4	
$\text{SP}_{\text{M},t}$	1987-1	1991-2	1999-2	2009-3	1987-4	1995-1	2008-4	
$\text{GDP}_{\text{M},t}$	1993-1	2002-2	2011-4		1986-1	1995-2	2008-4	2013-1

Notes: The turning points are documented using the BBQ algorithm of Bry and Boschan (1971) extended by Harding and Pagan (2002). The parameters for the algorithm were set as follows: a window length is 12 quarters, min phase length 2 quarters, min cycle length 12 quarters. See Notes of Table 1 for definitions of the indicators.

crisis in 1995. This episode is not reflected in the troughs of US indicators. This supports a specification of US indicators as exogenous to the Mexican economy. We also see that there are no clear patters regarding the peak-trough regularities between US and Mexican leverage cycles.

Principal component analysis indicates that three to four factors suffice to model co-movements in the eight indicators.[7] Four factors explain 57% of total variance. Table 3 shows their factor loadings.

The first factor loads most heavily on Mexican leverage growth. We label this as the global financial cycle. The second factor loads most on US household leverage growth, US investor sentiment and the Mexican net capital account. We label this the global business cycle. The third factor has the highest loadings on Mexican stock price index returns and Mexican GDP growth, hence we label this the Mexican business cycle. The fourth factor loads the most on US GDP growth, the Mexican net financial account and GDP growth. We label this the global business cycle. In our multivariate model section we will proceed on the assumption that co-movements in the indicators can be summarized with these four (cyclical) factors, labeled the US and Mexican financial and business cycles.

[7]Kaiser's criterion is to include all factors with eigenvalues equal to or exceeding one. We estimate three eigenvalues larger than one: 1.898, 1.479, 1.142. Inspection of the scree plot indicates four factors.

Table 3: Factor analyses of indicator co-movements

Indicator	Factor 1	Factor 2	Factor 3	Factor 4
$\text{HHLEV}_{\text{U},t}$	0.041	0.997	−0.002	0.013
$\text{SENT}_{\text{U},t}$	−0.273	0.242	−0.089	0.057
$\text{GDP}_{\text{U},t}$	−0.066	−0.063	0.109	0.489
$\text{HHLEV}_{\text{M},t}$	0.991	0.071	0.060	0.072
$\text{NFLEV}_{\text{M},t}$	0.602	−0.017	0.041	−0.213
$\text{FINACC}_{\text{M},t}$	0.042	−0.252	0.113	−0.570
$\text{SP}_{\text{M},t}$	−0.073	−0.047	0.307	0.407
$\text{GDP}_{\text{M},t}$	0.191	−0.041	0.972	0.115

Notes: Varimax rotation is applied on three factor space.

4 Model

This section introduces a model to investigate the roles of US and Mexican financial and business cycles in describing the long and short term movements of Mexican macroeconomic indicators. As in Koopman, Lit and Lucas (2016) we define a state-space model such that indicators of a country can contain financial and business cycles (see also Koopman and Lucas, 2005). However, in order to analyze the cyclical dynamics of an emerging economy, one necessary extension is to link its indicators to the cyclical components of the global economy. In the case of Mexico, the role of the US is important and hence we need to include Mexican and US financial and business cycle components.

We assign a separate role to the financial cycle components found in US investor and household sentiment indicators. While consumer sentiment depends on income and demand for real estate, investor sentiment depends upon future profit expectations translated into capital asset prices and the conditions under which short and long term finance are available (Minsky, 1978). Thus their effects on Mexican indicators may differ from consumer sentiment effects.

Let the N-vector $\boldsymbol{y}_t = [\boldsymbol{y}'_{U,t}, \boldsymbol{y}'_{M,t}]'$ contain stationary US and Mexican indicators. Two variants of the observation vector for US are given by

$$\boldsymbol{y}_{U,t} = (\text{HHLEV}_{\text{U},t}\ \text{GDP}_{\text{U},t})' \quad \text{or} \quad \boldsymbol{y}_{U,t} = \text{SENT}_{\text{U},t}, \quad t = 1, \ldots, T$$

and Mexican indicators are given by

$$\boldsymbol{y}_{M,t} = (\mathrm{HHLEV}_{\mathrm{M},t}\ \mathrm{NFLEV}_{\mathrm{M},t}\ \mathrm{FINACC}_{\mathrm{M},t}\ \mathrm{SP}_{\mathrm{M},t}\ \mathrm{GDP}_{\mathrm{M},t})'$$

where U refers to US and M to Mexico. The observed indicators ($\boldsymbol{y}_t$) are related to unobserved cyclical components ($\boldsymbol{\alpha}_t$) defined by

$$\begin{aligned} \boldsymbol{y}_t &= \boldsymbol{Z}\boldsymbol{\alpha}_t + \boldsymbol{e}_t, \quad \boldsymbol{e}_t \sim N(\boldsymbol{0}, \boldsymbol{H}), \\ \boldsymbol{\alpha}_t &= \boldsymbol{T}\boldsymbol{\alpha}_{t-1} + \boldsymbol{\eta}_t, \quad \boldsymbol{\eta}_t \sim N(\boldsymbol{0}, \boldsymbol{Q}) \end{aligned} \tag{1}$$

where the k-state vector $\boldsymbol{\alpha}_t = (\boldsymbol{\psi}'_{U,t}, \boldsymbol{\gamma}'_{U,t}, \boldsymbol{\psi}'_{M,t}, \boldsymbol{\gamma}'_{M,t})'$ collects long term ($\boldsymbol{\psi}_{U,t}$) and short term ($\boldsymbol{\gamma}_{U,t}$) cyclical components. Each cyclical component of the US is of the form $\boldsymbol{\psi}_{G,t} = (\psi_{U,t}, \psi^*_{U,t})'$ and $\boldsymbol{\gamma}_{U,t} = (\gamma_{U,t}, \gamma^*_{U,t})'$ and similarly for Mexico. The components marked with a superscript star result from writing the trigonometric components in a recursive form and can be interpreted as the partial derivatives of a cycle.

