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Determinants of the onshore and offshore Chinese Government yield curves

by

Horst Loechel, Natalie Packham and Fabian Walisch*

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Sonnemannstr. 9 – 11 60314 Frankfurt am Main, Germany
Phone: +49 (0) 69 154 008 0 Fax: +49 (0) 69 154 008 728
Internet: *www.frankfurt-school.de*

Abstract

As part of its effort to internationalize the Renminbi, China's government has promoted the establishment of a regulated offshore Renminbi capital market hub in Hong Kong, where, among other activities, it issues RMB-denominated government bonds providing foreign investors access to Chinese bond markets. In a VAR model where yield curves are represented by Nelson-Siegel latent factors and which includes macroeconomic variables, we find that onshore government bond yields are primarily driven by policy-related factors such as the policy rate and money supply, whereas offshore government bond yields are additionally driven by market-related factors such as consumer confidence, GDP and FX rate expectations as well as liquidity constraints. At the current stage of market development there are virtually no spillover effects between the onshore and offshore government bond curves. Our results add quantitative evidence that China's efforts to internationalize its currency results in a simultaneous liberalization of its financial system.

Key words: Chinese government bond yields, Chinese offshore market, RMB, Hong Kong

JEL classification: E43, E47, E63, G18

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Contact:

Prof. Dr. Horst Löchel
Frankfurt School of Finance and Management
Sonnemannstraße 9-11, 60314 Frankfurt am Main
Germany
h.loechel@fs.de

Prof. Dr. Natalie Packham
Frankfurt School of Finance and Management
Sonnemannstraße 9-11, 60314 Frankfurt am Main
Germany
n.packham@fs.de

Fabian Walisch
fabian.walisch@googlemail.com

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Contents

1 Introduction

In order to establish Hong Kong as a fully fledged offshore market for China's currency – the Renminbi (RMB) –, the Ministry of Finance of China has been pushing forward the creation of a liquid offshore RMB sovereign bond market. The first bond issue was launched in autumn 2009. Although the market is still relatively small in terms of volume, its merit lies in the provision of a benchmark yield curve that can be used as a reference for the pricing of corporate and other institutional bonds. This paper aims to identify the determinants of the Hong Kong offshore sovereign yield curve and to test the hypothesis that, other than its onshore equivalent, the respective offshore curve is not predominantly driven by policy-related factors.

The activities through which China's government is fostering the position of the RMB as an international currency since the outbreak of the global financial crisis in 2007 can be classified into three main channels, (e.g. Cockerell and Shoory, 2012; Gao and Coffman, 2013; McCauley, 2013): establishing swap lines between China's central bank, the People's Bank of China (PBoC), and its foreign counterparts; granting companies to use RMB for cross-border trade settlement; and establishing a regulated offshore RMB capital market hub in Hong Kong. Together with a range of other liberalization efforts, these measures have led to the creation of a strictly separated offshore bond market with its very own features. Simultaneously, the volume of cross-border trade denominated in RMB is increasing steadily, and within Asia, the RMB is already underway to take the role of an anchor currency (Fratzscher and Mehl, 2011; Subramanian and Kessler, 2012).

From an economic point of view, one of the most interesting features of the RMB internationalization process is the concurrent liberalization and marketization of China's financial system. Indeed, in the case of China, internationalization can be even seen as synonymous to liberalization, given the fact that its financial system was mostly locked prior to the global financial crisis. This becomes evident from China's formerly closed capital account, a non-convertible currency, and managed exchange and interest rate systems, (Dobson and Masson, 2009; Hong et al., 2010; Eichengreen, 2013; Tobin, 2013), as well as from a heavily regulated banking sector (Lardy and Douglass, 2011; Chang and Löchel, 2012). In the literature, such a conjunction between internationalization and liberalization is generally recognized as the cost of currency internationalization (Gao and Yu, 2012; Kenen, 2012).

By discussing the features of the RMB-denominated offshore sovereign yield curve in Hong Kong, the paper focuses on one particular aspect of the conjunction between internationalization and liberalization. Our interest lies in determining whether the development of the offshore benchmark yield curve follows the same path as RMB internationalization in general. More precisely, in contrast to the onshore government yield curve, which is determined by the policy of the PBoC, we conjecture its offshore counterpart to be driven in addition by market forces.

For the purpose of analyzing the determinants of yield curves, we employ a vector autoregression (VAR) model including both the yield curve and macroeconomic variables as in Diebold et al. (2006). Here, following Nelson and Siegel (1987), a yield curve is expressed in terms of three latent factors, representing level, slope and curvature. Because of the parsimonious representation of yield curves, this model type is frequently used in the macro-finance literature (see e.g. Afonso and Martins (2012) for a recent analysis of fiscal policy on sovereign yield curves in the US and in Germany). Further, in the spirit of Maziad and Kang (2012) who analyse spillover effects between the RMB/USD onshore and offshore foreign exchange rate markets, we study spillover effects between the onshore and offshore yield curves.

While China's onshore government yield curve and its determinants have been subject to a large body of literature (Fan and Johansson, 2009, 2010; Fan et al., 2012; Luo et al., 2012), existing studies about the offshore bond market, the so-called "Dim Sum" bond market, are relatively new and of rather descriptive nature (e.g. Fung et al., 2012; Fung and Yau, 2012).

Our definition of a policy-driven yield curve refers to a setting in which the central bank governs the whole term structure of interest rates instead of targeting only the short end of the yield curve as in the typical case of a fully fledged market economy. Such a constellation applies to China's onshore market in which the PBoC uses the money supply and a set of official rates in order to control both the short and long end of the curve. This unique feature of China's financial architecture has been frequently highlighted in the literature (e.g. Fan and

Johansson, 2009; Li et al., 2012). According to evidence provided by Fan et al. (2012), the one-year deposit rate provides the most accurate approximation of China's policy rate (PR). In our analysis, we therefore consider it as a potential determinant of the onshore yield curve.

It is important to note that China's Mainland sovereign and corporate bond markets are distinct. This difference grounds on another unique feature of China's financial system, the so-called "sterilization" mechanism, which constitutes an element of the the managed exchange rate system. Under this measure, the PBoC urges China's big state-owned banks to buy government bonds as well as central bank bills in order to sterilize the RMB money supply resulting from its foreign exchange market operations so as to dampen inflationary pressures (Wang, 2010; Zhang, 2012; Chang et al., 2013). Consequently, in addition to the deposit rate, one would expect that developments in money supply, measured by the M2 aggregate, as well as the amount of foreign exchange reserves (FXR) are variables that significantly influence the onshore government yield curve as well.

In contrast, we expect the offshore curve to be also driven by factors other than policy measures. In case of the US sovereign bond yield curve, Diebold et al. (2006) verify that macro variables such as capacity utilization and inflation have an effect on the sovereign yield curve. Analogously, in our analysis, we employ real GDP growth (GDP), the consumer confidence index (CCI), and inflation expectations (CPIE) as potential determinants for a yield curve that is based on additional, non-policy-related factors.

In addition, the offshore yield curve exhibits some specific features that are different from the situation in a fully fledged market economy. First and foremost, these differences refer to exchange rate expectations (Li et al., 2012). The managed exchange rate regime in conjunction with comparably high growth rates in GDP persistently causes appreciation expectations (Goldstein and Lardy, 2006; Liu and Pauwels, 2012; Minikin and Lau, 2013). These expectations ultimately have an impact on the demand in the offshore market for RMB-denominated sovereign bonds. We account for this issue by including expectations on the exchange rate of the RMB against the US-Dollar (FXE) as another independent variable in our model. As an indicator for these expectations, related research typically resorts to the one-year USD-CNY non-deliverable forward rate as a suitable predictor, (Minikin and Lau, 2013).

The liquidity situation is a second outstanding feature of the offshore RMB market, (Cockerell and Shoory, 2012). Given that China's capital account is still not open and the RMB is not freely convertible yet, liquidity in the offshore RMB market is still limited, (Rossi and Jackson, 2011). At the same time, with a still underdeveloped equity market, investment opportunities are mostly limited to fixed income products. Therefore, any change in the proportion of ready-to-be-invested liquidity and the outstanding amount of bonds should affect the yield curve. To control for the liquidity level in the offshore market, we employ the ratio of outstanding offshore bonds relative to the volume of outstanding offshore RMB deposits (LIQ).

Based on daily mid-prices of Chinese RMB-denominated sovereign bonds from January 2011 to December 2012, we provide empirical evidence that the onshore yield curve is dominated by policy-related factors like the deposit rate and the volume of the money aggregate M2, whereas the respective offshore curve is also driven by market-related factors. More specifically, it turns out that there is a significant influence of the GDP growth rate, the consumer confidence index as well as exchange rate expectations and the liquidity ratio. This result is particularly strong when restricting the analysis to the period from August 2011 to December 2012, when the offshore market was significantly more liquid than before. However, inflation expectations are neither significant for the onshore nor for the offshore curve. One possible explanation for this somewhat unexpected result particularly with regard to the offshore curve could point to limitations in the availability of data, which, unfortunately, restricts the time horizon of the inflation expectations to one year. Furthermore, we find no empirical evidence for spillover effects, which reflects the still disjunctive character of the onshore and offshore markets.

Overall, the results support our hypothesis that contrary to the onshore market, the respective offshore curve is not predominantly policy-driven but more market-driven. Moreover, our results are in line with the observation that the offshore yield curve is well below the domestic yield curve, but converges towards the onshore curve for longer-term maturities. This premium payment in Hong Kong reflects not only the lack of access to the mainland bond market, but also expectations of yet another opening of the capital account in the long run, (McCauley, 2013).

The rest of the paper is structured as follows. After a brief review of the institutional features of the offshore market in Hong Kong in Section 2, Section 3 introduces the latent factor model for describing yield curves and the VAR model involving both the latent factors and the macroeconomic data. Results from VAR models involving onshore and offshore yield curves, and respective sensitivity analyses and impulse responses are presented in Section 4. Potential spillover effects are also investigated in Section 4 by analysing a VAR model involving both onshore and offshore latent factors. We conclude in Section 5.

2 The Renminbi offshore bond market

In contrast to China's mainland bond market, which emerged during the 1980's, (Neftci and Ménager-Xu, 2007), the foundations for the establishment of the market for RMB-denominated offshore bonds in Hong Kong were laid just ten years ago by the official appointment of the Bank of China Hong Kong to act as the gateway for RMB clearing and by the licensing of 32 banks to conduct retail RMB business, thereby laying the cornerstone for the accumulation of an offshore RMB deposit base.[1] With the inaugural bond issuance by China Development Bank, the "Dim Sum bond" market was then initiated in July 2007.

During the first three years, issuance activity in the offshore bond market remained low, since, aside from China's government, only financial entities incorporated in China were allowed to issue "Dim Sum" bonds. With the support of various regulatory relaxations (especially the signing of the Supplementary Memorandum in July 2010, (Minikin and Lau, 2013)), the market experienced a strong uptick during 2011 and 2012. Given its short lifetime, the market's size is still comparably low: At the end of 2012, the outstanding notional amount of bonds reached RMB 357.7 bn., which corresponds to 1.51% of the equivalent amount in the onshore market (own calculations using data from Bloomberg and CCDC). Nevertheless, besides

[1] See website of Hong Kong Monetary Authority (HKMA), in particular http://www.hkma.gov.hk/eng/key-information/press-release-category/renminbi-business.shtml.

deposits, RMB-denominated bonds reflect the most dominant product in the offshore market, whereas equity and syndicated loan markets are still underdeveloped, (Cockerell and Shoory, 2012). Due to their popularity, the range and sophistication of available debt instruments is continuously rising. Next to standard products such as medium-term notes, commercial papers and certificates of deposits, there also exist exotic debt structures, such as floating rate notes or convertible bonds with payment options in alternative currencies. Lately, the Hong Kong Monetary Authority (HKMA) introduced a liquidity facility, allowing banks to participate in RMB business in Hong Kong (meanwhile 139 authorized institutions) to make use of repurchase agreements.[2] Also, the CNH HIBOR as a reference for credit products was launched.[3] The main issuers in the offshore bond market include China's Ministry of Finance, Mainland China- and Hong Kong-domiciled banks as well as corporations. The rest is made up of quasi-sovereign as well as supranational institutions and real estate issuers, (Wong, 2012). Typical primary and secondary market investors are asset managers, financial institutions, and private banks.

