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Historical Interest Rate Sensitivity of Emerging Market Sovereign Debt: Evidence of Regime Dependent Behavior

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Interest rate sensitivity of USD-denominated emerging market sovereign debt over 1997-2017 is studied through comparative price dynamics of emerging market sovereign bonds versus US governmental securities. The proposed methodology derives important insights for practical strategies of managing interest rate risk in the banking book. We find that the direct positive interest rate sensitivity under normal economic conditions is interchanged with the inverted negative sensitivity during distressed crisis-affected market turbulences. Due to the time-varying behavior of interest rate sensitivity, the hedging of interest rate risk must be a dynamic process linked to phases of the business cycle.

Key Words: Fixed Income; Portfolio Performance Evaluation; Downside Risk Management; Emerging Markets; Sovereign Debt; Interest Rate Sensitivity; Capital Gains.

JEL Classification Numbers: E43, G11, G12, G15, G20.

1. INTRODUCTION

Interest rate (IR) risk is the risk of negative effects on the financial results and capital of banks and financial institutions caused by changes in IRs. Thus, IR risk management represents one of the most critical components of the complex structure of financial management.

In contrast to the credit, foreign exchange, and operational risks, which are subject to strict prudential regulation within the Pillar I of the Basel III capital accord, a relatively low level of regulatory scrutiny in respect to

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the IR risk had resulted in a potential vulnerability of banks and financial institutions to adverse impacts of IR movements. Such vulnerability is related to the fact that a vast majority of the financial instruments are IR sensitive.

Tightening of the monetary policy by the US Federal Reserve System and raising IRs put a great pressure on the global financial system, as IRs movements potentially place significant strain on banks' profitability and capital adequacy levels. This challenge has stimulated much attention of financial sector players and academics to IR sensitivity of assets, IR risk and downside risk management.

A volume of recent scientific research addressing effects of IR changes on bank performance and solvency keeps growing. See, for example Berends et al (2013), Bessis (2015), Neal et al (2015), Aussenegg et al (2016), Dupoyet et al (2016), Gubareva and Borges (2016; 2017; 2018), Beutler et al (2017), Yasuoka, T. (2017), and references therein.

The regulatory bodies also try to create a widespread awareness of possible negative impacts of IRs on bank balance sheets and profitability. E.g., the Basel Committee on Banking Supervision (2016) issued "Standards for interest rate risk in the banking book".

On the other hand, the European Banking Authority (EBA, 2015) published the "Guidelines on the management of interest rate risk arising from non-trading activities". The guidance provided in these guidelines applies to the IR risk arising from non-trading activities.

The above-cited documents by the Basel Committee on Banking Supervision and by the EBA comprehensively outline several possible effects of IR increases, including changes to net interest margins, balance sheet structure, and values of interest-sensitive assets and liabilities. At this point, it becomes especially important assessing IR sensitivity of assets, which is a measure of how much the price of a fixed-income asset will fluctuate because of changes in IRs. The more the price fluctuates, the more sensitive to IR is the asset.

However, what is important for managing Interest Rate Risk in Banking Book (IRRBB) is how the prices of assets react on medium term downward or upward trends in IR dynamics. Nevertheless, the IR sensitivity of sovereign, corporate, and financial sector debt is traditionally analyzed in terms of yield sensitivity of bonds to changes in the yield curve of risk-free assets, see Manzoni (2002), Landschoot (2008), Boulkeroua and Stark (2010 and 2013), and references therein. In this context, IR impacts in asset prices are obfuscated as researchers main interests are centered at spread-to-rate relationship, and not at final IR impacts in present value of risky securities. This paper aims to fill this gap by addressing the IR sensitivity of EM sovereign debt from the perspective of the price dynamics.

Differently from the above-mentioned analyses, we assess the price response considering the medium term investment in the banking book. Our research is centered at interrelations between year-on-year changes in present value of risky and risk-free assets. This feature distinguishes the proposed methodology from the approaches, which employ averaging of daily statistics on IRs and credit spreads over extended time intervals in order to come out with a kind of average sensitivities.

This paper goes beyond the IR and credit spreads dynamics. We analyze the IR sensitivity as a sensitivity of the EM Sovereigns capital gains to the capital gains of US Treasury bonds. Note that price changes of the latter determine changes in the risk-free IRs.

The developed herein methodology is applied to assess the sensitivity of emerging markets (EM) sovereign debt to the changes in risk-free IR over the period of 1997—2017. This time interval permits examining IR sensitivity under the pre-crisis, crisis, and post-crisis economic conditions.

We provide empirical evidence of a binary behavior of IR sensitivity of EM sovereign debt and demonstrate that IR sensitivity depends on a phase of the business cycle. We detect switching from a direct positive sensitivity under the normal economic conditions to an inverted negative sensitivity during the distressed crisis-affected market turmoil, and then back to the direct positive sensitivity under the new normal post-crisis conjuncture.

This empirical finding allows solving the controversy between the Merton's (1974) structural model and Kamin and Kleist (1999) theoretical approach, which both have been supported by empirical observations.

The Merton's (1974) structural model, which is based on application of contingent claims analysis to the valuation of corporate debt obligations, provides theoretical interpretation of spread-to-rate relationship. Merton (1974) advocates a negative response of credit spreads to IRs, implying that the probability of default is affected by changes in the IR.

Following Merton's pioneering work, several studies have been dedicated to the application of the Merton's model in the context of sovereign debt for the purpose of measuring sovereign risk, see Gray et al (2007), Hilscher and Nosbusch (2010), Francois et al (2011), Jeanneret (2015), and references therein. As in the case of corporate, the outcomes of contingent claims analysis applied to sovereign entities also imply a negative response of credit spreads to IRs and a probability of default dependent on IR levels.

On the other side, Kamin and Kleist (1999) model supports a positive relationship between changes in yield spreads and changes in the risk-free rate. Authors demonstrate that risky bond yield must rise by even more than the safe bond yield to appropriately compensate bondholder for default risk.

The proposed herein methodology focused on price changes, i.e. capital gains, rather than on spread dynamics, permits to reconcile the Merton's

(1974) model with Kamin and Kleist (1999) findings, ascribing them to different phases of the business cycle.

The described theoretical reconciliation provides empirical implications for practical strategies of managing IR risk in the banking book. Particularly, the paper targeting to find the answers to the following question: does it make sense to hedge IR risk of US dollar denominated EM sovereign debt by short positions in US Treasury bonds?

The answer to this question is of particular importance for interest rate risk management and for dimensioning economic capital to allocate for mitigating this type of risk. We theoretically explain and empirically demonstrate that due to the time-varying behavior of IR sensitivity along the economic time, the hedging of IR risk ought to be a dynamic process linked to phases of the business cycle.

This paper is structured as follows. Section 2 describes the data and details the scope of the research. Section 3 introduces the methodology and assumptions developed for analyses of asset prices' volatility. Section 4 presents empirical results. Section 5 provides discussions and illustrations of the implications of the obtained results, and Section 6 offers concluding remarks.

2. EMPIRICAL DATA

Our research is focused on IR sensitivity analyses of an aggregate EM sovereign bonds portfolio to risk-free IR rather than on IR sensitivity of certain EM governmental assets selected on individual basis. Thus, with a purpose of assessing the aggregate portfolio performance we employ two yield indices: one to model relatively risky EM sovereign debt and another to gauge the price dynamics of risk-free US Treasury (UST) bonds.

For the EM sovereign debt the J.P. Morgan Emerging Market Global Sovereign Blended Yield index (Bloomberg ticker JPEGSOBY) is used. This is a rule-based index engineered to measure blended yield of international government bonds being constituents of the J.P. Morgan Emerging Markets Bond Global Index (EMBI Global), which in its turn tracks total returns for traded external debt instruments in the EMs. The J.P. Morgan EMBI Global index is a market capitalization-weighted index based on EM bonds, which covers the USD-denominated traded external debt instruments in the EMs with a minimum face value outstanding of $500 million

The J.P. Morgan EMBI Global Index is constructed with well-defined criteria to ensure that the index provides a fair and replicable benchmark and hence represents a confident base for gauging EM sovereign debt performance. When launched there were twenty-seven EM countries, and now the coverage extends to over the forty developing economies. Currently, the respective blended yield index (JPEGSOBY) calculations are based on more than one hundred sovereign bonds issued by the sovereign issuers from over the forty EM countries.