The $(N \times k)$ matrix $\boldsymbol{Z} = [\boldsymbol{Z}_U\ \boldsymbol{Z}_M] \otimes \boldsymbol{e}'_1$ contains factor loadings for the US and Mexican cyclical components. Based on univariate analysis to be discussed in Section 6.1, $\boldsymbol{Z}$ has two variants. If $\mathrm{FI}_{G,t}$ is defined as $\mathrm{HHLEV}_{\mathrm{U},t}$ hence $\boldsymbol{y}_t = (\mathrm{HHLEV}_{\mathrm{U},t}\ \mathrm{GDP}_{\mathrm{U},t}\ \boldsymbol{y}'_{M,t})'$ then $\boldsymbol{Z}$ consists of

$$\boldsymbol{Z}_{\mathrm{U}} = \begin{pmatrix} 1 & 0 & * & * & * & 0 & 0 \\ 0 & 1 & * & * & * & * & * \end{pmatrix}', \quad \boldsymbol{Z}_{\mathrm{M}} = \begin{pmatrix} 0 & 0 & 1 & * & * & 0 & 0 \\ 0 & 0 & * & * & * & 1 & * \end{pmatrix}' \tag{2}$$

but if $\mathrm{FI}_{U,t}$ is defined as $\mathrm{SENT}_{\mathrm{U},t}$ and hence $\boldsymbol{y}_t = (\mathrm{SENT}_{\mathrm{U},t}\ \boldsymbol{y}'_{M,t})'$, $\boldsymbol{Z}$ consists of

$$\boldsymbol{Z}_{\mathrm{U}} = \begin{pmatrix} 1 & * & * & * & 0 & 0 \\ 1 & * & * & * & * & * \end{pmatrix}', \quad \boldsymbol{Z}_{\mathrm{M}} = \begin{pmatrix} 0 & 1 & * & * & 0 & 0 \\ 0 & * & * & * & 1 & * \end{pmatrix}' \tag{3}$$

where $*$ denotes an unrestricted element and $\boldsymbol{e}'_1 = (1\ 0)$. $\boldsymbol{Z}_U$ and $\boldsymbol{Z}_M$ contain identification restrictions. In order to fix the scale of a cyclical component, one observed indicator is chosen as a base and is linked to one cyclical component with a fixed factor loading equal to one (see e.g., Koopman et al., 2005). We assume that none of the US indicators is influenced by the Mexican indicators, hence factor loadings for Mexican factors in US series are zero. Other restrictions are based on univariate analysis to be discussed in more detail in Section 6.1.

The (8×8) matrix $\boldsymbol{T} = \mathrm{blkdiag}[\boldsymbol{R}_\psi, \boldsymbol{R}_\gamma, \boldsymbol{R}_\psi, \boldsymbol{R}_\gamma]$ is a block diagonal matrix and describes the state transition for long and short term US and Mexican cyclical components. The cyclical components are specified in the form of a stochastic trigonometric cycle with a state transition matrix given by

$$\boldsymbol{R}_j = \phi_j \begin{pmatrix} \cos \lambda_j & \sin \lambda_j \\ -\sin \lambda_j & \cos \lambda_j \end{pmatrix}, \ j = \psi, \gamma, \tag{4}$$

where the persistence parameter $\phi_j \in (0, 1)$ and $\lambda_j \in (2\pi/T, \pi)$ is a frequency parameter (see Harvey, 1989). The period of a cycle expressed in years is given by $P_j = (2\pi/\lambda_j)/4$.

In the model there are two sets of similar cycles. First, the Mexican and US business cycles are similar. Second, the Mexican and US financial cycles are restricted to be similar. Hence they share the same frequency and persistence parameters (see Harvey and Koopman, 1997). Similar cycles can still have different peaks and troughs and scales.

The (8×8) matrix $\boldsymbol{Q} = \text{diag}[\sigma^2_{\psi_U}, \sigma^2_{\gamma_U}, \sigma^2_{\psi_M}, \sigma^2_{\gamma_M}] \otimes \boldsymbol{I}_2$ and the $(N \times N)$ matrix $\boldsymbol{H}$ are both diagonal and positive definite. To see the relative importance of each factor, the covariance of observed indicators can be decomposed into the cyclical variance resulting from each factor and the noise part given by

$$\boldsymbol{\Sigma_y} = \boldsymbol{Z}\boldsymbol{P}\boldsymbol{Z}' + \boldsymbol{H}, \tag{5}$$

where $\boldsymbol{P}$ has elements given by $\text{vec}(\boldsymbol{P}) = \boldsymbol{I}_{64} - (\boldsymbol{T} \otimes \boldsymbol{T})^{-1}\boldsymbol{Q}$, $\boldsymbol{H}$ is the noise part.

5 Estimation strategy

Model (1) is estimated by maximizing the log-likelihood over the set of model parameter values ($\boldsymbol{\delta}$). The parameters are then used to filter the unobserved states using a Kalman filter. Finally we apply the Kalman smoother which improves a Kalman filter estimates of unobserved states at time t by using the full sample information (see e.g., Durbin and Koopman, 2001).

Since all the state variables are covariance stationary, their initial values are set to have unconditional distributions. For example the initial state of the US long term cyclical component is distributed as $\psi_{U,0} \sim N(0, \sigma^2_{\psi_U}/(1 - \phi^2_{\psi_U}))$.

To implement the optimization process without constraints some model parameters are re-parametrized (e.g., Koopman and Azevedo, 2007). A typical diagonal element of a covariance matrix is specified as $\exp(2c_i)$ for some $c_i \in \mathbb{R}$. A cyclical component ψ_t has a period $P_\psi = \exp(\theta)$ where $\theta \in \mathbb{R}$ hence the corresponding frequency parameter is $\lambda_\psi = 2\pi/P_\psi$. A persistence parameter for a cyclical component is parametrized as $\phi_\psi = \exp(\nu)/(1 + \exp(\nu))$ for some $\nu \in \mathbb{R}$.

Our model is linear and Gaussian with linear constraints on parameters. Hence, finding the global maximum in theory does not constitute a problem. To improve the parameter empirical identification, which may be inhibited by flat likelihood regions, we still choose to use the global optimization algorithm in `Matlab`, i.e., simulated annealing (`simulannealbnd`). Since this algorithm perturbs all the parameter values simultaneously, in the second stage we optimize with local optimization methods to find even better parameter estimates. For this task we invoke `fminsearch` and `fmincon`. In the process of maximizing log-likelihood ($\log L$), `fmincon` provides the Hessian matrix which is then used to obtain the standard errors for the model parameters ($\boldsymbol{\delta}$) taking the square root of the diagonal entries of: $\boldsymbol{\Omega} = [-\partial^2 \log L/\partial \boldsymbol{\delta}\boldsymbol{\delta}']^{-1}$.