The offshore market for RMB sovereign bonds first emerged in September 2009, when China's government issued three bonds, (Prasad and Ye, 2012). Initially, the longest tenor was only five years. Today's offshore government yield curve is made up of yields from more than 20 RMB-denominated sovereign bonds with tenors of up to 30 years.The outstanding amount of offshore government bonds grew from RMB 6 bn. in H1 2010 to RMB 64.5 bn. in H1 2013. China's Ministry of Finance's sole aim in issuing sovereign bonds is to establish a liquid benchmark yield curve, which serves as a pricing reference for non-sovereign bonds, (Ebias, 2012). Such a curve also serves as a sign for mature market conditions.

The secondary market generally still lacks liquidity as many fixed income products are only quoted infrequently and merely on a daily basis. This is partially related to the relative short average tenors of the debt instruments in the market. Due to these circumstances, investors usually prefer to hold their investment until maturity, (Minikin and Lau, 2013). In spite of that, sovereign bonds are quoted liquidly on a permanent basis.

[2]See HKMA website.
[3]See HKMA website.

Due to the special institutional setting, the offshore RMB market possesses some unique features. More specifically, the market is artificially separated from its onshore counterpart and is hence subject to distinct drivers, which are also valid for the market segment of government bonds. These drivers basically comprise appreciation expectations with regards to the RMB exchange rate as well as the amount of free liquidity in the market, (Capon, 2012). This helps to explain why the onshore and offshore yield curves deviate from each other, (McCauley, 2013).

3 A yield curve factor model with macroeconomic data

3.1 Model

For determining macroeconomic effects on the onshore and offshore government yield curves, we essentially follow the methodology outlined in Diebold and Li (2006) and Diebold et al. (2006). In Diebold and Li (2006), a yield curve is expressed by three latent factors representing level, slope and curvature in a Nelson-Siegel model, (Nelson and Siegel, 1987), which are fitted to a VAR model. Diebold et al. (2006) augment the VAR model to include macroeconomic variables.

This model choice serves several purposes: First, the Nelson-Siegel model allows for a parsimonious and unified representation of yield curves through time, reflecting the well-known fact that a yield curve is driven by fewer factors than the bond prices available, (e.g. Diebold et al., 2005). Second, the VAR model naturally accounts for the autocorrelation present in yield curves and, when including macroeconomic variables, allows to study their explanatory power on the yield curve. Third, the VAR model with macroeconomic variables allows to study impulse responses (shocks) to the system and, in particular, the effects of macroeconomic shocks on the yield curve, (e.g. Ang and Piazzesi, 2003; Piazzesi, 2005, and the above literature).

Let us first consider the Nelson-Siegel model. Let $P_t(\tau)$ denote the price at time t of a zero bond with notional 1 maturing at τ, and let $y_t(\tau)$ denote its continuously compounded yield, so

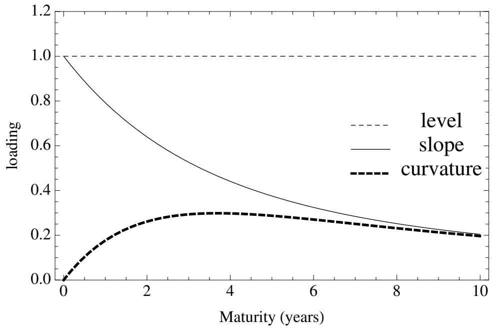

Figure 1: Factor loadings of the Nelson and Siegel model; left: level, middle: slope, right: curvature.

that

$$P_t(\tau) = \mathbf{e}^{-(\tau-t)y_t(\tau)}. \tag{1}$$

In practice, since market data are usually given as yields of coupon-bearing bonds, zero yields are determined via bootstrapping (also known as Fama/Bliss yields, (Fama and Bliss, 1987)).

In the Nelson-Siegel model, the representation of the (zero-rate) yield curve at time t is given by

$$y_t(\tau) = L_t + S_t \frac{1-\mathbf{e}^{-\lambda\tau}}{\lambda\tau} + C_t \left(\frac{1-\mathbf{e}^{-\lambda\tau}}{\lambda\tau} - \mathbf{e}^{-\lambda\tau} \right), \tag{2}$$

where τ is the maturity, L_t, S_t and C_t are time-varying *latent factors* that are multiplied with the respective factor loadings 1, $\frac{1-\mathbf{e}^{-\lambda\tau}}{\lambda\tau}$ and $\left(\frac{1-\mathbf{e}^{-\lambda\tau}}{\lambda\tau} - \mathbf{e}^{-\lambda\tau} \right)$, and where λ is a constant that governs amongst other things the maturity at which the loading on C_t achieves its maximum.[4] The factor loadings, depicted in Figure 1, can be interpreted as denoting level, slope and curvature of the yield curve. The Nelson-Siegel model is a popular term-structure model as it captures important stylized facts of yield curves, in particular allowing for upward sloping, downward sloping, humped and inverted humped term structures, while at the same time being a parsimonious model with only four factors (λ included).

Given zero-yields $y_t(\tau_1), \ldots, y_t(\tau_N)$ for maturities $\tau_1, \ldots, \tau_N$, the time-t latent factors are

[4]One could also choose λ to be time-varying, but we follow (Diebold and Li, 2006) and choose λ to be constant across time. Details on the choice of λ are given in Section 4.

determined by solving the following linear system for L_t, S_t, C_t:[5]

$$\begin{pmatrix} y_t(\tau_1) \\ y_t(\tau_2) \\ \vdots \\ y_t(\tau_N) \end{pmatrix} = \begin{pmatrix} 1 & \frac{1-\mathbf{e}^{-\lambda\tau_1}}{\lambda\tau_1} & \frac{1-\mathbf{e}^{-\lambda\tau_1}}{\lambda\tau_1} - \mathbf{e}^{-\lambda\tau_1} \\ 1 & \frac{1-\mathbf{e}^{-\lambda\tau_2}}{\lambda\tau_2} & \frac{1-\mathbf{e}^{-\lambda\tau_2}}{\lambda\tau_2} - \mathbf{e}^{-\lambda\tau_2} \\ \vdots & \vdots & \vdots \\ 1 & \frac{1-\mathbf{e}^{-\lambda\tau_N}}{\lambda\tau_N} & \frac{1-\mathbf{e}^{-\lambda\tau_N}}{\lambda\tau_N} - \mathbf{e}^{-\lambda\tau_N} \end{pmatrix} \begin{pmatrix} L_t \\ S_t \\ C_t \end{pmatrix} + \begin{pmatrix} \varepsilon_t(\tau_1) \\ \varepsilon_t(\tau_2) \\ \vdots \\ \varepsilon_t(\tau_N) \end{pmatrix}, \tag{3}$$

where $\varepsilon_t(\tau_i)$, $i = 1,\dots,N$, are assumed to be white noise (i.e., with expectation 0, constant variance and no serial correlation).

Assuming that latent factors follow a VAR process of p-th order with exogenous variables $X_1,\dots,X_q$, the dynamics are given by

$$\begin{pmatrix} L_t - \mu_L \\ S_t - \mu_S \\ C_t - \mu_C \end{pmatrix} = A \cdot \begin{pmatrix} L_{t-1} - \mu_L \\ S_{t-1} - \mu_S \\ C_{t-1} - \mu_C \\ \vdots \\ L_{t-p} - \mu_L \\ S_{t-p} - \mu_S \\ C_{t-p} - \mu_C \\ X_1 \\ \vdots \\ X_q \end{pmatrix} + \begin{pmatrix} \eta_t(L) \\ \eta_t(S) \\ \eta_t(C) \end{pmatrix}, \tag{4}$$

where A is an $(3p+q) \times 3$ matrix of factor loadings, μ_L, μ_S, μ_C denote the means of L, S, C, respectively, and $(\eta_t)_{t\in\mathbb{Z}}$ are white-noise processes, uncorrelated with $(\varepsilon_t)_{t\in\mathbb{Z}}$.

Contrary to Diebold et al. (2006), in our setting, the macroeconomic variables are all exogenous variables and only the latent factors are endogenous variables. This model choice is motivated by the short time horizon (1.5–2 years) for which reliable data is available: since we are primarily interested in the macroeconomic determinants on the yield curve, this is the

[5]Observe that if λ is allowed to be time-varying, this becomes a non-linear problem.

most straightforward model that allows to incorporate both latent factors on a daily basis and macroeconomic data, which are typically updated only on a monthly or quarterly basis.[6]

A further deviation from the setup in Diebold et al. (2006) lies in the method how the model is fitted. As the factors from the Nelson-Siegel model are latent factors, it is natural in this setting to use a Kalman filter for estimating the model. This requires yield-curve data with constant time-to-maturities, that is, $\tau_i - t$, $i = 1,\dots,N$, are equal for all t. In mature markets, where abundant bond data is available, such a selection of yields can always be achieved. Analysing a nascent market, such as the offshore market in Hong Kong, requires using all available data impeding the use of constant time-to-maturities. Hence, instead of using Kalman filter techniques to estimate the model, we fit the model in two steps: first, we estimate the latent factors from Equation (3) using OLS, and then we estimate the parameters of the VAR system, cf. Equation (4).

As a further consequence of using daily data, the lag of the system will typically be greater than one, which in Diebold et al. (2006), whose study is based on monthly data, is sufficient to remove autocorrelation from the residuals. In our setting, properly dealing with autocorrelation requires lags between 3 and 10, depending on the market.

As outlined in Section 1, the macroeconomic data are the policy rate (PR), money supply (M2), foreign exchange reserves (FXR), consumer confidence (CCI), real gross domestic product (GDP), inflation expectations (CPIE), FX rate expectations (FXE) and a Hong-Kong related liquidity proxy (LIQ), defined by

$$\mathrm{LIQ} = \frac{\text{outstanding amount of bonds}}{\text{outstanding amount of deposits}}. \tag{5}$$

3.2 Data

The sample period is from 3 January 2011 until 31 December 2012. All data are from Bloomberg. We have daily samples of mid prices of Chinese RMB-denominated sovereign bonds, where the

[6] Incorporating the macroeconomic data as endogenous variables requires techniques for dealing with mixed data sampling, such as MIDAS, where the regressor is sampled more frequently than the regressor. We refer to Clements and Galvão (2008); Andreou et al. (2010), and references therein.

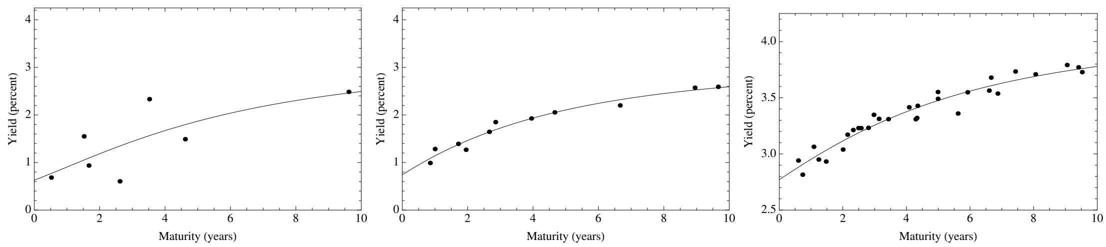

Figure 2: Left: Offshore zero-yield curve, 20 April 2011; middle: Offshore zero-yield curve, 20 December 2011; right: onshore zero-yield curve, 20 April 2011. Dots: zero yields derived from bootstrapping; line: fitted Nelson-Siegel curve.

data are either given as zero yields, or transformed to (continuous) zero rates via bootstrapping. We include government bond data with maturities up to ten years. We exclude several trading days where only scarce data is available (e.g. two days in October 2012 around some public holidays). In total we have yield data for 470 days in the above-mentioned period. The onshore yield curves consist of 31.18 zero yields on average (standard deviation 1.24). The offshore yield curve consists of 10.56 data points on average (standard deviation 3.02). In addition, the offshore curve was subject to significant changes during July 2011 and August 2011. Prior to July 2011 the observed zero yields exhibit large variation between consecutive data points. Amongst several measures to improve the attractiveness of the offshore Hong Kong market, (Minikin and Lau, 2013), the government issued four bonds with maturities 3, 5, 7 and 10 years on 17 August 2011, giving rise to a more consistent yield curve. For this reason, we conduct the analysis of the offshore market on both the full sample and a restricted sample starting on 28 July 2011, but overall we deem the restricted sample to be more appropriate. Examples of zero-yield term structures are given in Figure 2.