The chosen JPEGSOBY index provides almost 20-year long historical yield series, starting at December 31, 1997, thus covering the aftermath of the Asian (1997), the Russian (1998), and the Brazilian (2002) crises, as well as spreading over the periods preceding, comprising and following the global financial and economic crisis of 2008.

In our research, the final date of analyzed data is June 30, 2017. In order to study a price dynamics of EM sovereign debt portfolio, the price index would perhaps be a better choice, but to the best of our knowledge, no price indices with similar issuer, geography and historic coverage are available in the market. Thus, instead of researching individual bond price histories and/or developing a range of bond price indices from a selected universe of individual bonds data, we opt for using the above mentioned yield index to study dynamics of EM sovereign debt performance.

The reinvestment of the net interest income proceeds does not enter into the scope of our research, focused solely on time dynamics of assets' present values. Thus, we are not interested in working with total return indices and hence do not employ them in our study.

Additionally, addressing the price dynamics of modeled EM sovereign bonds portfolio hedged against IR risk, we model the basic IR risk hedging as holding short positions in UST with the five-year maturity similar to the maturity of the above mentioned EM Global Sovereign blended yield index. To describe the price dynamics of the IR risk hedge positions, we employ the US Global Generic yield index available through the Bloomberg platform under the USGG5YR ticker.

The next section describes the methodology allowing for comprehensive analysis of EM sovereigns portfolio based on the time series of the chosen EM Global Sovereign blended yield index, along with our approach to tackle IR risk hedge based on shorting UST bonds, relying on the historical series of the US Global Generic yield.

3. METHODOLOGY

The basis element of our yield-based technique is a transformation of the available through the yield index information into the average price of the modeled portfolios, namely EM sovereigns and UST portfolios. For this purpose, we employ the fundamental principle of bond valuation stating that the bond's value is equal to the present value of its future cash flows.

Below we present an example employing for simplicity reasons only one bond. The present value of a bond is but the present value of a bond's interest payments, plus the present value of a bond's maturity amount.

Considering a 5-year bond with annual coupon c and face value p, the price P of this bond could be written as

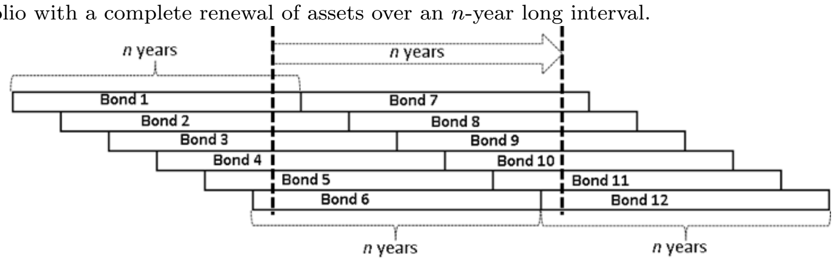
$$P = \frac{c}{1+y} + \frac{c}{(1+y)^2} + \frac{c}{(1+y)^3} + \frac{c}{(1+y)^4} + \frac{c+p}{(1+y)^5} \tag{1}$$

where y is a market IR for the level of riskiness associated with the bond under analysis.

However, a yield index provides us only with time series of yield value y. Consequently, we do not have readily available information on the subjacent bonds coupons. Therefore, at this point, we employ an assumption that allows us estimating the daily average coupon values of the modeled portfolios and hence to calculate their prices. To this end, we assume a continuous rebalancing of the portfolio. This assumption is frequently used to study risk minimization strategies for portfolio immunization, see for instance Fong and Vasicek (2015).

In our study, we assume a continuous "cruising speed" rebalancing with a constant rate. This assumption means that a bond entering the model portfolio stays in the portfolio for a certain holding period, for example, n years, and by the end of this period, the bond is sold out. We consider that all bonds in the modeled portfolio represent equal weights. Figure 1 schematically represents the rebalancing of the modeled portfolio consisting of six bonds with the identic face value at any given moment in time.

FIG. 1. Continuous rebalancing of the hypothetical equally weighted six-bond portfolio with a complete renewal of assets over an n-year long interval.



Lifetimes, or periods of stay in the portfolio, of the consecutively issued bonds are presented as horizontal lanes. If in our schematic example we assume that n equals 1 year, the "continuous" rebalancing would change portfolio composition every two months.

Any bond after an n-year long holding period is substituted by a newly issued on-the-run security. The vast majority of bonds are issued at par; hence, the bond coupon c at issuance is equal to the yield y of the bond. This gives us a key to finding an average coupon of the modeled portfolio at the date d as an average of the yield daily values observed over the n

years prior to this date d.

$$c = \frac{1}{(n \times 260)} \sum_{i=1}^{n \times 260} y_i \tag{2}$$

In this study, the holding periods n of 1, 2, and 3 years are employed. One 1 year is assumed to consist of 260 banking days.

This research performs modeling of the portfolios mimicking the compositions of the JPEGSOBY and USGG5YR indices. So, the average coupon for EM Sovereigns portfolio, as well as for UST portfolio, is calculated assuming that the complete rebalancing is completed within either 1, or 2, or 3-years. For the sake of simplicity, the interval, gauging the price changes, is set equal to 1 year for all the three different rebalancing rates.

Based on the assumption described above, it is possible to price each of the modeled portfolios at any date, for which there are available data on yield and coupon. E.g., for 1-year long stay of bonds in a portfolio, the coupon is but a 1-year moving average of the yield index values, and hence the available time window of the generated portfolio prices is December 31, 1998 — June 30, 2017. Although the index coverage starts in December 31, 1997, the first coupon due to our assumption is available only for the December 31, 1998, because of the necessity to compute the respective 1-year moving average.

Similarly for the 2 and 3-year long rebalancing, the available time windows of the generated portfolio prices are, respectively, December 31, 1999 — June 30, 2017 and December 31, 2000 — June 30, 2017.

The access to historical price series for the EM Sovereigns and the UST modeled portfolios enables us to quantify the portfolios' price variations over any chosen period as the difference between portfolio prices subjacent to the two chosen dates:

$$CG_{EM\_SOV}(t, H) = P_{EM\_SOV}(t + H) - P_{EM\_SOV}(t) \tag{3}$$

$$CG_{UST}(t, H) = P_{UST}(t + H) - P_{UST}(t) \tag{4}$$

where CG_{EM_SOV} and CG_{UST} stand for the capital gains of the EM Sovereigns and UST portfolios, respectively; t is the initial date of the analyzed time interval; and H stands for a horizon over which the capital gains are assessed — herein chosen to be 1 year for all the considered rebalancing rates.

Equations (3) and (4) allow for calculating time series of the annual capital gains, CG_{EM_SOV} and CG_{UST}, respectively. At this stage, the pair of the CG_{UST} and CG_{EM_SOV} time series could be used for assessing the sensitivity of the relatively risky EM Sovereigns capital gains to the capital gains of the risk-free U.S. government bond portfolio.

This sensitivity can be assessed as the ratio of a capital gain change of EM sovereign bonds portfolio ΔCG_{EM_SOV} over a chosen, from t_1 to t_2, time window, to the capital gain change ΔCG_{UST} of the UST portfolio over the same time interval:

$$\begin{aligned} S_{EM\_SOV/UST}(t_2, t_1, H) &= \frac{CG(t_2, H)_{EM\_SOV} - CG(t_1, H)_{EM\_SOV}}{CG(t_2, H)_{UST} - CG(t_1, H)_{UST}} \\ &= \frac{\Delta CG(t_2, t_1, H)_{EM\_SOV}}{\Delta CG(t_2, t_1, H)_{UST}} \end{aligned} \tag{5}$$

where $S_{EM\_SOV/UST}(t_2, t_1, H)$ stands for a capital gain-wise sensitivity of EM Sovereigns when the investment time horizon H, herein $H = 1$ year, is moved forward on by the number of days equal to $(t_2 - t_1)$. We posit that for the more meaningful assessment of the capital gain-wise sensitivity, the capital gain gauging window of the length H should be consecutively dislocated forward on in such manner that its displacement fits the more pronounced moves in capital gains time series of the modeled UST portfolio. It is quite an intuitive remark as smaller value in the denominator of formula (5) could amplify computation uncertainty during the calculation of the ratio, as at the limit, the zero capital gain change of the UST portfolio turns the ratio incomputable.