6 Results

In this section we estimate short and long term cyclical co-movements between the US and Mexican macroeconomic indicators. Section 6.1 motivates the specification choices for the multivariate model described in Section 4. Section 6.2 estimates US financial and business cycle effects for the Mexican economy during 1981–2016. In Section 6.3 we look at the two subsamples to see how the short term cyclical dynamics of the Mexican indicators has changed from 1981–1999 to 2000–2016.

6.1 Univariate analysis

The literature classifies all growth (rate) cycle components into two groups. short term cycles with periodicity from two to eight years describe a business cycle whereas components from eight to 30 years describe a financial cycle (see e.g., Drehmann et al., 2012). Each indicator can contain several business and financial cycle components. The first objective of this section is to estimate the strongest two for each indicator separately. A priori, we do not impose that each univariate model should contain one financial and one business cycle component. Hence it is possible that both extracted cyclical components correspond either to a financial or a business cycle frequency. The second objective is to classify each variable as a business cycle indicator and (or) a financial cycle indicator. These findings are incorporated in the specification of the factor loading matrices shown in Section 4. Lastly, across both groups and all the indicators we compare how similar cyclical components, obtained from univariate models, are. Cycles are called similar if they share the same frequency and persistence parameters but retain distinct stochastic innovations. A multivariate similar cycle model is more parsimonious in parameters but may be too restrictive for the data.

For univariate estimations we adopt the multivariate model described in Section 4. Further specification details can be found in Appendix A. We estimate two cyclical and one idiosyncratic component for each indicator. Table 4 lists both cycles in the increasing order of their cycle length. Each cyclical component is described by persistence ($\hat{\phi}_1$, $\hat{\phi}_2$), frequency, ($\hat{\lambda}_1$, $\hat{\lambda}_2$), cycle length in years (P_1, P_2) and state innovation variance ($\hat{\sigma}_1^2$,$\hat{\sigma}_2^2$). An idiosyncratic term is described by its measurement error variance ($\hat{\sigma}_\epsilon^2$).

Table 4 shows that US household leverage growth rates ($\text{HHLEV}_{\text{U},t}$) contain only a 17 year long ($P_1 = 17$) financial cycle component. The other cyclical component has a periodicity ($P_1 = 1$) of one year and is likely to capture some remaining seasonal variation. The latter is omitted from our further analysis.

Four indicators contain business and financial cycles. US investor sentiment ($\text{SENT}_{\text{U},t}$) contains a four year long ($P_1 = 4$) and a 17 year long ($P_2 = 17$) cyclical components. The indicator has no noise term since it is the first principal component of multiple averaged financial market series (see Baker and Wurgler, 2006). Financial and business cycles are present also in Mexican household and non-corporate leverage growth and the Mexican net financial account. The shortest business cycle component is found in the Mexican non-financial corporate leverage growth. It takes on average three years. We estimate that the longest business cycle component is found in the Mexican net financial account. Its duration on average is six years.

Several indicators contain only business cycle components. US and Mexican GDP growth rates contain the longest business cycle components. They take on average five years ($P_2 = 5$) and have similar persistence. The shortest business cycle components of two years are found in Mexican stock price index returns and GDP growth rates.

For all business (financial) cycle components, we sequence the estimated cycle length. We obtain that the median length of a business cycle is four years. The mode values for business cycle length are five and four years. For a financial cycle duration the median and mode values are 17 years. All the estimated financial cycle components have high persistence and relatively similar frequencies. Thus the assumption of similar

Table 4: Business and financial cycle components found in univariate model estimations.

Indicators	cycle 1				cycle 2				noise	
	$\hat{\phi}_1$	$\hat{\lambda}_1$	P_1	$\hat{\sigma}_1^2$	$\hat{\phi}_2$	$\hat{\lambda}_2$	P_2	$\hat{\sigma}_2^2$	$\hat{\sigma}_\epsilon^2$	$\log L$
Financial cycle indicators										
$\mathrm{HHLEV}_{\mathrm{U},t}$	0.773^c	2.859^c	1	0.120	0.984	0.090	17	0.013	0.354^c	-168
	(0.110)	(0.111)		(0.115)	(0.024)	(0.015)		(0.014)	(0.147)	
Business and Financial cycle indicators										
$\mathrm{SENT}_{\mathrm{U},t}$	0.887^c	0.446^c	4	0.028^b	0.923^c	0.095^c	17	0.030^c	0.000	-6
	(0.046)	(0.070)		(0.015)	(0.037)	(0.052)		(0.015)	(0.000)	
$\mathrm{HHLEV}_{\mathrm{M},t}$	0.937^c	0.352^c	5	0.030^c	0.983^c	0.099^c	16	0.011^a	0.293	-147
	(0.031)	(0.037)		(0.014)	(0.014)	(0.014)		(0.007)	(0.041)	
$\mathrm{NFLEV}_{\mathrm{M},t}$	0.820^c	0.501^b	3	0.048^a	0.984^c	0.092^c	17	0.007^a	0.322^c	-151
	(0.096)	(0.110)		(0.030)	(0.014)	(0.014)		(0.005)	(0.052)	
$\mathrm{FINACC}_{\mathrm{M},t}$	0.837^c	0.273	6	0.031	0.962^c	0.108^c	15	0.019	0.034^c	-164
	(0.169)	(0.237)		(0.057)	(0.042)	(0.035)		(0.022)	(0.061)	
Business cycle indicators										
$\mathrm{GDP}_{\mathrm{U},t}$	0.996^c	0.425^c	4	0.002^c	0.763^c	0.346^b	5	0.156^c	0.347^c	-168
	(0.021)	(0.054)		(0.010)	(0.110)	(0.108)		(0.076)	(0.071)	
$\mathrm{SP}_{\mathrm{M},t}$	0.979^c	0.774^c	2	0.003	0.768^c	0.414^c	4	0.087	0.289^c	-151
	(0.021)	(0.020)		(0.004)	(0.104)	(0.108)		(0.043)	(0.051)	
$\mathrm{GDP}_{\mathrm{M},t}$	0.946^c	0.862^c	2	0.010	0.755^c	0.334^c	5	0.038	0.326^c	-148
	(0.041)	(0.040)		(0.009)	(0.216)	(0.199)		(0.045)	(0.057	

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$. For each indicator, cycle 1 has a shorter duration than cycle 2. Cycles are described with parameters: λ_i is a frequency, ϕ_i is a persistence, $\hat{\sigma}_i^2, i = 1, 2$ is a variance of the cyclical innovations, $P_i, i = 1, 2$ is a cycle period in years calculated as $P_i = (2\pi/\lambda_i)/4$. Idiosyncratic term has a variance parameter $\hat{\sigma}_\epsilon^2$. $\mathrm{FINACC}_{\mathrm{M},t}$ contains also a third cyclical component with $\lambda = 2.621$, not reported.

financial cycles seems to be well founded. The five year business cycles have persistence parameters which are slightly more similar as compared to the four year cycles. We observe that business cycle components have smaller persistence as compared to financial cycles. Overall, the assumption of similar business cycle components seems to be more restrictive. Still, in the multivariate analysis we assume that Mexican indicators can be described with two pairs of similar cycles representing the US and Mexican financial and business cycles.