All macroeconomic variables are stated on a year-on-year growth basis, except for the policy rate, which enters with its absolute percentage rate, and the liquidity variable, which is stated on a quarter-on-quarter growth basis. The latter is due to the fact that this is a purely market-driven variable in a yet immature and fast changing market so that year-on-year data are subject to quite extreme changes. The policy rate and inflation expectations are adjusted on a non-regular basis, GDP is reported on quarterly basis and FX rate expectations are available on a daily basis. All other macroeconomic data are given on a monthly basis. Inflation

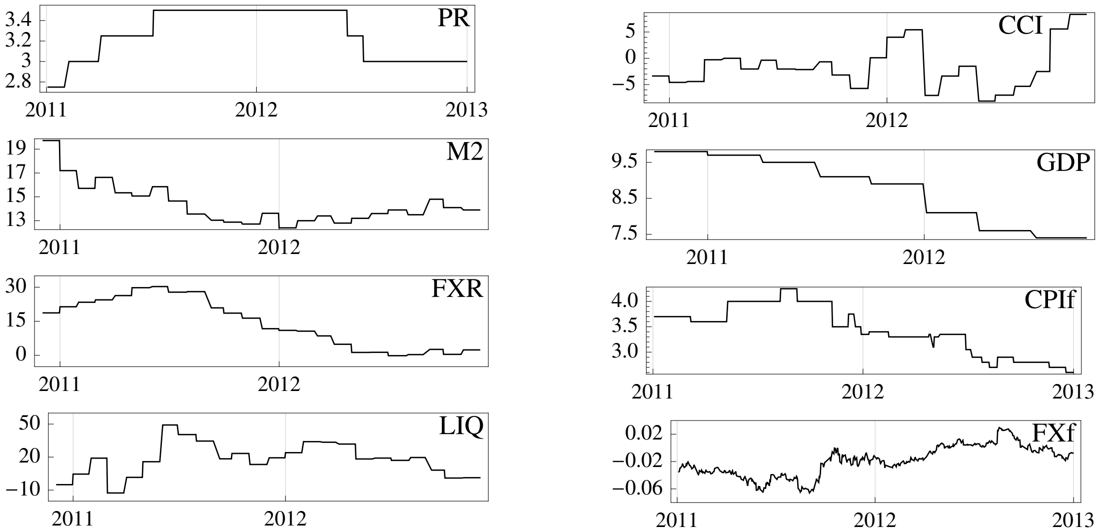

Figure 3: Macroeconomic data. Source: Bloomberg.

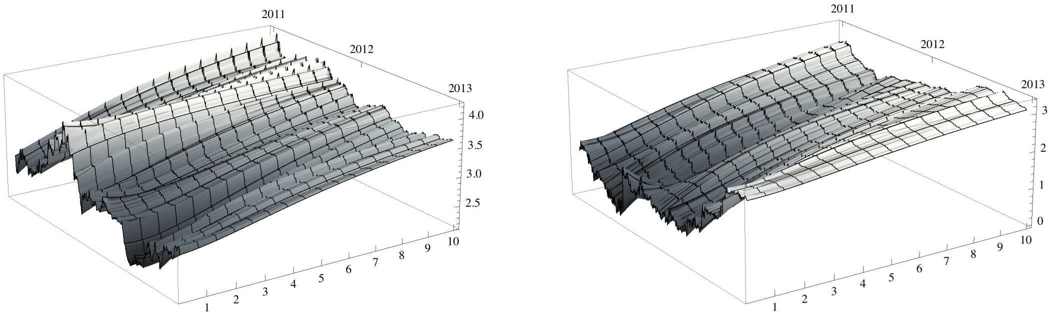

Figure 4: Fitted Nelson-Siegel term structures. Left: onshore; right: offshore.

expectations are given by a composite index derived from monthly and quarterly surveys conducted by Bloomberg (Bloomberg ticker: ECPICN12). Foreign exchange rate expectations are given by year-on-year changes in 12-month non-deliverable FX forward rates on the US Dollar (Bloomberg ticker: CCN+12M). The macroeconomic data are shown in Figure 3.

4 Results

Figure 4 shows the daily Nelson-Siegel fitted yield curves for 2011 and 2012, and Figure 5 shows the corresponding latent factors, cf. Equation (2).[7] Summary statistics for the onshore

[7]We determine λ as follows: first, we calibrate the latent factors in a non-linear least squares sense allowing for time-varying λ, but forcing the extremum of the yield curve to fall within 1.5 and 5 years of maturity. This corresponds to enforcing $\lambda_t \in [0.3587, 1.1955]$. The mean and standard deviation of the resulting λ factors are 0.4823 and 0.1729 for the onshore data and 0.4894 and 0.1801 for the offshore data. This corresponds to mean

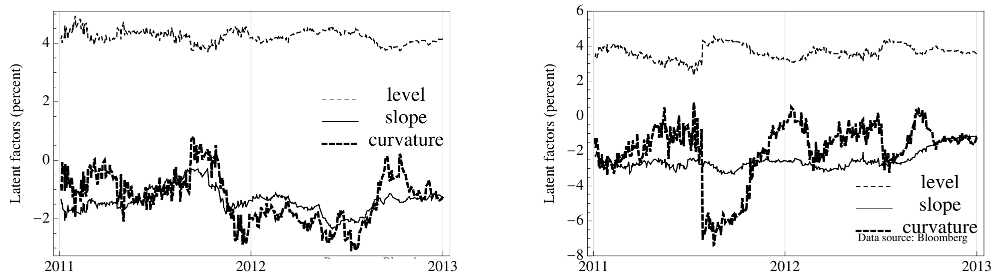

Figure 5: Latent factors of Nelson-Siegel term structures. Left: onshore; right: offshore.

Table 1: Summary statistics of latent factors

(a) Onshore latent factors, observations 1 Jan 2011 until 31 Dec 2012

Variable	Mean	Median	Min.	Max.	St.Dev.	Skew	Ex. kurt.	5% perc.	95% perc.	IQ R.
L_t	4.226	4.223	3.712	4.939	0.2117	−0.112	−0.226	3.847	4.534	0.299
S_t	−1.384	−1.400	−2.343	−0.290	0.428	0.334	0.312	−2.102	−0.533	0.403
C_t	−1.290	−1.247	−3.108	0.805	0.827	−0.004	−0.674	−2.710	0.046	1.256

(b) Offshore latent factors, observations 28 Jul 2011 until 31 Dec 2012

Variable	Mean	Median	Min.	Max.	St.Dev.	Skew	Ex. kurt.	5% perc.	95% perc.	IQ R.
L_t	4.185	4.188	3.712	4.565	0.210	−0.181	−0.812	3.828	4.499	0.312
S_t	−1.377	−1.346	−2.343	−0.290	0.471	0.267	−0.019	−2.175	−0.395	0.431
C_t	−1.450	−1.629	−3.108	0.805	0.885	0.359	−0.679	−2.778	0.114	1.329

and offshore yield curves are given in Table 1(a) and Table 1(b), respectively. Correlations among the latent factors are given in Table 2.

In the following analysis, all variables are demeaned. A summary of the results from VAR models for onshore and offshore yield curves including macroeconomic data is given in Table 3. We consider three different VAR models: a VAR model for the onshore yield curve, and two VAR models for the offshore yield curves, one for the full time horizon and one with the restricted time series. The macroeconomic data entering on each day are those *known* on that day.

The corresponding VAR models based only on the latent factors and excluding the macroeconomic variables produce relatively comparable results. The models themselves are not shown here, but can be easily recovered from Tables 6–8 for the onshore yield curve and from Tables 9–11 for the offshore yield curve: Since each row in a VAR model corresponds to a standard OLS regression, in each of the above-mentioned tables model (1) corresponds to a regression

humps at maturities 3.7182, resp. 3.6643 years. We choose as λ the average of the two mean λ factors, which is 0.48585.

Table 2: Correlation coefficients of latent factors; left: onshore, right: offshore

	L	S	C
L	1.0000	−0.4972	−0.6461
S		1.0000	0.6183
C			1.0000

	L	S	C
L	1.0000	−0.5681	−0.8376
S		1.0000	0.7644
C			1.0000

only on the latent factors excluding the macroeconomic data.

Overall, the results shown in Table 3 support the hypothesis that the onshore yield curve is primarily affected by policy-related variables, as both the policy rate and M2 money supply are significant for some latent factors, whereas both policy-related and non-policy-related variables affect the offshore yield curve, that is, are significant for some of the latent factors. In particular, when considering the results related to the restricted time series, Table 3(c), we observe that aside from the policy rate, liquidity has an effect on the yield curve's level, while the slope of the yield curve is predominantly influenced by non-policy-related variables. Detailed results and robustness tests are discussed in the following sections.

In each VAR model the number of lags of the latent factors is chosen according to the Akaike Information Criterion (AIC). This leads to lags of $3, 5$ and 10 days, respectively. The principal reason for allowing different time lag structures is to take care of any potential autocorrelation in the respective time series, while still allowing a high degree of parsimony. The results are robust with respect to a lag of 10 for each model.

Although in each equation of the VAR model, the Durbin-Watson test statistic is near 2, so that first-order autocorrelation in the residuals can be rejected, running Breusch-Godfrey tests are inconclusive about the presence of higher-order autocorrelation in the residuals, so that all results are derived with HAC-consistent standard errors.

4.1 Results for the onshore market

We discuss the results from the onshore market analysis in more detail. The optimal lag length both when excluding and when including the macroeconomic factors varies between 2 (BIC and HQC) and 3 (AIC), so we choose a lag length of 3. The autoregressive structure and the lag length are also supported by the autocorrelation and partial autocorrelation functions, where

Table 3: VAR models including macroeconomic data. Parameter estimates significant at the 5% level are bold. Parameter estimates: significant at the 10 per cent (*), 5 per cent (**), and 1 per cent (***) level. Robust errors (HAC).

(a) VAR for onshore yield curves including macroeconomic data; 3 lags; time horizon: 1 Jan 2011–31 Dec 2012. Excludes lags that are insignificant.