Such approach to IR sensitivity arises from the fact that we are interested in average capital gains over rather extended, 1-year long, time intervals. Our method fits well with the basis IR risk hedging strategy consisting of shorting UST. Thus, while assessing the performance of the EM sovereign debt portfolios, we can assess whether short positions in UST could perform the role of efficient hedge instrument.

The mechanics of our capital gain-wise sensitivity assessment is discussed in more detail in the next sections dedicated to the empirical results, discussions, and theirs implications.

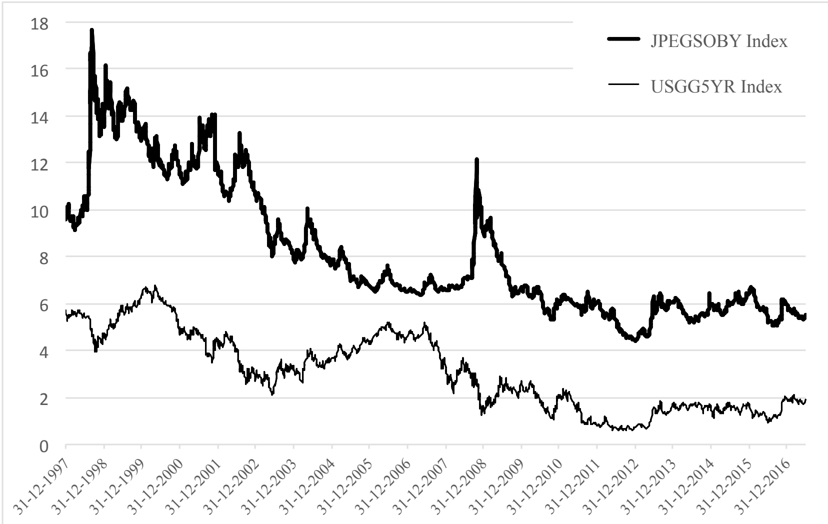
4. RESULTS

4.1. A first look at the EM sovereign debt yield

Figure 2 presents the historical series of the yields of the JPEGSOBY index plotted along with the US Global Generic rate, represented by the USGG5YR index.

This chart depicts a substantial widening of EM sovereign debt spreads over risk-free rates during the Russian crisis in 1998, during the Brazilian election crisis in 2002, and since second half of 2007 until the end of 2009, corresponding to the gigantic flight-to-quality effect coinciding with the development of the global financial crisis.

FIG. 2. Blended yield of EM Sovereigns vs. US Global Generic rate.



After each of these crises, the yield spread of risky EM Sovereigns exhibits a pronounced tightening. Additionally, since 2010 the yields of risky EM Sovereigns and risk-free UST bonds appear to move on parallel courses, creating an impression that during the six recent years the short position in UST would be a good hedge for portfolios composed by EM Sovereigns. As we show later on, the analysis based on capital gains of the respective portfolios reveals that the situation is more complex and that even during this post-crisis period the adequacy of such hedge is rather questionable.

In further sections, impacts of the IR dynamics on the present values of modeled portfolios are quantified for a 1-year long investment horizon for both portfolios: EM sovereigns and UST. For that purpose, we use the yield data to generate price histories for the selected herein portfolios with the three different rebalancing rates.

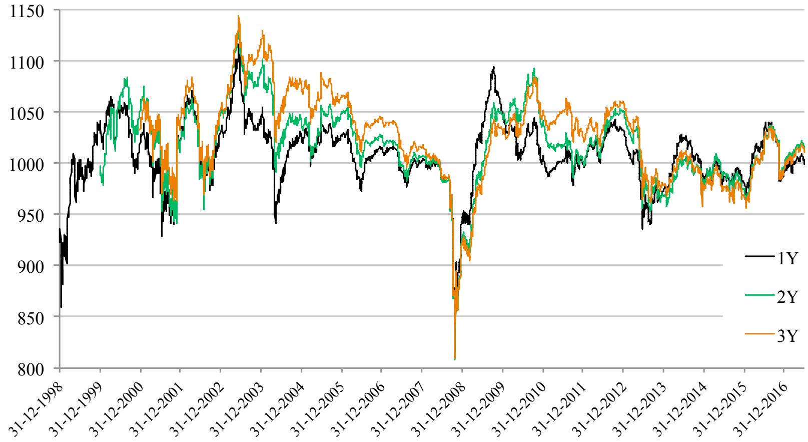
4.2. Present value dynamics of the modeled EM Sovereigns and the UST portfolios

In this subsection, we present the historic price series generated for the modeled portfolios fully rebalanced within 1, 2, and 3 years. We consider the face value of the portfolio to be equal to 1000 million USD.

Figure 3 shows the price dynamics of the three EM Sovereigns portfolio with three different bond holding periods equal to 1, 2, and 3 years. These portfolios are completely renovated within 1, 2, and 3 years, respectively.

The three price plots appear to be quite similar, though, as expected, not identical because the average coupons of the portfolio depend on the

FIG. 3. Prices of the EM Sovereigns portfolios with the different rebalancing rates.



rebalancing rate. All three plots clearly indicate a huge decay in portfolio value in the apogee of the global financial crisis, namely, by the end of 2008, telling the very same story.

Nevertheless, during the recovery phase, one could observe some differences in the price behaviors. Note that the major upside in portfolio prices under the 1-year rebalancing condition occurs within one year after the bottom is reached while for the portfolios with the bond holding periods of 2 and 3 years, the recovery spikes are not so sharp, occurring, respectively over the 2 (instead of 1) and 3-year long periods.

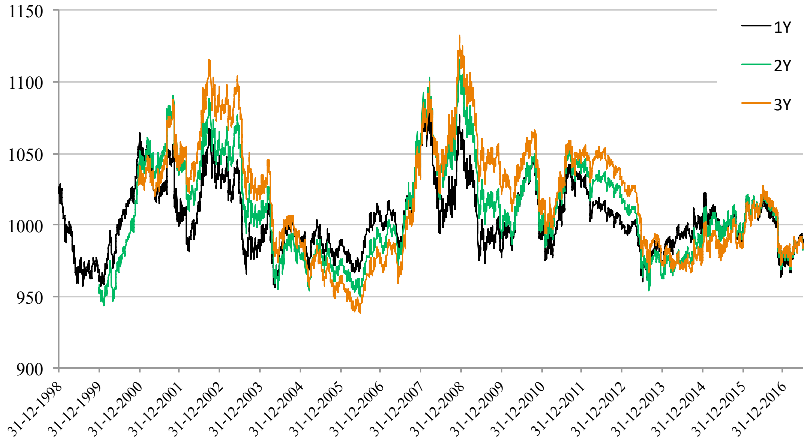
Figure 4 depicts the price dynamics of the UST long portfolios with different bond holding periods equal to 1, 2, and 3 years.

The behavior of the three price plots above appear to be quite alike over the whole span of the analyzed period, meaning that the rebalancing rate of the UST portfolio does not considerably change tendencies of the portfolio present value dynamics.

On the other hand, comparing the price behavior of the risk-free UST portfolios and the risky EM sovereign bonds portfolios, we conclude that the global financial crisis represents a huge flight-to-quality event as the prices of safe UST assets increase and the prices of risky EM sovereign bonds decrease.

Additionally, it is worth noting, that the range of UST price changes (roughly $-5\%/+12\%$, see Figure 4) is narrower than the range of price changes for the EM sovereign debt issues (roughly $-20\%/+15\%$, see Figure 3), especially strong is the difference on the downside. This serves as an alerting indication of a non-suitability of short positions in UST for IR risk

FIG. 4. Prices of the UST long portfolios with the different rebalancing rates.



hedging of EM Sovereigns. The next section presents the study of capital gains dynamics, which further corroborates to this conclusion.

4.3. Modeled capital gains

In this section, the annual capital gains are calculated on a daily frequency for portfolios with 1, 2, and 3-year long rebalancing. These historical series generated for the EM Sovereigns and UST portfolios allow investigating the dynamics of the respective portfolios' performance. Additionally, while taken together, this data allows generating the capital gain time series for the EM sovereign debt portfolios hedged by the short positions in the UST. The time spans of the series are limited by the availability of data and depend on the rebalancing rate selected for the portfolio modeling.