6.2 Multivariate analysis

In this section we analyze long and short-run co-movements between the US and Mexican indicators. The univariate analyses showed that both US household leverage growth rates and investor sentiment index contain a 17 year long financial cycle component. Despite this similarity, consumer and investor sentiment effects on Mexican indicators may differ (see Section 4). Thus we measure US market sentiment with US household leverage growth ($\mathrm{FI}_t = \mathrm{HHLEV}_{\mathrm{U},t}$) or alternatively with the US investor sentiment index ($\mathrm{FI}_t = \mathrm{SENT}_{\mathrm{U},t}$).

The univariate analyses showed that US household leverage growth rates contain a financial but not a business cycle component. Hence our first identifying restriction is that the US financial cycle explains 100% of cyclical variation in the US household leverage growth. To identify the US business cycle, our observation vector includes US GDP growth rates. Our second identifying restriction is that 100% of cyclical movements in US GDP growth rates are due to the US business cycle. For our alternative model specification, the US market sentiment is measured with Baker and Wurgler's investor sentiment index. The univariate analyses showed that the US investor sentiment index contains financial and business cycle frequencies. Hence our identifying restrictions are that 100% of its short term cyclical movements are due to the US business cycle and 100% of the long term movements are due to the US financial cycle. For Mexico, our identifying restriction is that all the cyclical movements in Mexican GDP (Stock price index) growth rates which are not due to the US business cycle, are explained by the Mexican business cycle. Our last identifying restriction is that all the long term cyclical movements which are not due to the US financial or business cycles, or the Mexican business cycle are explained by the Mexican financial cycle.

Table 5 shows the estimated co-movements between US and Mexican cyclical components. Each cyclical component is linked to its reference indicator with the factor loading one. In terms of magnitude, a statistically significant factor loading above one indicates that an indicator has a stronger association with a cyclical component as compared to its reference indicator. Sign-wise, a negative (positive) factor loading indicates a counter-cyclical (pro-cyclical) co-movement with respect to its reference indicator.

Table 5: Factor loadings describing US and Mexico's financial and real integration.

	Household sentiment					Investor sentiment				
	US		MX			US		MX		
$\boldsymbol{y}_t$	$\psi_{U,t}$	$\gamma_{U,t}$	$\psi_{M,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$	$\psi_{U,t}$	$\gamma_{U,t}$	$\psi_{M,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$
	Factor loadings $[\boldsymbol{Z}_G, \boldsymbol{Z}_M]$				$H(i,i)$	Factor loadings $[\boldsymbol{Z}_G, \boldsymbol{Z}_M]$				$H(i,i)$
$\mathrm{FI}_{\mathrm{U},t}$	1	0	0	0	0.584^c	1	1	0	0	0
$\mathrm{GDP}_{\mathrm{U},t}$	0	1	0	0	0.486^c	NA	NA	NA	NA	NA
$\mathrm{HHLEV}_{\mathrm{M},t}$	0.686	-0.109	1	2.572^a	0.275^c	-0.496^b	0.556^a	1	0.451^c	0.249^c
	(0.425)	(0.157)		(1.414)		(0.222)	(0.310)		(0.173)	
$\mathrm{NFLEV}_{\mathrm{M},t}$	0.302	-0.337^b	0.775^c	2.075^a	0.515^c	-0.525^c	0.928^b	0.508^c	-0.274	0.487^c
	(0.334)	(0.167)	(0.098)	(1.101)		(0.183)	(0.389)	(0.129)	(0.200)	
$\mathrm{FINACC}_{\mathrm{M},t}$	-0.698^c	-0.438^c	-0.210	1.165^a	0.625^c	-0.397^c	0.738^b	-0.542^b	-0.278	0.582^c
	(0.189)	(0.160)	(0.133)	(0.662)		(0.141)	(0.361)	(0.230)	(0.192)	
$\mathrm{SP}_{\mathrm{M},t}$	0	0.574^c	0	-0.966	0.806^c	0	-0.086	0	1	0.609^c
		(0.160)		(0.744)			(0.352)			
$\mathrm{GDP}_{\mathrm{M},t}$	0	0.173	0	1	0.919^c	0	0.522	0	0.530^b	0.834^c
		(0.151)					(0.329)		(0.226)	
λ_i	0.080^c	0.332^c	0.080^c	0.332^c		0.118^c	0.436^c	0.118^c	0.436^c	
P_i	20	5	20	5		13	4	13	4	
ϕ_i	0.995^c	0.888^c	0.995^c	0.888^c		0.942^c	0.859^c	0.942^c	0.859^c	
$\boldsymbol{Q}$	0.007	0.123	0.003	0.010		0.080^c	0.046^c	0.055^c	0.122^c	

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$. The standard errors for the coefficients are reported in brackets. In the table a factor loading "1" indicates which observed series were used as a reference for an unobserved cyclical component, a loading of zero excludes a factor from an indicator. Cyclical components considered are: $\psi_{U,t}$ a global financial cycle , $\gamma_{U,t}$ a global business cycle, $\psi_{M,t}$ a Mexican financial cycle, $\gamma_{M,t}$ a Mexican business cycle, $\sigma_{\epsilon,i}$ a noise component. Zero factor loadings not reported here are for $\psi^*_{U,t}$, $\gamma^*_{U,t}$, $\psi^*_{M,t}$, $\gamma^*_{M,t}$, $H(i,i)$ denotes the i-th diagonal element of the matrix $\boldsymbol{H}$. We define $\mathrm{FI}_{G,t} = \mathrm{HHLEV}_{t,G}$ for the "Household sentiment" block and $\mathrm{FI}_{G,t} = \mathrm{SENT}_{t,G}$ for the "Investor sentiment" block.