	L_{t-1}	L_{t-3}	S_{t-1}	C_{t-1}	PR_t	$M2_{t-1m.}$	$FXR_{t-1m.}$	$CCI_{t-1m.}$	$GDP_{t-3m.}$	$CPIE_t$	FXE_t	LIQ_t	R^2
L_t	**0.495*****	0.316	0.107	−0.001	**0.105****	**0.017****	0.001	0.001	−0.010	0.027	−0.252	0.000	0.79
	(0.190)	(0.204)	(0.103)	(0.057)	(0.043)	(0.007)	(0.002)	(0.001)	(0.017)	(0.031)	(0.356)	(0.005)	
S_t	**0.537*****	**−0.330****	**0.951*****	0.051	−0.060*	−0.010*	0.002	−0.001	−0.012	−0.030	−0.123	0.000	0.96
	(0.194)	(0.153)	(0.103)	(0.529)	(0.035)	(0.006)	(0.002)	(0.001)	(0.014)	(0.029)	(0.331)	(0.000)	
C_t	0.343	−0.690	−0.450	**0.810***)**	**−0.301*****	−0.021	0.0003	−0.002	0.018	−0.022	0.827	0.000	0.91
	(0.534)	(0.527)	(0.291)	(0.158)	(0.110)	(0.017)	(0.005)	(0.003)	(0.039)	(0.082)	(0.962)	(0.001)	

(b) VAR for offshore yield curves including onshore macroeconomic data; 5 lags; time horizon: 1 Jan 2011–31 Dec 2012.

	lags not shown	PR_t	$M2_{t-1m.}$	$FXR_{t-1m.}$	$CCI_{t-1m.}$	$GDP_{t-3m.}$	$CPIE_t$	FXE_t	LIQ_t	R^2
L_t		−0.0765	0.01	−0.0062*	−0.0004	0.0263	−0.0106	**−1.166****	**0.0022****	0.91
		(0.0751)	(0.0101)	(0.0037)	(0.0017)	(0.0304)	(0.0420)	(0.487)	(0.0009)	
S_t		0.0312	0.0013	**0.0097*****	0.0021	**−0.0915*****	0.0027	**1.477*****	−0.0009	0.96
		(0.0067)	(0.0070)	(0.0022)	(0.0013)	(0.0244)	(0.0343)	(0.337)	(0.0006)	
C_t		0.344	−0.0320	0.0029	−0.0085	0.0344	−0.0274	4.0759	**−0.0092*****	0.92
		(0.249)	(0.0377)	(0.137)	(0.007)	(0.111)	(0.155)	(2.082)	(0.0034)	

(c) VAR for offshore yield curves based on onshore macroeconomic data; 10 lags; time horizon: 28 July 2011–31 Dec 2012. Coefficients for lags shown in model (2) of Tables 9–11.

	lags not shown	PR_t	$M2_{t-1m.}$	$FXR_{t-1m.}$	$CCI_{t-1m.}$	$GDP_{t-3m.}$	$CPIE_t$	FXE_t	LIQ_t	R^2
L_t		**−0.339*****	−0.0092	0.0051	0.0032	−0.0963	−0.0588	−0.186	**0.0041*****	0.93
		(0.125)	(0.0135)	(0.0067)	(0.0025)	(0.0607)	(0.0486)	(1.029)	(0.0014)	
S_t		−0.0370	0.0005	**0.0184*****	**0.0053*****	**−0.166*****	0.0613*	**2.574*****	−0.0006	0.98
		(0.0678)	(0.0094)	(0.0039)	(0.0015)	(0.0395)	(0.0314)	(0.662)	(0.0009)	
C_t		**1.390*****	0.0379	**−0.0548****	**−0.0261****	**0.652*****	0.0641	−1.731	**−0.0167*****	0.96
		(0.483)	(0.0533)	(0.0259)	(0.0105)	(0.241)	(0.184)	(4.535)	(0.0062)	

the former is infinite in extent, but tails off, and the latter is (close to) zero for lags greater than 3 for all latent factors.

Table 3(a) indicates that there is significant autocorrelation in each of the factors, and in addition, the level factor is significant for the slope factor. As to the macroeconomic data, it turns out that both the policy rate and money supply are significant for the yield curve structure, while none of the other variables are significant. Of the non-policy-related data, the lowest p-value is 0.2159 (CCI for the level factor).

To ascertain the robustness of these results, observe first the null hypothesis that the autocorrelation of the residuals is zero cannot be rejected at the 5% significance level (p-values of Ljung-Box test with lag 10 are 0.215, 0.101, 0.321 for level, slope and curvature, respectively).

Since the model is subject to high multicollinearity, we test the robustness of the results by omitting variables step-by-step with either a high variance inflation factor or a high p-value. The corresponding results of the regressions on the level factor are shown in Table 6. Here, model (2) corresponds to the results of the level factor in the VAR model. For model (8) all variance inflation factors are smaller than 10, suggesting that multicollinearity is not an issue. In models (4)–(8), FXR is in addition significant at the 10% level, which may point to inflated standard errors due to multicollinearity in models (1)–(3). The Ljung-Box test with a lag of 10 for model (8) yields a p-value of 0.178 indicating that the null hypothesis of no autocorrelation cannot be rejected. Finally, the null hypothesis that all coefficients corresponding to macro-related data are zero produces an F-statistic with p-value 0.0028, so that this can be rejected at the 1% level.

For the slope factor, the regression results when omitting variables are shown in Table 7. Model (2) corresponds to the results for the slope factor in the VAR model. For model (9), variance inflation factors for the lags of the slope are greater than 10. In model (9), M2 is in addition significant at the 5% level. The Ljung-Box test with a lag of 10 for model (9) yields a p-value of 0.167, and finally, the F-statistic associated with the null hypothesis that all coefficients of the macro-related variables are zero has a p-value 0.1726, so that the null hypothesis cannot be rejected.

For the curvature factor, detailed regression results are given in Table 8. As usual, model (2) corresponds to the results for the curvature factor in the VAR model. For model (8), variance inflation factors for the lags of the curvature factor remain high, but are sufficiently small (2.2 and below) for the macroeconomic data. The significance of the policy rate is consistent throughout, and the corresponding coefficient is relatively robust against different model specifications. The FXR factor is significant at the 5% level in models (4)–(8), which may again point to multicollinearity issues in models (1)-(3). In addition, the liquidity factor is significant at the 5% level for model (8); its magnitude is roughly 10 times smaller than what we observe for the offshore curvature factor, though. The Ljung-Box test with a lag of 10 for model (5) yields a p-value of 0.259, and finally the null hypothesis that all coefficients related to the macro variables are zero can be rejected at the 5% level (F-statistic has p-value of 0.01626).

Summing up, there is evidence that policy-related variables affect the onshore yield curve, whereas non-policy-related variables have no effect.

4.2 Results for the offshore market

4.2.1 Full data set

The optimal lag length for the offshore market is between 2 (BIC, HQC) and 5 (AIC), so we choose a lag length of 5. The results of the VAR model are given in Table 3(b). Again, there is significant autocorrelation in each of the latent factors. As to the macroeconomic data, FX rate expectations and FX reserves as well as GDP are significant for the slope factor, while none of the policy-related variables are significant for the other latent factors. The Ljung-Box (lag 10) p-values for the latent factors are 0.948, 0.945 and 0.972 and thus do not allow to reject the null hypothesis of no autocorrelation in the residuals.

As the model is again subject to multicollinearity issues, we have checked the robustness of the results by omitting certain variables. There is only slight variation in the significance of the variables, permitting the conclusion that the VAR results are indeed robust. More detailed results are available on request.

4.2.2 Restricted data set

The optimal lag length is between 2 (BIC, HQC) and 10 (AIC), so we choose a lag length of 10. The results of the VAR model are given in Table 3(c). There is significant autocorrelation in each of the latent factors, which are not shown in the table due to space restrictions. The interested reader is referred to model (2) in each of Tables 9–11. As to the macroeconomic data, the policy rate, foreign exchange reserves, consumer confidence, GDP, FX rate expectations and the liquidity proxy are significant at the 5% level. In other words, both policy-related and non-policy-related variables appear as determinants for the offshore yield curve.

The Ljung-Box (lag 10) p-values for the latent factors are 0.796, 0.587 and 0.566, respectively, implying that the null hypothesis of no autocorrelation in the residuals cannot be rejected.

As before, we check the robustness of the results to resolve potential multicollinearity issues. The results for the level factor are given in Table 9. Model (2) corresponds to the results for the level factor in the VAR model. In model (6), variance inflation factors are large (greater than 10) for lags of the level variable as well as for the policy rate. Both the policy rate and the liquidity proxy are significant throughout, and it turns out that GDP is significant at the 5% level when FXR is removed. The Ljung-Box test (lag length 10) on the residuals of model (9) has a p-value of 0.815 so that the hypothesis of no autocorrelation in the residuals cannot be rejected. The null hypothesis that all coefficients corresponding to macro-related data are zero produces an F-statistic with p-value 0.0051.

For the slope factor, the regression results are shown in Table 10, with model (2) corresponding to the VAR model. In model (7) all variance inflation factors remain high for the lags of the slope factor as well as PR, FXR and GDP. The significance results and coefficients from the VAR model are robust, and in addition, the policy rate becomes significant as insignificant lags and macro-economic variables are removed from the model. The Ljung-Box test with a lag of 10 for model (7) yields a p-value of 0.722 and, finally, the F-statistic associated with the null hypothesis that all coefficients related to macroeconomic variables are zero has a p-value of $5.9236 \cdot 10^{-5}$, so the hypothesis can be rejected.

For the curvature factor, detailed regression results are given in Table 11. For model (8), variance inflation factors are greater than 10 for lags of the latent factors and for the policy rate and GDP, both of which are significant. Both, the policy rate and the liquidity proxy are significant throughout with little variation in the magnitude of the coefficients. GDP is significant throughout, but the magnitude of the coefficient varies as variables are omitted. The Ljung-Box test (lag 10) for model (8) has a p-value of 0.488 and the F-statistic to test whether macroeconomic variables are significant has a p-value of 0.0024, so that the null hypothesis of zero coefficients can be rejected.

Overall, we can conclude that policy-related as well as non-policy-related variables and the

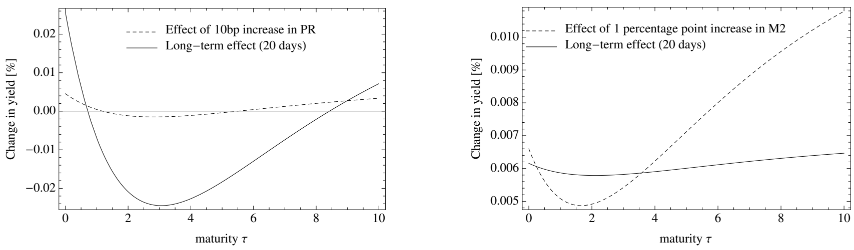

Figure 6: Change in the yield curve when the policy rate increases by 10bp (left) and when M2 money supply increases by one percentage point.

liquidity proxy are determinants of the yield curve.

4.3 Sensitivities of yield curve and impulse responses

In this section we study the effects of shocks to the macroeconomic variables on the yield curve and the latent factors. First, we consider the sensitivities of the yield curve. More specifically, we are interested in the instantaneous effect of a shock and in the long-term effect (20 days, i.e., approximately one month of trading days) of a persistent shock in the macroeconomic variables on the yield curve. Here, we consider only those macroeconomic variables that are significant for at least one latent factor. The principal idea behind analysing the long-term effect (20 trading days) is to take into account that the analysis is based on daily data and that a shock in a macroeconomic variable may not manifest itself instantaneously.

Second, we study impulse responses of shocks on the macroeconomic variables.

4.3.1 Sensitivities of yield curves

Figure 6 shows the instantaneous and long-term changes in the onshore yield curve when a (persistent) shock on the policy rate, resp. on M2 money supply occurs (both of these variables are significant for at least one factor). Overall the expected effect of an increase in the policy rate is positive on the short and the long end of the yield curve and more pronounced after 20 days, while the effect of M2 is positive for the whole term structure and more even across maturities after 20 days.