Figure 5 demonstrates the time behavior of the annual capital gains of the EM Sovereigns portfolios whose complete rebalancing occurs respectively, over 1, 2, and 3 years.

In Figure 5, any point of a chosen curve, corresponding to a selected rebalancing rate, at any given date (for example, December 31, 2005), represents the price change of the respectively rebalanced EM Sovereigns portfolio occurred over the 1-year long preceding period, i.e., capital gains gauging period (in our example, since December 31, 2004).

The three price plots are quite similar to each other over the whole span of the analyzed period. It means that the rebalancing rate of the EM Sovereigns portfolio does not considerably change annual capital gain dynamics.

FIG. 5. Annual capital gains of EM Sovereigns portfolios with different rebalancing rates.

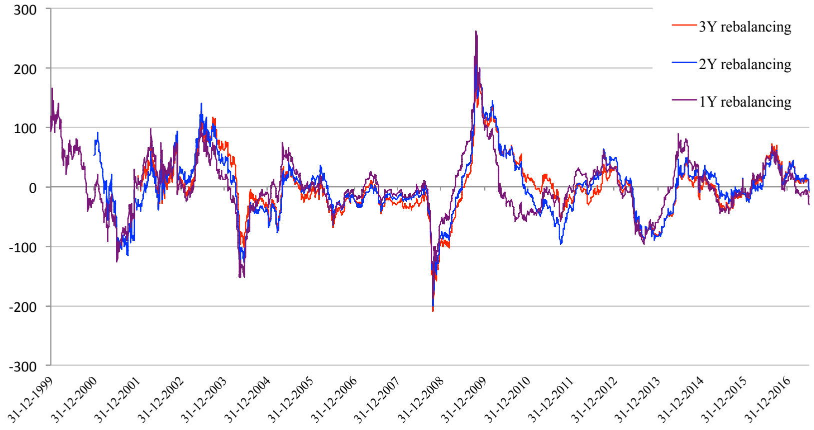
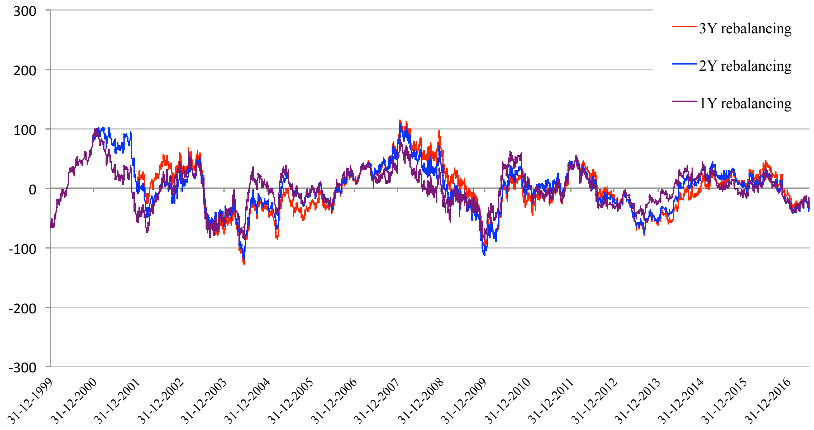


Figure 6 shows the time behavior of the annual capital gains of the UST portfolios whose complete rebalancing occurs respectively, over 1, 2, and 3 years.

FIG. 6. Annual capital gains of UST portfolios with different rebalancing rates.



In Figure 6, any point of a chosen curve, corresponding to a selected rebalancing rate, at any given date (for example, June 17, 2003), represents the price change of the respectively rebalanced UST portfolio occurred over the 1-year long preceding period, i.e., capital gains gauging period (in our example, since June 17, 2002).

Conclusions from analyses of the plots in Figure 6 are similar to those obtained analyzing Figure 5. Once again, now for the UST portfolios, it is evidenced that the rebalancing rate of the portfolio does not considerably change annual capital gain dynamics.

Nevertheless, as the 1-year long rebalancing results in the most extended available capital gains history, the 1-year rebalancing rate is used in further sections of this paper.

Figure 7 shows the time behavior of the annual capital gains of the risky EM Sovereigns portfolio plotted against the annual capital gains of the risk-free UST bond portfolio. The complete rebalancing of both portfolios occurs over 1 year.

FIG. 7. Annual capital gains of the EM Sovereigns and UST portfolios with 1-year rebalancing.

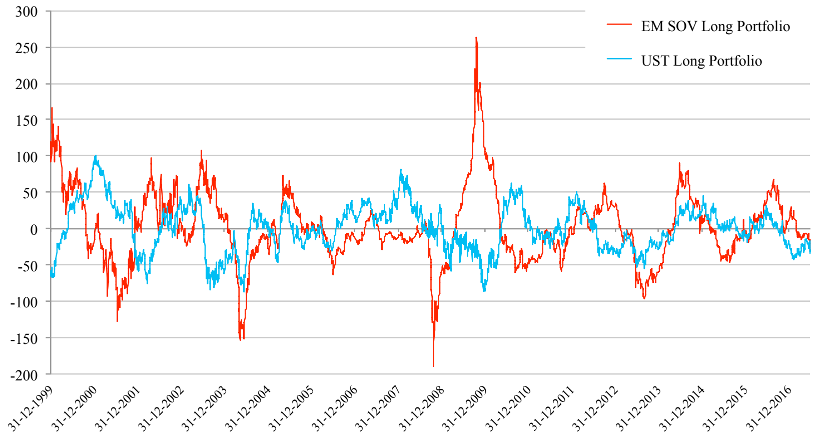


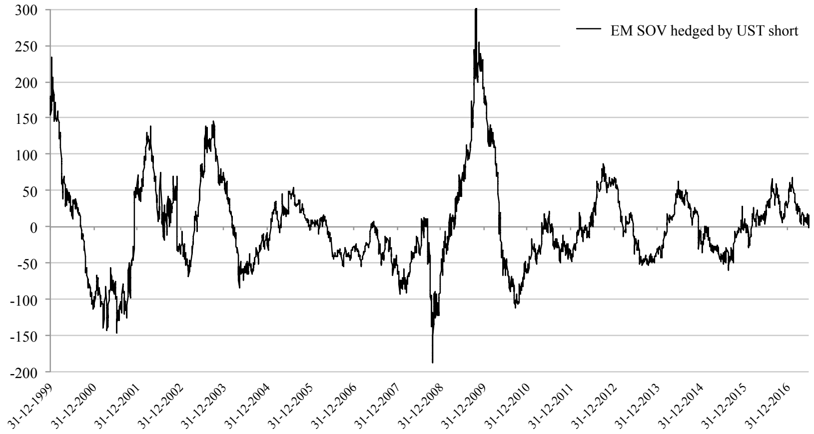
Figure 7 evidences that prior to 2004, the period affected by the Asian, Russian, and Brazilian crises, and during the 2007—2012 turmoil years (i.e., prior and after the apogee of the global financial crisis), the annual capital gains of the two considered portfolios behave in an opposite mode.

Hence, the hedging of the EM sovereign debt portfolio with the short UST positions does not compensate the negative impacts, during the periods when such setoff is most needed.

Figure 8 illustrates the time behavior of the annual capital gains for the modeled EM Sovereigns portfolio hedged by the short positions in UST bonds, under the assumption of the complete portfolio rebalancing over the 1-year long time interval.

As we can see by comparing Figures 7 and 8, the observed range of the annual capital gains of the EM sovereign debt portfolio hedged by short positions in UST is wider than the range of the annual capital gains of the non-hedged portfolio. Figure 8 evidences that such hedge does not function properly, neither within the crisis periods, nor in general as it

FIG. 8. Annual capital gains of the EM Sovereigns portfolio hedged by short UST.



does not compensate the decreases in present value of risky EM Sovereigns portfolios.

Although, the capital gain analysis provides important insights into the adequacy of interest rate risk hedge strategies, it is also important to comment that the performance of a portfolio assessed through its capital gains does not incorporate the interim coupon payments, pocketed within the annual time window used to gauge the portfolios price changes. As the blended yield of EM sovereign debt always stays above 4%, see Figure 2, thus, such interest income revenue in part compensates holders of EM Sovereigns for the decays in value of their assets along several EM crises and the recent global financial crisis.