The left-hand side of Table 5 labeled "Household sentiment" shows several noteworthy patterns. There is long term counter-cyclicality between US household leverage growth and the Mexican net financial account. The two main sub-accounts of a net financial account are domestic ownership of foreign assets and foreign ownership of domestic assets. A negative value of the net financial account implies an outflow of money.

Thus Mexican investors tend to acquire foreign-owned assets when US households expand their balance sheets.

We observe short term counter-cyclicality between US GDP growth and the Mexican net financial account and leverage growth rates. However, US GDP growth rates are short term pro-cyclical to Mexican stock price index returns. We infer that Mexican investors acquire foreign-owned assets when their domestic economy grows and Mexican leverage decreases. The origins of counter-cyclicality between Mexican non-financial corporate leverage and US GDP growth rates are not immediately clear. One possible is that a positive productivity shock does not only increase output, but also increases the net worth of entrepreneurs, thereby reducing leverage. Following a positive productivity shock, an initially leveraged entrepreneur will earn high profits, increase equity by more than debt and therefore deleverage (see e.g., Fernández and Gulan, 2015). This implies that leverage and income move in opposite directions.

We also observe cyclical co-movements shared by Mexican indicators only. First, we estimate long term pro-cyclicality between Mexican household and corporate leverage growth. Co-movements of these variables describe the Mexican financial cycle. Second, there is short term pro-cyclicality between the Mexican net financial account, leverage and GDP growth rates. Thus Mexican-owned assets decrease as Mexican economy and leverage grows. In this estimation block, the combination of these variables define a Mexican business cycle.

The right-hand side of Table 5 labeled as "Investor sentiment" provides additional insights in the indicator co-movements. There is long term counter-cyclicality between US investor sentiment and the Mexican net financial account. Thus Mexican-owned assets increase as US investor sentiment increases. We estimate that US investor sentiment is long term counter-cyclical to Mexican household and non-corporate leverage growth. The long term counter-cyclicality may have several explanations. One possible is that softening of foreign monetary policy increases the supply of loans by foreign banks to Mexican firms. In particular, it increases more the supply of credit to borrowers with higher ex-ante loan rates and with substantially higher ex-post loan defaults. Hence credit expansion to riskier firms leads to more risk-taking rather than improve real outcomes (see e.g., Morais, Pedro and Ruiz, 2015).

As expected, we observe short term pro-cyclicality between US investor sentiment and Mexican leverage ratios. Positive global investor sentiment improves chances to obtain external finance. Simultaneously, we observe short term pro-cyclicality between US investor sentiment and the Mexican net financial account. This implies that Mexican-owned assets decrease with positive US investor sentiment and expanding Mexican household and non-financial corporation balance sheets. Lastly, we observe short-run pro-cyclicality between Mexican household leverage growth, stock price index returns and GDP growth rates. Co-movements in these variables describe a Mexican business cycle.

Figure 2 shows the two blocks of four four smoothed cyclical components each block containing US and Mexican financial and business cycle components. Smoothed cycles are obtained using a multivariate model described in Section 4 with the estimated parameter values shown in Table 5. A zero value for a cyclical component corresponds to the historical average, positive (negative) values indicate episodes above (below) historic average. Based on US household leverage and GDP growth rates as the indicators for the US market sentiments and business cycle, we estimate that financial cycles take 20 years and business cycles four years. Based on the US investor sentiment index, the length of a financial cycle is 13 years and of a business cycles five years .

We compute the contribution of each cyclical component in explaining variation in Mexican indicators. For orthogonal cyclical components the variance decomposition is given by Eq.(5) with the input parameter values as shown in Table 5. For example, unconditional variance for a US financial components is given by $\sigma^2_{\psi_{\mathrm{U}}}/(1-\phi^2_{\psi_{\mathrm{U}}})$. The amount of variance it explains in $\mathrm{HHLEV}_{\mathrm{M},t}$ is proportional to the corresponding squared factor loading. Table 6 shows variance decompositions.

Table 6: Decomposition of variance for the Mexican indicators (%).