The overall effects of a macroeconomic variable on the offshore term structure are shown

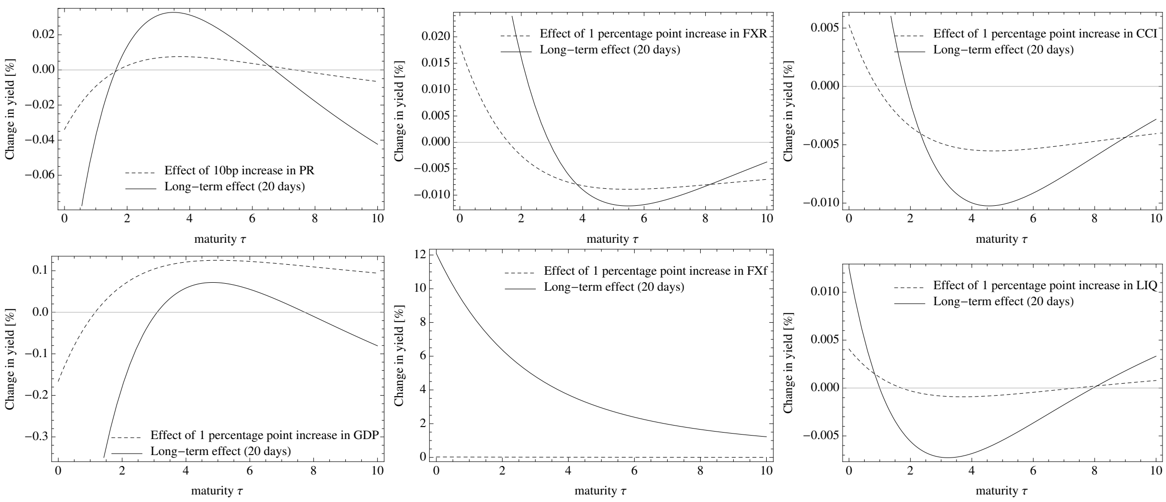

Figure 7: Change in the term structure when a particular macroeconomic variable is changed.

in Figure 7. The effect of an increase in the policy rate is two-fold: for maturities at the short end and the long end (smaller than 1.8 and greater than 6.6 years) the respective zero yields decrease, whereas they increase for maturities in-between. This is just opposite to the effect on the onshore yield curve. Again, the effect is more pronounced for a persistent long-term shock. An interpretation is somewhat difficult; this may be associated with the small number of 5 actual changes in the policy rate during the observation period. For FX reserves, the overall effect is an increase for small to mid-term maturities and a decrease in the yield for longer maturities. An increase in the yield is in-line with theoretical expectations following increasing FX reserves. An increase in CCI implies a decrease in the whole yield curve term structure, except for the short term, whereas an increase in GDP on the other hand implies an increase in the term structure (except for maturities smaller than 1 year). FX rate expectations have an overall positive effect on the term structure. These effects are consistent with expected behaviour. Finally, the effect of an increase in the liquidity proxy (quarter-on-quarter percentage changes) is positive for short-term and long-term maturities, and negative in-between. Here, one would expect a predominantly positive effect, since an increase in the outstanding amount of bonds per unit of deposits would decrease bond prices.

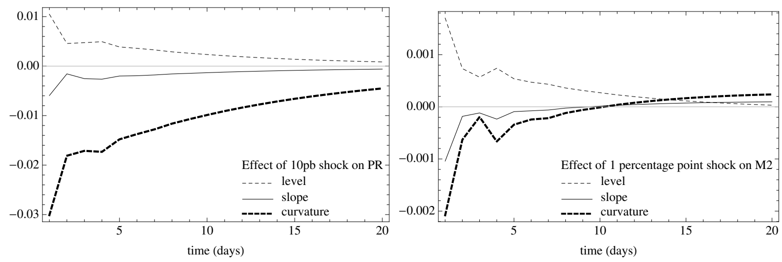

Figure 8: Effect of a shock on day 0 on policy rate, resp. M2 for the next 20 days.

4.3.2 Impulse responses

Next, we study the propagation on the latent factors through time when applying a (non-persistent) shock to individual macroeconomic factors. As the macroeconomic variables are exogenous variables, the analysis ignores effects from a shock on the macroeconomic variables themselves and the ensuing propagation through the system. However, as the macroeconomic data are monthly or quarterly data and the impulse responses are based on 20 days, one would expect no or little effect over this time horizon, anyway.

The impulse responses on the latent factors over 20 days are shown in Figure 8 for the onshore market and in Figure 9 for the offshore market.

In all cases, the impulse responses on the yield curve, that is, when further translated from the latent factors to the yield curve, can be summarized as follows: the shock manifests itself initially as in the instantaneous sensitivities studies in the previous subsection and then dies down over the time period of 20 days.

4.4 Spillover effects

Finally, to study spillover effects between the onshore and the offshore markets, we consider a VAR model of lag length 3 involving both the onshore and offshore latent factors. We test for Granger causality and examine the associated impulse responses and variance decompositions. The VAR results involving both yield curves are shown in Table 4. Here, we consider a VAR that excludes the macroeconomic variables, although including the macroeconomic variables does not change the implications of the results. The table is partitioned into four quadrants.

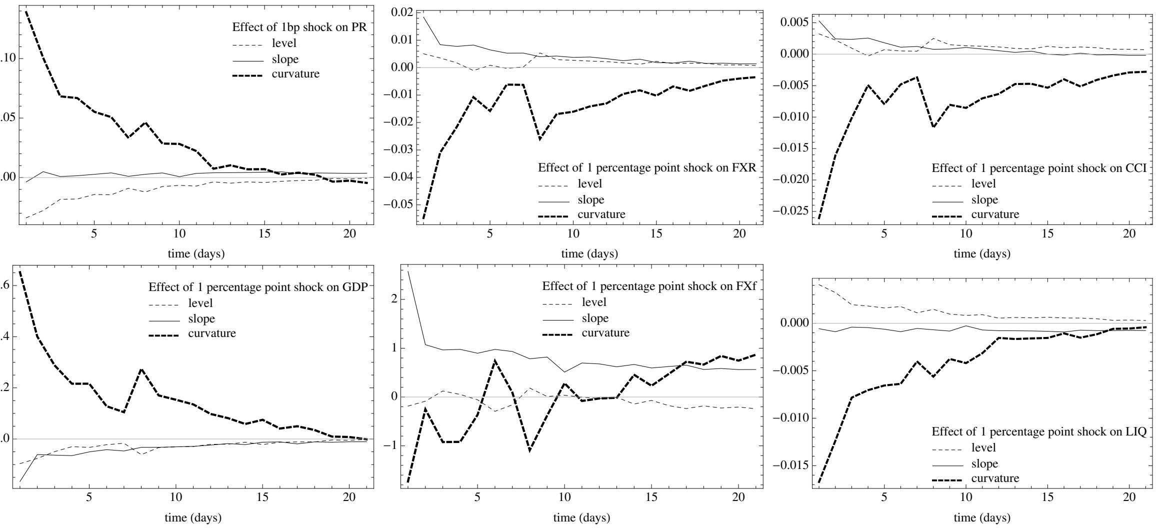

Figure 9: Effect of a shock on day 0 on various macroeconomic factors for the next 20 days.

The top-left and bottom-right quadrants show the effects of the onshore curve on itself and the offshore curve on itself, respectively. The top-right and bottom-left quadrant point to potential spillover effects. Judging from the number of significant variables, we observe that the onshore curve has a stronger effect on the offshore curve than vice versa. However, none of the two cases can be interpreted as evidence for spillover effects, in particular, when one takes into account that the effects of the onshore level variables on the offshore slope factor net each other.

Table 5 shows the p-values of F-tests where the lags of particular latent factors are collectively omitted. Evidence for Granger causality is given if both the standalone coefficients of a particular latent factor are significant and the F test indicates an overall significance of the latent factor's lags. At the 5% significance level one would therefore conclude that L_h and C_h Granger cause C_y and that C_y Granger causes S_h (at the 1% significance level L_h Granger causes C_y). One would interpret this as the offshore level and curvature helping to predict the onshore curvature, and as the onshore curvature helping to predict the offshore slope.

Figure 10 shows the impulse responses when shocks of one standard deviation are applied to the onshore latent factors. For the impulse responses, the residuals have been orthogonalized using the Cholesky transform, where the first two factors are the onshore and offshore level factors, next are the onshore and offshore slope factors and last are the onshore and offshore

Table 4: VAR involving both yield curves, observations 28 July 2011 until 31 Dec 2012; Variables with index y refer to the onshore yield curve (CNY) whereas variables with index h refer to the offshore yield curve (CNH). Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level

	$L_{y,t}$	$S_{y,t}$	$C_{y,t}$	$L_{h,t}$	$S_{h,t}$	$C_{h,t}$
$L_{y,t-1}$	0.0346	**1.02*****	**2.02*****	0.191	0.0367	−0.988
	(0.195)	(0.181)	(0.555)	(0.261)	(0.161)	(1.16)
$L_{y,t-2}$	0.455	**−0.721*****	−0.448	0.11	**−0.402****	−0.0596
	(0.322)	(0.265)	(0.904)	(0.294)	(0.201)	(1.28)
$L_{y,t-3}$	0.287	−0.155	**−1.07***	−0.259	**0.445****	0.594
	(0.213)	(0.162)	(0.569)	(0.203)	(0.185)	(0.841)
$S_{y,t-1}$	−0.128	**1.20*****	0.256	0.12	−0.104	−0.423
	(0.0921)	(0.09)	(0.282)	(0.107)	(0.0856)	(0.443)
$S_{y,t-2}$	0.102	−0.173	−0.0552	−0.165	−0.0286	0.607
	(0.177)	(0.133)	(0.524)	(0.161)	(0.12)	(0.689)
$S_{y,t-3}$	−0.0694	−0.00229	0.0751	0.087	**0.161***	−0.451
	(0.119)	(0.0857)	(0.336)	(0.117)	(0.0957)	(0.508)
$C_{y,t-1}$	**−0.149*****	**0.202*****	**1.29*****	−0.00696	0.0452	−0.0978
	(0.0533)	(0.0453)	(0.158)	(0.074)	(0.049)	(0.306)
$C_{y,t-2}$	0.0638	**−0.142***	0.00902	0.128	**−0.141****	−0.367
	(0.0867)	(0.074)	(0.24)	(0.0845)	(0.0585)	(0.352)
$C_{y,t-3}$	0.078	−0.0453	**−0.306****	**−0.131****	**0.127****	**0.435****
	(0.0539)	(0.0459)	(0.144)	(0.0576)	(0.0525)	(0.213)
$L_{h,t-1}$	**−0.316***	−0.0302	**0.920*****	**0.926****	−0.398	0.195
	(0.175)	(0.148)	(0.457)	(0.309)	(0.273)	(1.16)
$L_{h,t-2}$	0.242	−0.0877	−0.504	0.342	0.404	−1.33
	(0.238)	(0.174)	(0.698)	(0.448)	(0.407)	(1.89)
$L_{h,t-3}$	−0.0354	0.188	−0.118	−0.309	0.108	1.09
	(0.218)	(0.176)	(0.595)	(0.294)	(0.217)	(1.2)
$S_{h,t-1}$	−0.103	−0.00184	0.197	0.0434	**0.449*****	0.409
	(0.0901)	(0.0726)	(0.228)	(0.186)	(0.122)	(0.695)
$S_{h,t-2}$	0.0511	−0.0595	0.0319	0.129	**0.343***	−0.799
	(0.107)	(0.0832)	(0.291)	(0.245)	(0.174)	(1.02)
$S_{h,t-3}$	0.0483	0.0662	−0.223	−0.169	**0.192***	0.387
	(0.0854)	(0.0754)	(0.235)	(0.143)	(0.11)	(0.572)
$C_{h,t-1}$	**−0.0772***	−0.00862	**0.235****	0.0047	−0.0681	**0.905****
	(0.0451)	(0.0382)	(0.113)	(0.0935)	(0.0635)	(0.373)
$C_{h,t-2}$	0.0648	−0.0384	−0.128	0.113	0.0582	−0.395
	(0.0636)	(0.0471)	(0.182)	(0.132)	(0.0935)	(0.564)
$C_{h,t-3}$	−0.0168	0.0627	−0.0287	**−0.116***	0.041	0.416
	(0.0572)	(0.0457)	(0.155)	(0.07)	(0.0483)	(0.286)
R^2	0.88	0.98	0.94	0.91	0.98	0.95

curvature factors. The top three rows show the impulse responses of the onshore curve's latent factors, while the three lower rows show the impulse responses of the offshore curve's latent factors. Overall, the effects on the offshore latent factors are smaller than the effects on the onshore latent factors. More specifically, shocking the level or slope factors has virtually no effect on the offshore latent factors, especially when compared to the responses of the respective onshore factors. When shocking the curvature factor, we observe a similar effect and in addi-

Table 5: Granger-causality test, observations 28 July 2011 until 31 Dec 2012. Table shows p-values from F-test when omitting lags of independent variable. The hypothesis that x Granger causes y is accepted if there are lags of x that are significant for y in the VAR model and if the null hypothesis of the F-test (all coefficients of lags of x are zero) is rejected.