This is consistent with conclusions from the upward trends of diverse total return indices along the referred time span evidencing a certain growth in value of EM portfolios; see for example J.P. Morgan EMBI Global Composite (Bloomberg ticker JPEGCOMP). Nevertheless, as we are focused at IR sensitivity of assets in a sense of impacts on the present value of portfolios, we opt to restrain from the interest income perspective and the total return considerations, leaving them out of the scope of our research.

4.4. Interest rate sensitivity of EM sovereign bonds

In this section, we perform a quantitative assessment of the capital gain-wise sensitivity of the modeled EM Sovereigns portfolio to changes in prices of the corresponding portfolio of UST. Instead of trying to come up with average sensitivity figures for all the 17-year long available data history, we are interested in gauging sensitivity behavior within much shorter time intervals defined by the local extrema, i.e. turning points, which separate opposite upward and downward tendencies in UST capital gains dynamics.

Following the UST big moves, i.e. capital gain ups and downs, allows for diminishing denominator-related uncertainty in Equation (5) and, hence, for more precise assessment of capital gain-wise sensitivity. Applying the methodology developed in Gubareva and Borges (2016), the local extrema of the modeled historical series of the UST portfolio capital gains, presented in section 4.3 (see Figure 7), are identified. The sensitivity figures are calculated separately for each gains/losses move.

There are 52 big moves, i.e., ups and downs, of the UST portfolio capital gains. They are distributed among 4 periods: (i) 13 moves in EM turbulence period, prior to 2004, (ii) 11 moves in the "old normal" period, preceding the global financial crisis, March 2004 — June 2007; (iii) 15 moves observed through the global crisis, June 2007 — April 2013; and (iv) 13 moves during the "new normal" post-crisis period, April 2013 — June 2017.

The first and the third periods exhibit the opposite behavior of capital gains observed in the EM Sovereigns and the UST portfolios, while the second and the fourth periods correspond to the similar dynamics of EM Sovereign and UST capital gains.

We approach the problem of IR sensitivity from the portfolio management and risk management perspective, and hence we try to understand how price changes, i.e. capital gains, of the portfolio composed by EM Sovereigns respond to the changes in UST capital gains. As already stated previously, we restrict the scope of our sensitivity research and select only one length for an investment horizon: 1 year. Thus, we assess annual capital gains, and distil IR sensitivity dynamics subjacent to the plots in Figure 7.

4.4.1. Interest rate sensitivity during the EM turbulence period

Table 1 shows 13 major moves in capital gains of the UST portfolio during the EM turbulence period, December 1999 — March 2004, affected among other events by the aftermath of the Asian 1997 crisis, and by the Russian and the Brazilian crises of 1998 and 2002, respectively.

For each of these 13 identified time windows we calculate the capital gain deltas for both, the UST and EM Sovereigns portfolios. We present the respective sensitivity coefficient calculated as the ratio of the capital gain delta observed in the EM Sovereigns portfolio to the "inducing" delta observed in the UST portfolio. For informative purposes, we present also the lengths of the move-elapsed time windows.

For the entire span of the EM turbulence period, the length-times-magnitude weighted average sensitivity is found to be -0.21. It means

TABLE 1.

EM turbulence sensitivity figures per major moves in the UST capital gains

Date	Elapsed Time (days)	ΔUST Capital Gains, \$mln	ΔEM Sovereigns Capital Gains, \$mln	Sensitivity ΔEM Sovereigns/ ΔUST
31-12-1999				
14-06-2000	166.00	93.71	−52.08	−0.56
19-07-2000	35.00	−12.83	−11.07	0.86
18-01-2001	183.00	80/15	−48.76	−0.61
03-07-2001	166.00	−86.69	−78.91	0.91
14-09-2001	73.00	24.14	−10.23	−0.42
08-01-2002	116.00	−95.44	86.29	−0.90
05-09-2002	240.00	88.19	14.32	0.16
17-10-2002	42.00	−41.69	−4.10	0.10
10-03-2003	144.00	71.87	−21.80	−0.30
03-09-2003	177.00	−144.81	44.68	−0.31
21-11-2003	79.00	41.70	−21.67	−0.52
30-12-2003	39.00	−20.33	−3.43	0.17
22-03-2004	83.00	58.92	−28.16	−0.48

that on average annual capital changes of the EM Sovereigns portfolio exhibit inverted behavior with much smaller, i.e., damped, amplitude while compared to the respective capital changes of the UST portfolio.

The change in capital gains of EM Sovereigns portfolio is opposite to the change observed in the portfolio of UST. Still the average values of sensitivity coefficient for the positive UST capital gain windows and for the negative UST capital gain windows, i.e., UST capital losses windows, are different.

For the positive UST capital gain windows, with total length of 968 days, the average magnitude of the inverted response is equal to -31% of the "inducing" change in the UST capital gains. In other words, during the EM turbulence around the beginning of the century, if the yield on the US government debt rises, the spread of EM Sovereigns tightens in such a way that it is absorbing all the increase in risk-free rates and even causes a decrease in the average yield of EM sovereign debt.

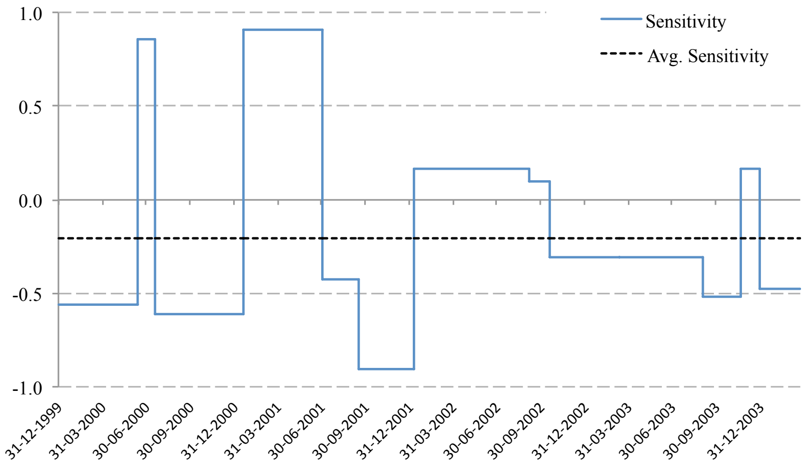
Such behavior corresponds to the outcomes of structural Merton's (1974) model, positing the negative influence of IR increases upon creditworthiness of obligors. Therefore, as our study evidences, during the EM turbulence period, the spread response of the EM sovereign bonds to risk-free IRs is negative while its magnitude is reduced relative to the original move in risk-free rates.

In the same manner, and also in accordance with the Merton's (1974) model, while the yield on a UST decreases, for example, the yield change equals to -1, the yield on EM sovereign debt increases 0,08. The total length of the UST capital loss windows is 575 days. Thus, although EM Sovereigns capital gains are less sensitive to a decrease in capital gains of UST, while compared to an increase in capital gains of UST of the same magnitude, the windows of UST capital losses represent 37% of the total EM turbulence interval versus 63% relative to the windows of positive UST capital gains.

Hence, the awareness that ups and downs in the UST capital gains influence differently the EM Sovereigns capital gains is important and can be used to tailor more robust hedge strategies.

Figure 9 below shows historic behavior of observed sensitivity during the EM turbulence interval at the beginning of the century as per the right-most column of Table 1.

FIG. 9. Sensitivity of EM Sovereigns during the EM turbulence period.



The dynamics of sensitivity exhibits certain volatility, but stays predominantly in the negative domain. So, for the EM turbulence time window, the impact of the risk-free IR changes on EM sovereign bond prices is inverted in respect to the impacts on prices of UST. The length-times-magnitude average of -0.21 is indicated by the dotted line.

4.4.2. Interest rate sensitivity during the "old normal" period

Following the same approach used in the sub-section 4.4.1 for the EM turbulence around the beginning of the century, Table 2 shows 11 major moves in capital gains of UST during the "old normal" pre-crisis period, March 2004 — July 2007.

TABLE 2.