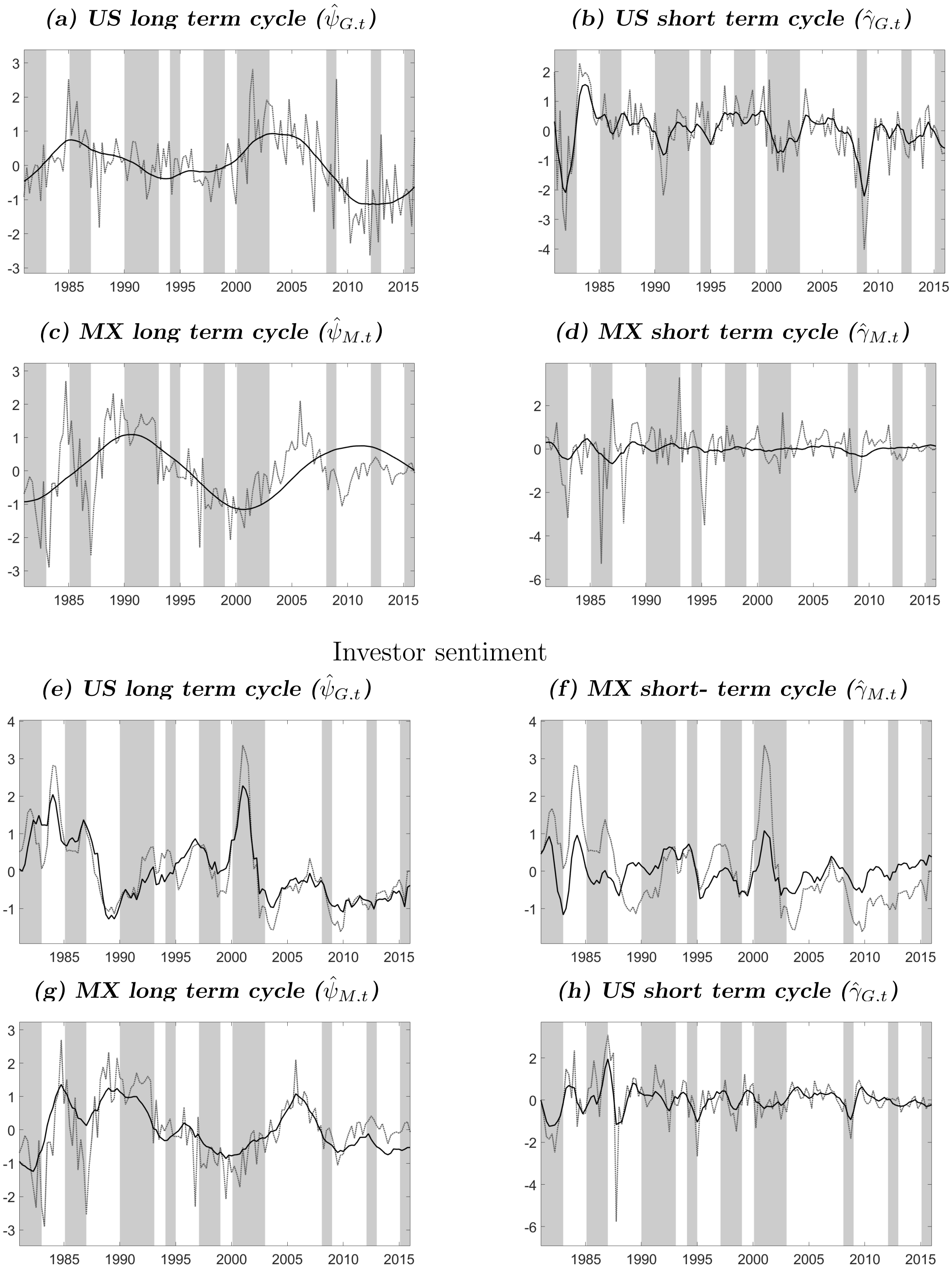
	$\mathrm{HHLEV}_{\mathrm{U},t}$					$\mathrm{SENT}_{\mathrm{U},t}$				
	US		MX			US		MX		
$\boldsymbol{y}_{\mathrm{M},t}$	$\psi_{\mathrm{U},t}$	$\gamma_{\mathrm{U},t}$	$\psi_{\mathrm{M},t}$	$\gamma_{\mathrm{M},t}$	$\epsilon_{i,t}$	$\psi_{\mathrm{U},t}$	$\gamma_{\mathrm{U},t}$	$\psi_{\mathrm{M},t}$	$\gamma_{\mathrm{M},t}$	$\epsilon_{i,t}$
$\mathrm{HHLEV}_{\mathrm{M},t}$	0	0	34	35	31	17	5	46	9	24
$\mathrm{NFLEV}_{\mathrm{M},t}$	0	7	19	21	53	20	16	13	0	51
$\mathrm{FINACC}_{\mathrm{M},t}$	30	10	0	6	55	12	10	15	0	62
$\mathrm{SP}_{\mathrm{M},t}$	0	19	0	0	81	0	0	0	43	57
$\mathrm{GDP}_{\mathrm{M},t}$	0	0	0	5	95	0	0	0	14	86

Notes: We compute percentage contribution of each cyclical components and of an idiosyncratic components to the Mexican indicator dynamics. We set all factor loadings to zero if their level of significance is less than 10% (see Table 5). Cyclical components considered are: $\psi_{U,t}$ a US financial cycle, $\gamma_{U,t}$ a US business cycle, $\psi_{M,t}$ a Mexican financial cycle, $\gamma_{M,t}$ a Mexican business cycle, $\sigma_{\epsilon,i}$ is a noise component.

Table 6 shows that most Mexican indicators have strong co-movements with the US

Figure 2: US and Mexican financial and business cycles.

Household sentiment



Notes: Shown are smoothed estimates of cycles (in black), their reference indicators (in grey), Mexico's OECD recession dates (grey bars).

business and financial cycles. We find that about one fourth of the Mexican household and corporate leverage growth has long run co-movement with the US investor sentiment. Approximately one third of the Mexican net financial account in the long run co-moves with the US household sentiment and 12% has long run co-movement with the US investor sentiment. We estimate that about one fourth of the Mexican stock price index growth co-moves with the US business cycle. However, Mexican GDP growth rates contain mostly idiosyncratic component. Given an increase in real integration between Mexico and the US, the latter finding is surprising. Hence in the next section we will investigate business cycle effects in the subsamples.

6.3 Exploring the role of NAFTA

As discussed by Kose, Meredith and Towe (2004) the North American Free Trade Agreement (NAFTA) had an effect on trade and financial flows between Mexico and US.[8] Thus the role of US factors increased for the Mexican economy. However, it is still difficult to isolate the NAFTA effects since part of it was anticipated by the markets. Also NAFTA led to gradual market liberalization over the first ten to fifteen years after the agreement was signed. In addition, Mexico and the US signed other bi-lateral trade agreements, increasing their global exposure in general (see e.g., Kose, Meredith and Towe, 2004). Since NAFTA was implemented only gradually, 2000 defines a good threshold year for a subsample analysis. By 2000 Mexico had opened up its banking sector and stock market to foreign participation, it had begun to issue long term treasury bonds and had stabilized its inflation level. Hence it seems reasonable to assume that if there are any effects of the integration to be found, these should become visible from year 2000 onwards.

Keeping in mind that the late NAFTA subsample analysis provides only an indirect evidence on trade liberalization effects, we now repeat the analysis of Section 6.2 for 1981:Q1–1999:Q4 and 2000:Q1–2016:Q1 subsamples with some modifications for the multivariate model. Since the number of observations in subsamples is not sufficient to make any reliable inference for financial cycles, we exclude both financial cycle components from the vector of unobserved factors $\boldsymbol{\alpha}_t$. We also exclude all the indicators which load on them: US and Mexican household leverage growth rates, the US investor

[8] For example trade barriers decreased, Mexico's exports shifted towards manufactured good, intra-firm trade among the NAFTA partners increased, provisions for investors legal rights were established etc.

sentiment index, Mexican non-financial corporate leverage growth and the net financial account. For our observation matrices $\boldsymbol{Z}$'s we only keep those columns which refer to factor loadings of global and Mexican business cycle components. For our unobserved cycles one identifying restriction is that 100% of cyclical variation in the US GDP growth is explained by the US business cycle. The other restriction is that 100% of cyclical variation in Mexican stock price index growth rates, not accounted by the US business cycle, is due to the Mexican business cycle. We refer to Appendix B for more details.

Table 7 shows the subsample differences in effects of US and Mexican business cycles on Mexican GDP and stock price index growth rates.