	Dependent variable					
	L_y	S_y	C_y	L_h	S_h	C_h
L_y	0.000	0.000	0.000	0.454	0.077	0.471
S_y	0.000	0.000	0.002	0.656	0.135	0.484
C_y	0.004	0.000	0.000	0.156	0.002	0.162
L_h	0.002	0.059	0.006	0.000	0.003	0.840
S_h	0.693	0.618	0.722	0.656	0.000	0.887
C_h	0.005	0.120	0.012	0.414	0.005	0.005

tion we observe that the offshore impulse responses are subject to a much greater 90 percent confidence band than the onshore impulse responses, which indicates not only a smaller effect, but also a higher uncertainty. The impulse response on S_h of a shock on C_y, for which there is evidence of Granger causality, shows a positive effect on S_h, which implies a flattening of a normal yield curve or a stronger inversion of an inverted yield curve, cf. Figure 1. Other than that, the impulse responses provide little or no evidence of a spillover effect from the onshore to the offshore curve.

The corresponding impulse responses when the offshore latent factors are shocked are shown in Figure 11. The situation here is similar: first, impulse responses of the onshore latent variables are close to 0 and where this is not the case, the respective confidence bands are typically larger, which points to uncertainty about the impulse response. Singling out the cases for which Granger causality holds, a shock on either L_h or C_h has a positive effect on C_y. Other than that, the impulse responses provide little evidence of a spillover effect from the offshore curve to the onshore curve.

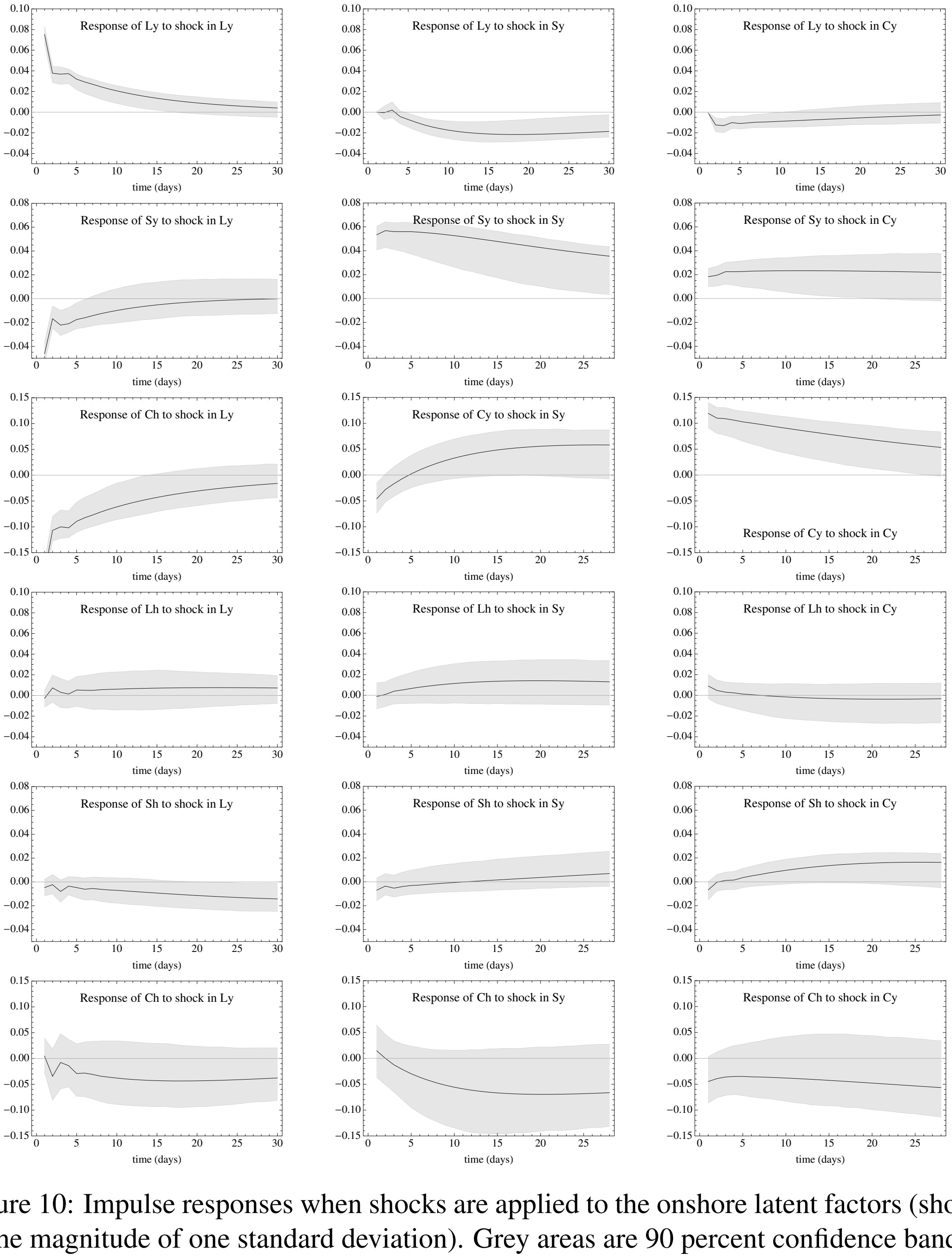

Figure 10: Impulse responses when shocks are applied to the onshore latent factors (shocks are of the magnitude of one standard deviation). Grey areas are 90 percent confidence bands.

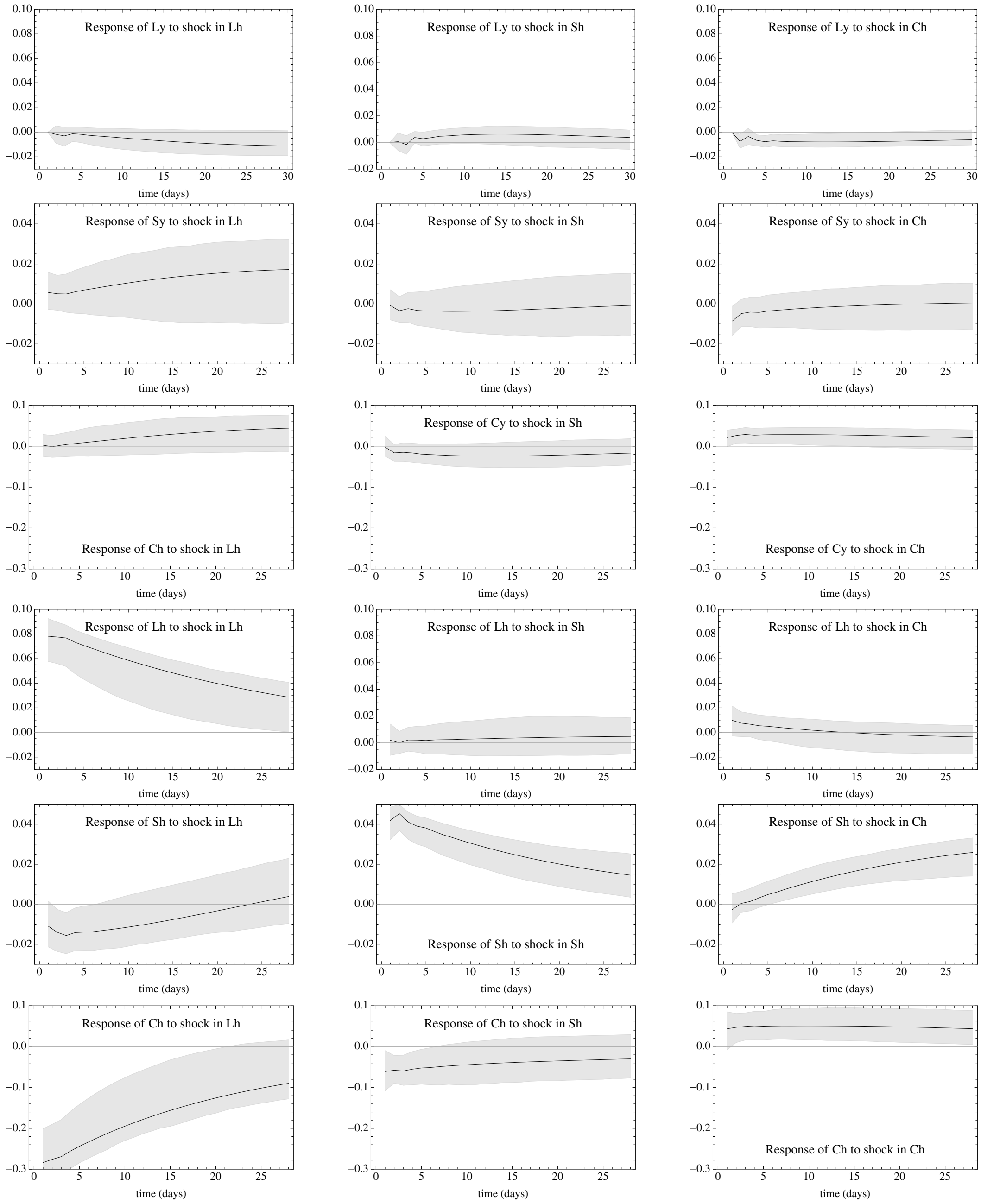

Figure 11: Impulse responses when shocks are applied to the offshore latent factors (shocks are of the magnitude of one standard deviation). Grey areas are 90 percent confidence bands.

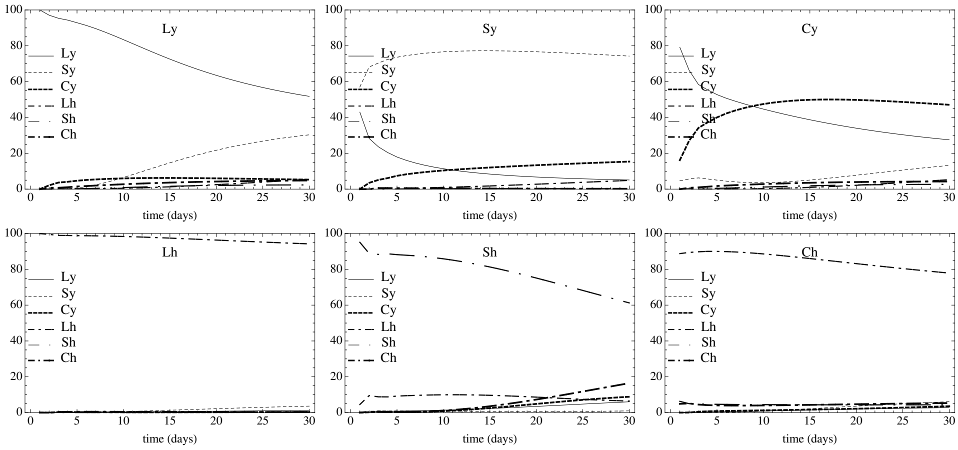

Figure 12: Forecast error variance decompositions, expressed in percentage points, for 30 days.

Finally, Figure 12 provides variance decompositions of the forecasts. More precisely, each graph shows the percentage amount of variance of each forecast error contributed by a shock to the various latent factors. Again, there is little evidence that the error variance contribution of any latent factors is driven by latent factors from the other respective market.

Overall, we find little evidence for spillover effects. At the 5% significance level we find some evidence for Granger causality between onshore and offshore latent factors, which is substantiated at the 1% level only as L_h Granger causing C_y. More specifically, a positive shock to the level of the offshore curve predicts a higher curvature in the onshore curve, which essentially corresponds to an increase in mid-term yields.

5 Conclusion

One of the most interesting aspects within China's efforts to internationalize its currency is the necessity to simultaneously liberalize its financial system. By comparing the RMB-denominated government offshore yield curve in Hong Kong to its onshore counterpart in a VAR framework involving macroeconomic data, we find that the offshore curve indeed proves to be more market-driven and does not adhere solely to policy-related factors as is the case for its onshore counterpart. In a further step, we verify that at this stage of market development there are virtually no spillover effects between the two curves.

The model framework introduced in this paper can be used as a starting point for future research to track market developments, in particular as the offshore market develops rapidly both in terms of volume and the number of alternative trading hubs. An interesting question, for instance, that necessarily arises is that of potential arbitrage between the offshore and the onshore curve under the condition that China further opens its capital account. This increases the likelihood that market forces will exert an ever stronger influence on the onshore yield curve as well. Furthermore, with the RMB exchange rate becoming more flexible, one would expect appreciation expectations to lose their importance in shaping the offshore yield curve. Finally, isolating the key determinants, our approach lays the foundations for developing models for forecasting the structure of the offshore RMB-denominated government bond yield curve as the market matures.