"Old normal" sensitivity figures per major moves in the UST capital gains

Date	Elapsed Time (days)	ΔUST Capital Gains, \$mln	ΔEM Sovereigns Capital Gains, \$mln	Sensitivity ΔEM Sovereigns/ ΔUST
22-03-2004				
14-06-2004	84.00	−83.17	−136.27	1.64
15-10-2004	123.00	112.78	127.00	1.13
11-01-2005	88.00	−37.81	−7.37	0.19
01-06-2005	141.00	50.00	88.74	1.77
03-11-2005	155.00	−66.68	−63.71	0.96
24-03-2006	141.00	39.13	25.96	0.66
26-06-2006	94.00	−42.31	−66.87	1.58
09-11-2006	136.00	64.97	41.37	0.64
23-01-2007	75.00	−24.41	−12.37	0.51
11-05-2007	108.00	30.34	38.72	1.28
12-06-2007	32.00	−38.12	−10.85	0.28

For the entire span of the "old normal" interval, preceding the global financial crisis, the length-times-magnitude weighted average of sensitivity is found to be 1.07. Thus, during this time interval, March 2004—June 2007, the nominal of short positions in UST to be considered as efficient IR risk hedge for the EM Sovereigns portfolio should, on average, equal to 107% of the nominal of the EM sovereign debt portfolio.

The change in capital gains of EM Sovereigns portfolio is in a direct mode to the change observed in the portfolio of UST. The average values of sensitivity coefficient are practically equal for the positive UST capital gain windows (1.08) versus the negative UST capital gain windows, i.e., UST capital losses windows (1.07). It certifies that during the "old normal" pre-crisis interval the average strength of sensitivity does not really depends on whether one analyses a decrease or increase in UST capital gains.

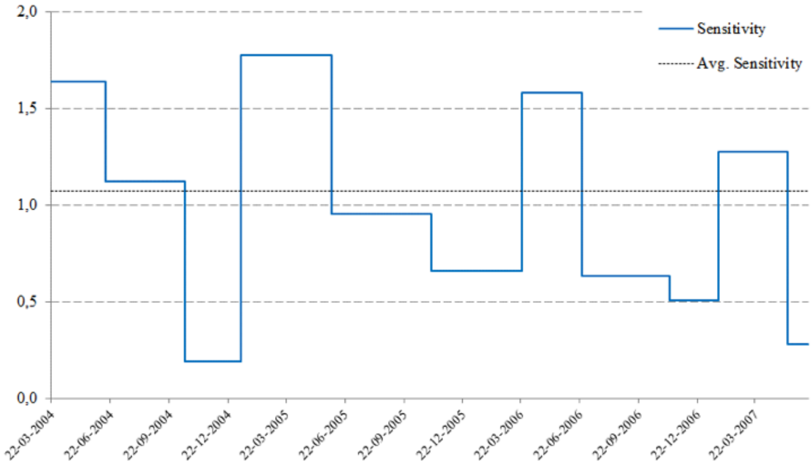
Changing from the capital gains paradigm to yields and spreads perspective, it could be stated that a move in the risk-free IR, determined by the move in prices of the risk-free assets, is passed through to the yield of

EM sovereigns entirely and even slightly amplified, as sensitivity coefficient value of 1.07 is above 1. It is in plain accord with the empirical observations and the theoretical interpretations of Kamin and Kleist (1999) whose work is focused on EM credit spreads.

In terms of IR risk hedge strategies, it seems plausible that for this period — and possibly for similar periods in the future — the notional of IR hedge by short positions in UST, should be slightly superior to the nominal value of the EM sovereign debt portfolio.

Figure 10 below shows historic behavior of observed sensitivity during the "old normal" interval, preceding the global financial crisis, as per the right-most column of Table 2.

FIG. 10. Interest rate sensitivity of EM Sovereigns during the "old normal" period.



The dynamics of sensitivity exhibits certain volatility. The length-times-magnitude average of 1,07 is indicated by the dotted line. When the value of sensitivity coefficient is below one, the impact of risk-free IR changes is damped. Conversely, if the value of sensitivity coefficient is above one, the impact of risk-free IR on EM sovereign debt is amplified.

In summary, we find that during the "old normal" period, preceding the global financial crisis, on average, when UST capital gains drop/increase USD1.00 then EM sovereigns capital gains drop/increase USD1.07.

4.4.3. Interest rate sensitivity through the global financial crisis

Following the same approach employed in the sub-sections 4.4.1 and 4.4.2, Table 3 shows 15 major moves in annual capital gains of UST during the "distressed" through-the-crisis period, spanning over June 2007 — April 2013. For each of these 15 time windows we calculate the corresponding capital gain deltas for both, the UST and EM Sovereigns portfolios. The respective sensitivity coefficients are also shown in the right most column.

TABLE 3.

Through-the-crisis sensitivity figures per major moves in UST capital gains

Date	Elapsed Time (days)	ΔUST Capital Gains, \$mln	ΔEM Sovereigns Capital Gains, \$mln	Sensitivity ΔEM Sovereigns/ ΔUST
12-06-2007				
10-09-2007	90	31.90	−22.83	−0.72
31-10-2007	51	−23.46	8.13	−0.35
22-01-2008	83	72.90	−3.79	−0.05
16-06-2008	146	−72.68	6.31	−0.09
15-07-2008	29	18.58	−4.84	−0.26
08-09-2008	55	−41.62	5.81	−0.14
23-12-2008	106	43.61	−59.96	−1.37
17-03-2009	84	−87.72	23.78	−0.27
27-04-2009	41	57.98	36.42	0.63
30-12-2009	247	−85.87	109.00	−1.27
10-08-2010	223	147.54	−133.17	−0.90
19-05-2011	282	−84.43	21.52	−0.25
08-02-2012	265	73.62	23.52	0.32
01-11-2012	267	−85.32	9.94	−0.12
04-04-2013	154	38.59	−19.91	−0.52

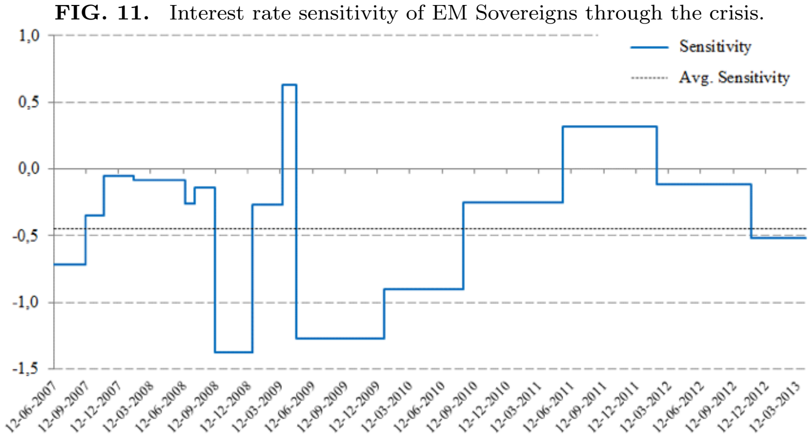
For the entire span of the "distressed" through-the-crisis interval, the length-times-magnitude weighted average sensitivity is found to be −0.45. It means that on average annual capital gain changes of the EM Sovereigns portfolio exhibit inverted behavior with damped amplitude while compared to the respective capital changes of the UST portfolio.

The change in capital gains of EM sovereign debt portfolio is opposite to the change observed in the UST portfolio. The average value of sensitivity coefficients is practically equal for the positive UST capital gain windows (−0.45) versus the negative UST capital gain windows, i.e., UST capital losses windows (−0.44). It certifies that during the through-the-crisis interval the average strength of sensitivity does not really depends on whether the UST capital gains decrease or increase.

The inverted behavior of the EM Sovereigns and the UST capital gains, observed through the global financial crisis, as well as within the early-century EM turbulence discussed in the subsection 4.4.1, is in line with the outcomes of structural Merton's (1974) model. This model results in the positive/negative influence of IR increases/decreases upon creditworthiness of obligors. As we demonstrate here, for the EM sovereign bonds, the spread response to IR is negative while its magnitude is reduced relative to the original move in risk-free rates.

Figure 11 depicts historic behavior of observed sensitivity during the "distressed" through-the-crisis interval as per the right-most column of Table 3.

FIG. 11. Interest rate sensitivity of EM Sovereigns through the crisis.



The dynamics of IR sensitivity exhibits considerable volatility, but stays predominantly in the negative domain. So, for the through-the-crisis time window, the impact of the risk-free IR changes on EM Sovereigns prices is inverted in respect to the impacts on UST prices. The length-times-magnitude average of -0.70 is indicated by the horizontal dotted line.