Table 7: Global and Mexican business cycle subsample effects on Mexican indicators

$\boldsymbol{y}_t$	1981–1999			2000–2016			1981–2016		
	$\gamma_{U,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\sigma^2_{\epsilon,i}$
	Factor loadings		$H(i,i)$	Factor loadings		$H(i,i)$	Factor loadings		$H(i,i)$
$\text{GDP}_{\text{U},t}$	1	0	0.471^c	1	0	0.452^c	1	0	0.440^c
$\text{SP}_{\text{M},t}$	0.481	1	1.073^c	0.475^c	1	0.148^c	0.495^c	1	0.771^c
	(0.301)			(0.140)			(0.178)		
$\text{GDP}_{\text{M},t}$	-0.174	0.841	1.222^c	0.669^c	-0.606	0.198^c	0.143	1.922	0.676^c
	(0.265)	(0.833)		(0.162)	(1.195)		(0.179)	(1.388)	
λ_i	0.465^c	0.465^c		0.532^c	0.523^c		0.430	0.430	
P_i	3	3		3	3		4	4	
ϕ_i	0.823^c	0.823^c		0.774^b	0.774^b		0.778^c	0.778^c	
$\boldsymbol{Q}$	0.182^c	0.131^c		0.179^c	0.010^c		0.201^c	0.035^c	
$\log L$	-343			-175			-569		

Notes: ^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$. Standard errors are reported in brackets. Cyclical components considered are: $\gamma_{U,t}$ a US business cycle, $\gamma_{M,t}$ a Mexican business cycle, $\sigma_{\epsilon,i}$ a noise component. In the table a factor loading "1" indicates which observed series were used as a reference for an unobserved cyclical component. Zero factor loadings not reported here are for $\gamma^*_{U,t}$, $\gamma^*_{M,t}$, $H(i,i)$ denotes the i-th diagonal elements of the matrix $\boldsymbol{H}$.

We estimate that in both sub-samples an average business cycle takes around three years. In the early sub-sample, we find no evidence of cyclical co-movement between any indicators. However, in the late NAFTA period there is short term pro-cyclicality between US and Mexican GDP growth and Mexican stock price index returns.

A cross-sample comparison of idiosyncratic variance ($\sigma^2_{\epsilon,i}$) shows a decrease for both indicators in the late NAFTA subsample. This finding is not surprising given that monetary stability with stable inflation and flexible exchange rate was achieved in the late 90s. From 1999 a fully fledged inflation target became the focal point of Mexican monetary policy; Mexico issued its local currency bonds and had reduced the external debt (see e.g., Carstens and Jácome, 2005). All of this helped to shield Mexico from exchange rate shocks.

Following the same procedure as for the full sample results, we calculate the relative proportions of variance explained by US and Mexican business cycles. The results are shown in Table 8. We find that both Mexican GDP and stock price index growth rates have increased their exposure to US business cycle component in the late NAFTA period. At the same time, the shares of idiosyncratic shocks decreased. These effects may be attributed to NAFTA however, Mexican and US global exposure in general has increased through other bilateral trade agreements.

Table 8: Decomposition of variance for the Mexican indicators over the subsamples (%)

	1981–1999			2000–2016		
$\boldsymbol{y}_{M,t}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\epsilon_{i,t}$	$\gamma_{U,t}$	$\gamma_{M,t}$	$\epsilon_{i,t}$
$\text{SP}_{\text{M},t}$	0	27	73	37	9	54
$\text{GDP}_{\text{M},t}$	0	0	100	50	0	50

Notes: We compute percentage contribution of each cyclical components and of an idiosyncratic components to the Mexican indicator dynamics. We set all factor loadings to zero if their level of significance is less than 10% (see Table 7). Cyclical components considered are: $\gamma_{U,t}$ a US business cycle, $\gamma_{M,t}$ a Mexican business cycle, $\sigma_{\epsilon,i}$ is a noise component.

We estimate that in the late NAFTA sub-sample one half of the Mexican GDP growth rate variance was driven by the US business cycle. About 40% of Mexican stock price index returns co-moved with the US business cycle. Strong presence of global dynamics motivates the need to develop macro-prudential frameworks aimed at smoothing out global risks for a domestic economy. Our findings illustrate that Mexico's economic growth outlook is linked to economic developments in the US.

7 Conclusion

Historically, Mexico has had tight trade ties with the US. Since 2000 it has opened up its equity and banking sectors. Thus there are many channels through which foreign financial and business cycles can be transmitted. In this context, understanding the scope of the domestic versus foreign dynamics is important. This paper investigates the cyclical properties of Mexican economic and financial activity indicators. The indicators are decomposed into Mexican and US business and financial cycle components. To extract US financial cycle components we select two reference indicators. First, household leverage growth rates reflect US household sentiment which depends upon demand for real estate and upon household income. Second, as a reference for a US financial cycle we use the US investor sentiment indicator which depends upon future profit expectations and capital asset prices. We find that factors extracted from these indicators link differently to Mexican indicators.

Our analysis provides us with several insights. First, Mexican household leverage and non-financial corporate leverage co-moves with the US financial and business cycle. We observe long term counter-cyclicality between US investor sentiment and Mexican leverage ratios, and pro-cyclicality in the short term. This finding may reflect that supply of funds by foreign banks and easing of credit conditions increase risk taking and long run default rates of economic agents. Consequently, an increase in default rates leads to negative long run effects for leverage growth (Morais et al., 2015).

Second, we observe short term counter-cyclicality between US GDP growth and Mexican non-financial corporate leverage growth. Also, in the short term Mexican stock price index returns are pro-cyclical to US GDP growth rates. Our interpretation is that a positive foreign demand shock increases domestic profits and equity hence decreasing leverage. We do not observe the same effect to be statistically significant for Mexican households.

Third, there is long term counter-cyclicality between the Mexican net financial account on one hand and US household and investor sentiment on the other. We also find a short term counter-cyclicality between US GDP growth rates and the Mexican net financial account. Thus Mexican investors acquire foreign held assets with an upswing in US investor and household sentiments and as the US economy grows.

In a separate analysis, we explore potential effects of NAFTA. We find that in the late NAFTA period, Mexican GDP growth rates and stock price index returns are short term pro-cyclical to US GDP growth. We estimate that idiosyncratic variation in Mexican GDP and stock price index returns has decreased in the late NAFTA subsample. This accords with the advent of monetary stability from 2000 onwards when exchange rate risks were tackled through reduction of external debt, bonds denominated in local currency and the central bank's commitment to low inflation target. These findings imply that the role of US has increased for the Mexican economy.