A Detailed results

A.1 Onshore market

Table 6: Regression results for dependent variable L_t (onshore). Presentation excludes insignificant latent factors. (2) contains all lags of latent factors, whereas (3) excludes lags for slope and curvature that are not significant. Sample size: 470. Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L_{t-1}	0.587***	0.495***	0.452***	0.453***	0.454***	0.456***	0.458***	0.458***
	(0.183)	(0.190)	(0.0677)	(0.0677)	(0.0675)	(0.0672)	(0.0671)	(0.0670)
L_{t-2}	−0.0369	−0.0580	0.247***	0.247***	0.248***	0.249***	0.250***	0.250***
	(0.288)	(0.280)	(0.0711)	(0.0711)	(0.0714)	(0.0718)	(0.0717)	(0.0718)
L_{t-3}	0.376*	0.316	0.188***	0.188***	0.189***	0.192***	0.192***	0.192***
	(0.205)	(0.204)	(0.0577)	(0.0577)	(0.0577)	(0.0574)	(0.0575)	(0.0573)
PR_t		0.105**	0.105**	0.108***	0.106***	0.116***	0.0987***	0.0984***
		(0.0429)	(0.0423)	(0.0391)	(0.0396)	(0.0397)	(0.0321)	(0.0325)
$\mathrm{M2}_{t-1m.}$		0.0170**	0.0159**	0.0160**	0.0160**	0.0175**	0.0177***	0.0177**
		(0.00685)	(0.00646)	(0.00655)	(0.00649)	(0.00683)	(0.00683)	(0.00690)
$\mathrm{FXR}_{t-1m.}$		0.000475	−0.00310*	−0.00296**	−0.00254**	−0.00149**	−0.00149**	−0.00149**
		(0.00226)	(0.00162)	(0.00137)	(0.00120)	(0.000727)	(0.000728)	(0.000731)
$\mathrm{CCI}_{t-1m.}$		0.00140	−0.000568	−0.000631	−0.000353	−0.000430	−4.14e-05	
		(0.00113)	(0.000949)	(0.000878)	(0.000919)	(0.000924)	(0.000814)	
$\mathrm{GDP}_{t-3m.}$		−0.0104	0.0158	0.0166	0.0160			
		(0.0168)	(0.0127)	(0.0122)	(0.0122)			
CPIE_t		0.0268	0.00577					
		(0.0306)	(0.0291)					
FXE_t		−0.252	−0.192	−0.191				
		(0.356)	(0.359)	(0.358)				
LIQ_t		0.000193	−0.000343	−0.000335	−0.000331	−0.000444		
		(0.000479)	(0.000413)	(0.000423)	(0.000427)	(0.000430)		
Adj. R^2	0.781	0.786	0.781	0.781	0.782	0.782	0.782	0.782

Table 7: Regression results for dependent variable S_t (onshore). Presentation excludes insignificant latent factors. (2) contains all lags of latent factors, whereas (3) excludes lags for level and curvature that are not significant. Sample size: 470. Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
L_{t-1}	0.505^{***}	0.537^{***}	0.307^{***}	0.313^{***}	0.313^{***}	0.313^{***}	0.313^{***}	0.318^{***}	0.318^{***}
	(0.195)	(0.194)	(0.0575)	(0.0578)	(0.0579)	(0.0580)	(0.0580)	(0.0584)	(0.0587)
L_{t-3}	-0.373^{**}	-0.330^{**}	-0.192^{***}	-0.191^{***}	-0.191^{***}	-0.194^{***}	-0.193^{***}	-0.191^{***}	-0.190^{***}
	(0.151)	(0.153)	(0.0575)	(0.0571)	(0.0571)	(0.0565)	(0.0563)	(0.0556)	(0.0555)
C_{t-3}	-0.0851^{*}	-0.0806^{*}							
	(0.0450)	(0.0437)							
S_{t-1}	0.963^{***}	0.951^{***}	0.817^{***}	0.825^{***}	0.825^{***}	0.826^{***}	0.826^{***}	0.831^{***}	0.832^{***}
	(0.105)	(0.103)	(0.0584)	(0.0587)	(0.0585)	(0.0589)	(0.0589)	(0.0611)	(0.0614)
S_{t-2}	0.131	0.125	0.279^{***}	0.280^{***}	0.280^{***}	0.280^{***}	0.280^{***}	0.279^{***}	0.279^{***}
	(0.149)	(0.148)	(0.0666)	(0.0669)	(0.0669)	(0.0670)	(0.0669)	(0.0671)	(0.0671)
PR_t		-0.0595^{*}	-0.0772^{**}	-0.0762^{**}	-0.0770^{**}	-0.0922^{***}	-0.0925^{***}	-0.0877^{***}	-0.0842^{***}
		(0.0350)	(0.0359)	(0.0362)	(0.0371)	(0.0316)	(0.0312)	(0.0292)	(0.0273)
$\mathrm{M2}_{t-1m.}$		-0.0104^{*}	-0.00814	-0.00730	-0.00749	-0.00918^{*}	-0.00913^{*}	-0.00814^{*}	-0.00847^{**}
		(0.00571)	(0.00528)	(0.00527)	(0.00534)	(0.00502)	(0.00498)	(0.00414)	(0.00415)
$\mathrm{FXR}_{t-1m.}$		0.00155	0.00199						
		(0.00178)	(0.00176)						
$\mathrm{CCI}_{t-1m.}$		-0.000499	-0.0001	-0.000445	-0.000450	-0.0001			
		(0.000979)	(0.00104)	(0.00102)	(0.00101)	(0.000893)			
$\mathrm{GDP}_{t-3m.}$		-0.0115	-0.0127	-0.00135					
		(0.0139)	(0.0138)	(0.0102)					
CPIE_t		-0.0295	-0.0213	-0.0109	-0.0127				
		(0.0291)	(0.0295)	(0.0264)	(0.0198)				
FXE_t		-0.123	-0.0897	-0.228	-0.219	-0.144	-0.141		
		(0.331)	(0.339)	(0.353)	(0.342)	(0.300)	(0.302)		
LIQ_t		0.0001	0.000184	0.000152	0.000160	0.000183	0.000193	0.000152	
		(0.000345)	(0.000346)	(0.000358)	(0.000371)	(0.000377)	(0.000347)	(0.000328)	
Adj. R^2	0.960	0.961	0.960	0.960	0.960	0.960	0.960	0.960	0.960

Table 8: Regression results for dependent variable C_t (onshore). Presentation excludes insignificant latent factors. (2) contains all lags of latent factors, whereas (3) excludes lags of level and slope that are not significant. Sample size: 470. Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L_{t-3}	-0.880^{*}	-0.690						
	(0.530)	(0.527)						
C_{t-1}	0.834^{***}	0.810^{***}	0.632^{***}	0.633^{***}	0.634^{***}	0.635^{***}	0.635^{***}	0.637^{***}
	(0.158)	(0.158)	(0.0670)	(0.0672)	(0.0667)	(0.0666)	(0.0668)	(0.0672)
C_{t-2}	0.286	0.282	0.197^{**}	0.197^{**}	0.197^{**}	0.199^{**}	0.200^{**}	0.200^{**}
	(0.233)	(0.228)	(0.0794)	(0.0795)	(0.0798)	(0.0798)	(0.0796)	(0.0798)
C_{t-3}	-0.171	-0.150	0.0979	0.0987	0.0997	0.101^{*}	0.101^{*}	0.104^{*}
	(0.157)	(0.154)	(0.0608)	(0.0606)	(0.0608)	(0.0608)	(0.0608)	(0.0604)
PR_t		-0.301^{***}	-0.294^{***}	-0.274^{***}	-0.264^{***}	-0.244^{**}	-0.168^{***}	-0.170^{***}
		(0.110)	(0.113)	(0.103)	(0.102)	(0.102)	(0.0651)	(0.0649)
$\text{M2}_{t-1m.}$		-0.0208	-0.0157	-0.0148	-0.0151	-0.0144		
		(0.0170)	(0.0156)	(0.0155)	(0.0152)	(0.0154)		
$\text{FXR}_{t-1m.}$		0.000257	0.00829^{*}	0.00906^{**}	0.00740^{**}	0.00728^{**}	0.00657^{**}	0.00252^{**}
		(0.00533)	(0.00438)	(0.00395)	(0.00334)	(0.00332)	(0.00306)	(0.00127)
$\text{CCI}_{t-1m.}$		-0.00192	0.00336	0.00288	0.00185			
		(0.00321)	(0.00267)	(0.00245)	(0.00245)			
$\text{GDP}_{t-3m.}$		0.0182	-0.0440	-0.0387	-0.0363	-0.0382	-0.0492	
		(0.0393)	(0.0336)	(0.0325)	(0.0321)	(0.0322)	(0.0337)	
CPIE_t		-0.0223	0.0369					
		(0.0824)	(0.0768)					
FXE_t		0.827	0.708	0.699				
		(0.962)	(0.972)	(0.976)				
LIQ_t		0.000125	0.00164^{*}	0.00169^{*}	0.00168^{*}	0.00147	0.00149	0.00185^{**}
		(0.00117)	(0.000983)	(0.00100)	(0.00100)	(0.000954)	(0.000956)	(0.000940)
Adj. R^2	0.904	0.905	0.900	0.900	0.900	0.901	0.901	0.901

A.2 Offshore market (restricted time horizon)