4.4.4. Interest rate sensitivity during the "new normal" period

Table 4 contains 13 major moves in capital gains of UST during the "new normal" post-crisis period, April 2013 — June 2017. For each of these 13 periods we calculate the capital gain deltas for both, the modeled UST and EM sovereigns portfolios. We compute the respective sensitivity coefficients as the ratio of the capital gain delta observed in the EM Sovereigns portfolio to the "inducing" delta observed in the UST portfolio.

The length-times-magnitude weighted average sensitivity is found to be 1,09 for the entire "new normal" post-crisis period. The sign of an average price response of the EM Sovereigns portfolio is the same as the sign of the

TABLE 4.

"New normal" sensitivity figures per major moves in the UST capital gains

Date	Elapsed Time (days)	ΔUST Capital Gains, \$mln	ΔEM Sovereigns Capital Gains, \$mln	Sensitivity ΔEM Sovereigns/ ΔUST
04-04-2013				
05-09-2013	154	−52.33	−88.47	1.69
14-03-2014	190	49.77	82.43	1.66
28-04-2014	45	−12.19	12.58	−1.03
05-09-2014	130	93.22	178.08	1.91
06-11-2014	62	−27.72	−47.72	1.72
15-01-2015	70	33.84	−22.47	−0.66
26-06-2015	162	−48.49	−51.12	1.05
06-10-2015	102	17.91	24.91	1.39
15-01-2016	101	−32.66	−0.93	0.03
27-06-2016	164	49.72	51.79	1.04
08-03-2017	254	−70.57	−38.13	0.54
02-06-2017	86	26.24	−1.69	−0.06
30-06-2017	28	−20.74	−25.01	1.21

"inducing" price change occurred in the portfolio of UST, while on average the amplitude of the price response observed in the EM sovereigns is equal just to 109% of the price change relative to UST securities. This average sensitivity (1.09) is very closed to the average sensitivity observed within the "old normal" time interval (1.07).

But there is an important feature, which distinguishes the post-crisis period from the pre-crisis period: the average values of sensitivity coefficient for the positive UST capital gain windows (1.33) and for the negative UST capital gain windows (0.87) are quite different.

For the positive UST capital gain windows, with total length of 742 days, the average magnitude of the response is above 1 and equals to 1,33% of the "inducing" change in UST capital gains, while for the UST capital loss windows of 806 days the average magnitude of response is below 1 and equals to 87%. In other words, during "new normal" post-crisis period EM Sovereigns are much more sensitive to decreases in risk-free rates benefiting from them more than suffering from the increase in UST yields.

It could be stated that when risk-free IR increases, such a move is only partially passed through to the yield of EM Sovereigns, as sensitivity coefficient value of 0.87 is below 1. This is in line with the Merton's (1974) view.

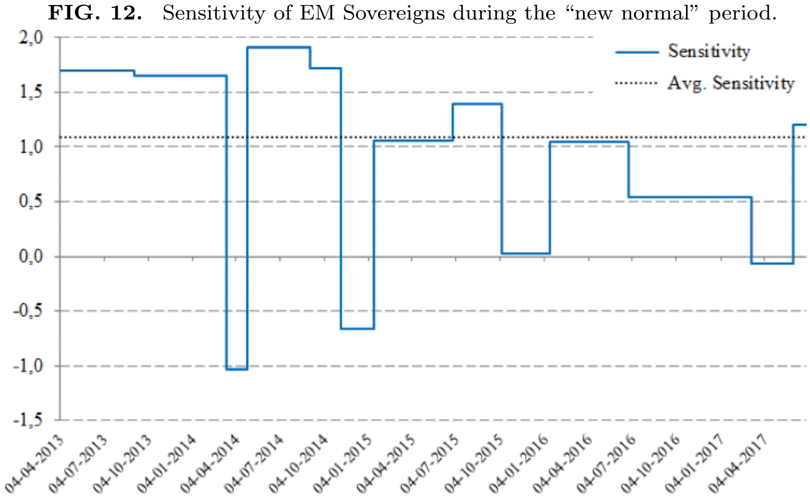
On the contrary, during the decreases in risk-free rates, such dynamics is passed through to the yield of EM Sovereigns entirely and even amplified by one third, as sensitivity coefficient value of 1.33 is above 1. This corroborates the view of Kamin and Kleist (1999).

Still, for this "new normal" post-crisis period the nominal of short positions in UST to be considered as efficient IR risk hedge for the EM Sovereigns portfolio should, on average, equal to 87% only, and not to 109%. It is so because there is a sense in hedging capital loss periods when sensitivity is 87% rather than positive capital gains with 133% sensitivity.

Changing from the capital gains paradigm to yields and spreads perspective, we pose that a move in the risk-free IR, determined by the move in prices of the risk-free assets, on average, is passed through to the yield of EM Sovereigns entirely and even slightly amplified, as sensitivity coefficient value of 1.09 is above 1. It is in line with the theoretical approach proposed by Kamin and Kleist (1999).

Figure 12 below shows historic behavior of observed sensitivity during the "new normal" post-crisis period as per the right-most column of Table 4.

FIG. 12. Sensitivity of EM Sovereigns during the "new normal" period.



During the "new normal" post-crisis time interval, similarly to the "old normal" period before the crisis, the sensitivity coefficient stays predominantly in the positive domain. However during the "new normal" post-crisis period, the dynamics of sensitivity is more volatile if compared with the "old normal" pre-crisis period.

The volatility range is centered at the positive level of 1.09, indicated by the horizontal dotted line. This certifies that the overall IR sensitivity of EM Sovereigns portfolio during the "new normal" post-crisis period is positive and that the average amplitude of the response is slightly amplified.

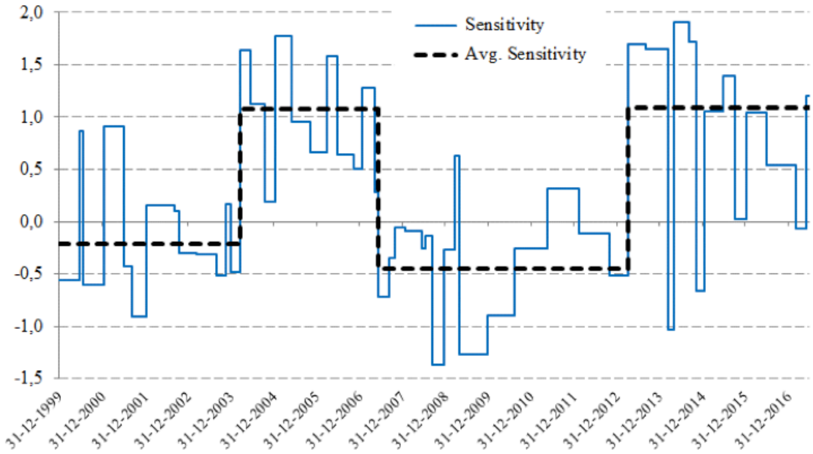
As follows from the data presented in Table 4 and Figure 12, during the "new normal" post-crisis period, the observed behavior of sensitivity corroborates with the outcomes of Kamin and Kleist (1999) approach, positing the absence of an influence of IR changes on creditworthiness of obligors.

From the credit spreads position, the average IR sensitivity coefficient value of 1.09 means that spreads react slightly positive to risk-free rates, as for spreads to be insensitive, IR sensitivity value must be equal to 1.

4.4.5. Holistic perspective: binary behavior of interest rate sensitivity

Figure 13 represents historic behavior of observed on-the-move sensitivity (as per the right-most columns of Tables 1-4) during the whole span of our analysis including EM early-century turbulence, pre-crisis, crisis, and post-crisis intervals. The phase-averaged sensitivity value is depicted constant over the intervals along which it was computed.

FIG. 13. Binarity of phase-averaged sensitivity of EM Sovereigns, 1999 — 2017.



Although the on-the-move sensitivity exhibits certain volatility, the dynamics of phase-averaged sensitivity clearly exhibits binary behavior. Figure 13 evidences three switches: from distressed regime negative sensitivity to normal regime positive sensitivity, then back to distressed regime negative sensitivity, and then again to the normal regime positive one.

The regime dependent behavior observed for the IR sensitivity is in line with similar findings by other researchers for diverse financial parameters. For example, Aussenegg et al (2016), evidence that European asset swap spreads exhibit regime-dependent behavior, while the switching between regimes is caused by the global financial crisis.