Our analysis suggest that economic forecasts for Mexico to a large extend depend on the US outlook. Second, designing a macro-prudential framework which smooths out US financial cycle effects on Mexican leverage growth rates could be beneficial for the Mexican economy. However, it is crucial to shed more light on the complex links between Mexican leverage growth dynamics, changes in Mexican asset ownership and the US economy. We have mentioned only briefly possible channels for financial and real cycles transmission. Measuring the importance of these channels is left to future research.

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A Univariate Unobserved components time series model

Consider an observation vector at $t = 1, \ldots, T$

$$\boldsymbol{y}_t = (\text{SENT}_{\text{U},t}\ \text{HHLEV}_{\text{U},t}\ \text{GDP}_{\text{U},t}\ \text{HHLEV}_{\text{M},t}\ \text{NFLEV}_{\text{M},t}\ \text{FINACC}_{\text{M},t}\ \text{SP}_{\text{M},t}\ \text{GDP}_{\text{M},t})',$$

where "U" refers to the US and "M" to Mexico. For each indicator $y_{i,t}$ the data generating process is given by

$$y_{i,t} = \boldsymbol{z}\boldsymbol{\alpha}_{i,t} + e_{i,t},\ e_{i,t} \sim N(0, \sigma^2_{e,i}),$$
$$\boldsymbol{\alpha}_{i,t} = \boldsymbol{T}_i\boldsymbol{\alpha}_{i,t-1} + \boldsymbol{\eta}_{i,t},\ \boldsymbol{\eta}_{i,t} \sim N(0, \boldsymbol{Q}_i)$$

where $\boldsymbol{\alpha}_{i,t} = (c_{1,i,t}\ c^*_{1,i,t}\ c_{2,i,t}\ c^*_{2,i,t})'$ are cyclical, trigonometric components, $e_{i,t}$ and $\boldsymbol{\eta}_{i,t}$, are mutually independent error and state innovation terms, $\boldsymbol{z} = [1, 1] \otimes \boldsymbol{e}'_1$ contains factor loadings, $\boldsymbol{T}_i = \text{blkdiag}[\boldsymbol{R}_{c_1,i}, \boldsymbol{R}_{c_2,i}]$ is a block diagonal state transition matrix where rotation matrices are specified

$$\boldsymbol{R}_{j,i} = \phi_{c_1,i} \begin{pmatrix} \cos\lambda_{c_1,i} & \sin\lambda_{c_1,i} \\ -\sin\lambda_{c_1,i} & \cos\lambda_{c_1,i} \end{pmatrix},\ i = 1 \ldots N;\ j = c_1,\ c_2$$

where $\phi_{c_1,i}$ is a persistence parameter, $\lambda_{c_1,i}$ a frequency, $\boldsymbol{Q}_i = \text{diag}[\sigma^2_{c_1,i}, \sigma^2_{c_2,i}] \otimes \boldsymbol{I}_2$ is a diagonal state innovation matrix. This implies that the two cyclical components are mutually independent.

B Post NAFTA business cycle effects

Consider an observation vector at $t = 1, \ldots, T$

$$\boldsymbol{y}_t = (\mathrm{GDP}_{\mathrm{U},t}\ \mathrm{SP}_{\mathrm{M},t}\ \mathrm{GDP}_{\mathrm{M},t})',$$

where U refers to US and M to Mexico. The observed indicators ($\boldsymbol{y}_t$) are related to unobserved cyclical components ($\boldsymbol{\alpha}_t$) defined by

$$\begin{aligned} \boldsymbol{y}_t &= \boldsymbol{Z}\boldsymbol{\alpha}_t + \boldsymbol{e}_t, \quad \boldsymbol{e}_t \sim N(\boldsymbol{0}, \boldsymbol{H}), \\ \boldsymbol{\alpha}_t &= \boldsymbol{T}\boldsymbol{\alpha}_{t-1} + \boldsymbol{\eta}_t, \quad \boldsymbol{\eta}_t \sim N(\boldsymbol{0}, \boldsymbol{Q}) \end{aligned}$$

where the k-state vector $\boldsymbol{\alpha}_t = (\boldsymbol{\gamma}'_{U,t}, \boldsymbol{\gamma}'_{M,t})'$ with short term cyclical components. Each cyclical component of the US is of the form $\boldsymbol{\gamma}_{U,t} = (\gamma_{U,t}, \gamma^*_{U,t})'$ and similarly for Mexico. The components marked with a superscript star result from writing the trigonometric components in a recursive form and can be interpreted as the partial derivatives of a cycle.

The observation matrix $\boldsymbol{Z} = \boldsymbol{Z}^* \otimes \boldsymbol{e}'_1$ is defined as

$$\boldsymbol{Z}^* = \begin{pmatrix} 1 & * & * \\ 0 & 1 & * \end{pmatrix}',$$

where $*$ denotes an unrestricted element and $\boldsymbol{e}'_1 = (1\ 0)$. The state transition matrix $\boldsymbol{T} = \boldsymbol{I}_2 \otimes \boldsymbol{R}_\gamma$ is defined by

$$\boldsymbol{R}_\gamma = \phi_\gamma \begin{pmatrix} \cos\lambda_\gamma & \sin\lambda_\gamma \\ -\sin\lambda_\gamma & \cos\lambda_\gamma \end{pmatrix},$$

where the persistence parameter $\phi_\gamma \in (0, 1)$ and $\lambda_\gamma \in (2\pi/T, \pi)$ is a frequency parameter.

C Unit root tests

Table 9: Dickey Fuller unit root test

$y_{i,t}$	probability	t-stats	lags
$\text{SENT}_{\text{U},t}$	0.007	-3.584	1
$\text{HHLEV}_{\text{U},t}$	0.051	-2.873	2
$\text{GDP}_{\text{U},t}$	0.000	-4.707	1
$\text{HHLEV}_{\text{M},t}$	0.051	-2.873	2
$\text{NFLEV}_{\text{M},t}$	0.002	-4.002	1
$\text{FINACC}_{\text{M},t}$	0.038	-2.989	3
$\text{GDP}_{\text{M},t}$	0.000	-8.701	1
$\text{SP}_{\text{M},t}$	0.000	-7.100	1

Notes: $y_{i,t}$ is a financial indicator where $i = 1, \ldots, 8$. The lag order was detected using the Akaike Information Criterion (AIC) information criteria. We do not have evidence for unit roots in the current data sample 1981–2006.

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