Table 9: Regression results for dependent variable L_t (offshore). Presentation excludes insignificant latent factors. (2) contains all lags of latent factors, whereas (3) excludes lags of slope and curvature that are not significant. Sample size: 339. Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
S_{t-4}	-0.366^{**}	-0.341^{**}	-0.0857^{**}	-0.0788^{*}	-0.0711^{*}	-0.0718^{*}	-0.0707^{*}	-0.0511	
	(0.180)	(0.161)	(0.0423)	(0.0413)	(0.0377)	(0.0377)	(0.0376)	(0.0322)	
C_{t-4}	-0.282^{**}	-0.282^{***}	-0.0833^{**}	-0.0910^{***}	-0.0768^{***}	-0.0763^{***}	-0.0700^{***}	-0.0660^{***}	-0.0426^{***}
	(0.111)	(0.104)	(0.0391)	(0.0347)	(0.0271)	(0.0260)	(0.0243)	(0.0236)	(0.0146)
L_{t-1}	1.01^{***}	1.07^{***}	0.822^{***}	0.828^{***}	0.831^{***}	0.832^{***}	0.834^{***}	0.838^{***}	0.849^{***}
	(0.304)	(0.264)	(0.0838)	(0.0932)	(0.0920)	(0.0933)	(0.0923)	(0.0928)	(0.0944)
L_{t-3}	0.671	0.580	0.225^{**}	0.226^{**}	0.227^{***}	0.226^{***}	0.230^{***}	0.231^{***}	0.236^{***}
	(0.457)	(0.420)	(0.0685)	(0.0679)	(0.0682)	(0.0675)	(0.0676)	(0.0672)	(0.0670)
L_{t-4}	-1.25^{***}	-1.26^{***}	-0.472^{**}	-0.500^{***}	-0.446^{***}	-0.443^{***}	-0.418^{***}	-0.398^{***}	-0.302^{**}
	(0.476)	(0.442)	(0.194)	(0.180)	(0.162)	(0.157)	(0.155)	(0.153)	(0.124)
L_{t-5}	0.519	0.552	0.189^{**}	0.191^{**}	0.192^{**}	0.192^{**}	0.192^{**}	0.194^{**}	0.194^{**}
	(0.386)	(0.365)	(0.0917)	(0.0936)	(0.0944)	(0.0956)	(0.0957)	(0.0962)	(0.0969)
L_{t-6}	-0.420	-0.451	-0.223^{***}	-0.225^{***}	-0.226^{***}	-0.225^{***}	-0.224^{***}	-0.224^{***}	-0.227^{***}
	(0.407)	(0.371)	(0.0827)	(0.0838)	(0.0842)	(0.0836)	(0.0843)	(0.0845)	(0.0865)
L_{t-7}	0.0716	0.0708	0.236^{***}	0.238^{***}	0.239^{***}	0.239^{***}	0.238^{***}	0.238^{***}	0.240^{***}
	(0.327)	(0.308)	(0.0859)	(0.0886)	(0.0884)	(0.0885)	(0.0887)	(0.0891)	(0.0896)
L_{t-8}	0.0804	0.0460	-0.230^{**}	-0.232^{**}	-0.231^{*}	-0.231^{*}	-0.230^{*}	-0.231^{*}	-0.230^{*}
	(0.370)	(0.346)	(0.114)	(0.117)	(0.118)	(0.118)	(0.118)	(0.119)	(0.120)
L_{t-9}	0.441	0.357	0.165^{*}	0.166^{*}	0.164^{*}	0.164^{*}	0.164^{*}	0.164^{*}	0.167^{*}
	(0.391)	(0.373)	(0.0903)	(0.0915)	(0.0918)	(0.0912)	(0.0913)	(0.0914)	(0.0927)
L_{t-10}	-0.297	-0.436^{*}	-0.0560	-0.0531	-0.0602	-0.0596	-0.0587	-0.0605	-0.0603
	(0.276)	(0.238)	(0.0509)	(0.0501)	(0.0502)	(0.0495)	(0.0502)	(0.0499)	(0.0500)
PR_t		-0.339^{***}	-0.357^{***}	-0.355^{***}	-0.365^{***}	-0.363^{***}	-0.293^{***}	-0.266^{***}	-0.220^{***}
		(0.125)	(0.136)	(0.136)	(0.135)	(0.132)	(0.0919)	(0.0829)	(0.0744)
$\mathrm{M2}_{t-1m.}$		-0.00917	-0.00849	-0.00672	-0.00903	-0.0102			
		(0.0135)	(0.0144)	(0.0146)	(0.0143)	(0.0119)			
$\mathrm{FXR}_{t-1m.}$		0.00505	0.00273						
		(0.00670)	(0.00663)						
$\mathrm{CCI}_{t-1m.}$		0.00322	0.00199	0.00122	0.00199	0.00187	0.00200		
		(0.00248)	(0.00259)	(0.00156)	(0.00157)	(0.00135)	(0.00141)		
$\mathrm{GDP}_{t-3m.}$		-0.0963	-0.0920	-0.0700^{**}	-0.0794^{**}	-0.0824^{**}	-0.0874^{**}	-0.0790^{**}	-0.0412^{**}
		(0.0607)	(0.0599)	(0.0325)	(0.0345)	(0.0359)	(0.0368)	(0.0356)	(0.0179)
CPIE_t		-0.0588	-0.0575	-0.0594					
		(0.0486)	(0.0499)	(0.0500)					
FXE_t		-0.186	0.313	0.190	0.139				
		(1.03)	(0.918)	(0.824)	(0.807)				
LIQ_t		0.00407^{***}	0.00382^{***}	0.00385^{***}	0.00387^{**}	0.00384^{***}	0.00354^{**}	0.00353^{**}	0.00441^{***}
		(0.00141)	(0.00144)	(0.00149)	(0.00151)	(0.00140)	(0.00138)	(0.00138)	(0.00144)
Adj. R^2	0.910	0.917	0.915	0.916	0.915	0.916	0.916	0.916	0.915

Table 10: Regression results for dependent variable S_t (offshore). Presentation excludes insignificant latent factors. (2) contains all lags of latent factors, whereas (3) excludes lags of level and curvature that are not significant. Sample size: 339. Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L_{t-1}	-0.553^{**}	-0.637^{**}	-0.0803^{***}	-0.0801^{***}	-0.0855^{***}	-0.0845^{***}	-0.0898^{***}
	(0.280)	(0.255)	(0.0260)	(0.0260)	(0.0242)	(0.0238)	(0.0213)
C_{t-1}	-0.106	-0.112^{*}					
	(0.0655)	(0.0573)					
C_{t-10}	0.0586	0.0932^{**}	0.00781	0.00595	0.00536	0.00511	
	(0.0401)	(0.0467)	(0.00533)	(0.00459)	(0.00448)	(0.00396)	
S_{t-1}	0.420^{***}	0.296^{**}	0.489^{***}	0.489^{***}	0.490^{***}	0.490^{***}	0.506^{***}
	(0.124)	(0.126)	(0.0755)	(0.0752)	(0.0753)	(0.0746)	(0.0729)
S_{t-2}	0.407^{**}	0.298^{**}	0.171^{**}	0.172^{**}	0.172^{**}	0.172^{**}	0.206^{**}
	(0.164)	(0.142)	(0.0771)	(0.0774)	(0.0774)	(0.0777)	(0.0828)
S_{t-3}	0.169	0.142	0.146^{**}	0.145^{**}	0.148^{**}	0.147^{**}	0.209^{***}
	(0.147)	(0.139)	(0.0687)	(0.0689)	(0.0699)	(0.0694)	(0.0581)
S_{t-9}	-0.201^{**}	-0.165^{*}	-0.0719	-0.0693	-0.0697	-0.0688	
	(0.0852)	(0.0841)	(0.0595)	(0.0593)	(0.0592)	(0.0597)	
S_{t-10}	0.120	0.187^{**}	0.0804^{*}	0.0804^{*}	0.0806^{*}	0.0819^{*}	
	(0.0770)	(0.0780)	(0.0465)	(0.0480)	(0.0482)	(0.0477)	
PR_t		-0.0370	-0.130	-0.108	-0.131^{**}	-0.121^{***}	-0.120^{***}
		(0.0678)	(0.0813)	(0.0769)	(0.0660)	(0.0429)	(0.0408)
$\mathrm{M2}_{t-1m.}$		0.000468	-0.00372	-0.00152	-0.00272		
		(0.00937)	(0.0115)	(0.0106)	(0.0102)		
$\mathrm{FXR}_{t-1m.}$		0.0184^{***}	0.0158^{***}	0.0161^{***}	0.0159^{***}	0.0156^{***}	0.0131^{***}
		(0.00387)	(0.00343)	(0.00341)	(0.00332)	(0.00294)	(0.00271)
$\mathrm{CCI}_{t-1m.}$		0.00528^{***}	0.00471^{***}	0.00428^{***}	0.00422^{***}	0.00424^{***}	0.00411^{***}
		(0.00152)	(0.00162)	(0.00151)	(0.00150)	(0.00152)	(0.00141)
$\mathrm{GDP}_{t-3m.}$		-0.166^{***}	-0.161^{***}	-0.153^{***}	-0.146^{***}	-0.144^{***}	-0.134^{***}
		(0.0395)	(0.0406)	(0.0395)	(0.0367)	(0.0345)	(0.0340)
CPIE_t		0.0613^{*}	0.0310				
		(0.0314)	(0.0276)				
FXE_t		2.57^{***}	2.41^{***}	2.42^{***}	2.47^{***}	2.54^{***}	1.92^{***}
		(0.662)	(0.491)	(0.498)	(0.515)	(0.512)	(0.416)
LIQ_t		-0.000571	-0.000592	-0.000573			
		(0.000927)	(0.000836)	(0.000855)			
Adj. R^2	0.981	0.983	0.981	0.981	0.981	0.981	0.981

Table 11: Regression results for dependent variable C_t (offshore). Presentation excludes insignificant latent factors. (2) contains all lags of latent factors, whereas (3) excludes lags of level and slope that are not significant. Sample size: 339. Standard errors in parentheses; (*) indicates significance at the 10 percent level; (**) indicates significance at the 5 percent level; (***) indicates significance at the 1 percent level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L_{t-3}	-2.80^{*}	-2.36						
	(1.69)	(1.53)						
L_{t-4}	4.53^{**}	4.43^{***}	1.48^{**}	1.45^{***}	1.37^{**}	1.66^{***}	1.63^{***}	1.51^{***}
	(1.83)	(1.58)	(0.625)	(0.542)	(0.544)	(0.641)	(0.567)	(0.530)
S_{t-4}	1.40^{**}	1.24^{**}	0.390^{**}	0.387^{**}	0.369^{**}	0.253^{*}	0.257^{*}	0.154
	(0.695)	(0.580)	(0.168)	(0.160)	(0.161)	(0.145)	(0.148)	(0.115)
C_{t-1}	0.907^{**}	0.618^{**}	0.730^{***}	0.730^{***}	0.733^{***}	0.768^{***}	0.768^{***}	0.775^{***}
	(0.354)	(0.275)	(0.0739)	(0.0739)	(0.0719)	(0.0941)	(0.0958)	(0.0961)
C_{t-3}	-0.499	-0.409	0.138^{**}	0.138^{**}	0.142^{**}	0.144^{**}	0.143^{**}	0.145^{**}
	(0.420)	(0.381)	(0.0645)	(0.0643)	(0.0641)	(0.0634)	(0.0629)	(0.0628)
C_{t-4}	1.06^{**}	1.03^{***}	0.353^{**}	0.346^{**}	0.327^{**}	0.397^{**}	0.389^{***}	0.362^{**}
	(0.435)	(0.384)	(0.165)	(0.143)	(0.144)	(0.161)	(0.150)	(0.144)
C_{t-6}	0.0548	0.0745	-0.119^{*}	-0.119^{*}	-0.119^{*}	-0.125^{*}	-0.124^{*}	-0.125^{*}
	(0.367)	(0.325)	(0.0623)	(0.0623)	(0.0627)	(0.0658)	(0.0648)	(0.0648)
C_{t-7}	0.483^{*}	0.424^{*}	0.203^{**}	0.203^{**}	0.203^{**}	0.215^{**}	0.215^{**}	0.216^{**}
	(0.268)	(0.254)	(0.0838)	(0.0835)	(0.0837)	(0.0901)	(0.0902)	(0.0909)
C_{t-9}	0.0532	0.119	0.148^{*}	0.148^{*}	0.149^{*}	0.155^{*}	0.155^{*}	0.154^{*}
	(0.366)	(0.344)	(0.0866)	(0.0860)	(0.0860)	(0.0919)	(0.0914)	(0.0921)
C_{t-10}	-0.113	0.0342	-0.101^{**}	-0.102^{***}	-0.101^{**}	-0.0891^{**}	-0.0882^{**}	-0.0905^{**}
	(0.268)	(0.226)	(0.0392)	(0.0391)	(0.0400)	(0.0375)	(0.0372)	(0.0370)
PR_t		1.39^{***}	1.54^{***}	1.55^{***}	1.31^{***}	1.38^{**}	1.32^{***}	1.17^{***}
		(0.483)	(0.546)	(0.551)	(0.503)	(0.565)	(0.430)	(0.383)
$\mathrm{M2}_{t-1m.}$		0.0379	0.0470	0.0486				
		(0.0533)	(0.0537)	(0.0523)				
$\mathrm{FXR}_{t-1m.}$		-0.0548^{**}	-0.0463^{*}	-0.0466^{*}	-0.0433^{*}			
		(0.0259)	(0.0268)	(0.0267)	(0.0261)			
$\mathrm{CCI}_{t-1m.}$		-0.0261^{**}	-0.0231^{**}	-0.0236^{**}	-0.0241^{**}	-0.0112	-0.0105^{*}	
		(0.0105)	(0.0112)	(0.0112)	(0.0111)	(0.00690)	(0.00610)	
$\mathrm{GDP}_{t-3m.}$		0.652^{***}	0.646^{**}	0.654^{**}	0.624^{**}	0.277^{**}	0.300^{**}	0.256^{**}
		(0.241)	(0.253)	(0.258)	(0.261)	(0.123)	(0.136)	(0.127)
CPIE_t		0.0641	0.0326					
		(0.184)	(0.179)					
FXE_t		-1.73	-2.51	-2.50	-3.43	-0.888		
		(4.53)	(4.08)	(4.09)	(3.81)	(3.00)		
LIQ_t		-0.0167^{***}	-0.0168^{**}	-0.0168^{**}	-0.0160^{**}	-0.0168^{**}	-0.0163^{**}	-0.0162^{**}
		(0.00621)	(0.00677)	(0.00679)	(0.00674)	(0.00738)	(0.00658)	(0.00667)
Ajd. R^2	0.949	0.955	0.954	0.954	0.954	0.953	0.953	0.953

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