In the case of our study, the regime dependent behavior, observed for the IR sensitivity, means that during reasonably normal economic conditions, on average, the capital gain-wise IR sensitivity is positive, while during crisis-driven financial turmoil the IR sensitivity is negative. Moreover, the stronger is the crisis, the more negative IR sensitivity.

From the standpoint of IR hedge economic efficiency, the short positions in UST resulted in losses during the EM early-century turbulence.

Then, all the gains from the IR hedge obtained during the "old normal" pre-crisis period were wiped away while crossing the crisis downturn and recovery.

Analyzing the trends, we conclude that even if now, under the "new normal" post-crisis period, shorting UST positions provide a certain efficiency to withstand negative effects of climbing IRs, it is reasonable to gradually diminish the nominal of the hedge anticipating the next financial turmoil.

Graphically this conclusion is supported by the fact that the area of the "old normal" pre-crisis 2004 — 2007 hedge-gains rectangle defined by the horizontal axis and the phase-averaged sensitivity line is inferior to the through-the-crisis hedge-losses rectangle. Of course, for this conclusion to be considered completely valid, apart from sensitivity, the amplitudes of changes in risk-free IR must be taken into account. But as crises are always characterized by more pronounced changes (drops) in risk-free IRs, this circumstance corroborate even more with our conclusion of inefficiency of all-weather hedge by short positions in UST.

In addition, when next turmoil comes, the losses in the short UST hedged EM sovereigns portfolio will be registered on both sides: at the asset side due to the widening of spreads because of augmenting sovereign credit risk and at the hedge side due to the drop of risk-free yields caused by the augmented demand for safe haven assets. That is but the flight-to-quality phenomenon described, for instance, in Gubareva and Borges (2016).

5. DISCUSSIONS AND IMPLICATIONS

5.1. Revisiting an old controversy: Merton's model vs. Kamin and Kleist approach

Based on the observed binary behavior of IR sensitivities we revisit an old controversy. On one side of the controversy there are conclusions of contingent claims analysis and structural model applied to sovereigns, see Gray et al (2007) and François et al (2011) who follow the ideas of original work by Merton (1974) developed for corporates. Their outcomes advocate the negative relation of credit spreads to IRs.

On the other side of the controversy frontier there is Kamin and Kleist(1999) approach, which posits that changes in risk-free IRs are passed through to yields of risky assets with the same or slightly augmented magnitude, and hence resulting in no or slightly positive relation of credit spreads to IRs.

However, the results of our research suggest that the origin of this apparent controversy lies in the ad-hoc defined measurement periods, overlapping either one, or another, or even both of the different regime dependent behaviors of binary IR sensitivity.

Negative relation of credit spreads to IRs is observed in many recent researches, see, Boulkeroua and Stark (2013), Neal et al (2015), and Dupoyet et al (2016). These empirical studies corroborate with Gray et al (2007) and François et al (2011). On the other hand, the empirical findings of Kamin and Kleist (1999) for EM bonds support their own hypothesis of risk-free rate changes passed through to yields of risky assets.

Considering the observed binarity, we conclude that for a chosen period there is one of the two above-mentioned models, i.e., Gray et al (2007) and François et al (2011) versus Kamin and Kleist approach (1999), which better fits our empirical findings.

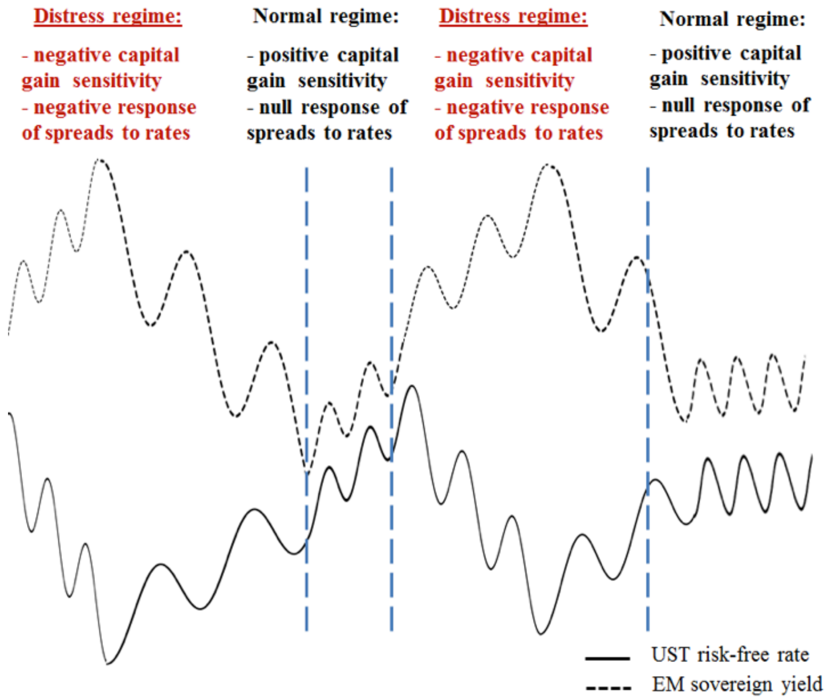
E.g., for the "old normal" pre-crisis period (March 2004 — June 2007) as well as for the "new normal" post-crisis period (April 2013 — June 2017), the capital gain sensitivity for EM sovereigns on average is 1.07 to 1. Thus, this is consistent with the theoretical thinking of Kamin and Kleist (1999), as it posits that the probability of default is not affected, perhaps just slightly augmented, by changes in the risk-free IR. Hence, no considerably strong response of credit spreads to risk-free IRs is observed.

It is worth noting that the null spreads-to-rates response corresponds to 1 to 1 capital gain-wise sensitivity, as in this case credit spread remains immune to the changes in risk-free IRs. Our findings attest the validity of this model for normal market conditions.

On the contrary, for the EM turbulence period (December 1999 — March 2004) and for the "distressed" through-the-crisis period (June 2007 — April 2013), negative sensitivity is observed for EM Sovereigns. This result is clearly in line with structural model based on contingent claims analysis, see Gray et al (2007) and François et al (2011), which implies a negative response of credit spreads to IRs, i.e., a probability of default is reduced by an increase in the risk-free IR.

Below, in Figure 14, we present a schematic behavior of a sovereign spread, which is the difference between the EM sovereign yield and the UST risk-free rate.

FIG. 14. Spreads vs. rates: negative sensitivity in distress along with insensitivity otherwise.



During normal regime, in our illustrative scheme no sensitivity of spreads to the risk-free IR is depicted. I.e., spreads remain constant; the changes in the risk-free rate are passed through to the yield. On the other hand, within the distressed period spanning over the contraction and sharp recovery, spreads exhibit negative sensitivity to the risk-free IRs. When the risk-free rates decrease spreads increase and vice versa, see Figure 14.

Therefore, under distressed conditions the changes in risk-free IRs impact creditworthiness of obligors.

At this point, we highlight perils of long run averaging as these algorithms could disguise the otherwise observable effects and risk to "throw the baby out with the bathwater". For instance, expanding the window of observations over both, the "normal" market regime with null spread sensitivity and the "distressed" regime with strong negative sensitivity of spread to risk-free rates, we could find ourselves observing on average a slightly negative sensitivity. This is because of the fact that strong negative sensitivity during the distressed regime becomes diluted by a null or a weak positive spread sensitivity within the normal regime.

In addition, the observed binarity of interest rate sensitivity, documented in our research, contrasts with the results of Dupoyet et al (2016), reporting consistent negative relation between credit spread and IRs for 1973-2014. Our study proves that it is not the case for the constituent short run intervals, at least for the EM Sovereigns portfolios along 1999-2017.

In terms of capital gain-wise sensitivities, long run averaging of sensitivities could disguise the observable short-run effects, as spanning the window of observations over both, the "normal" regime with positive and the "distressed" regime with negative sensitivity, we would observe on average only one of them, the predominant one, but damped by the other.

Eventually, depending on the span of the window over the two regimes we could even observe insensitivity to IR, if, on average, opposite effects fully damp one another.

We present a comparative analysis of the capital gain-wise sensitivity and spreads-to-rates sensitivities for the different time intervals, which correspond either to the structural model based on contingent claims analysis, see Merton (1974), Gray et al (2007), and François et al (2011) or to Kamin and Kleist (1999) approach for the EM sovereign debt. Table 5 below establishes a relation between the two different types of IRs sensitivity of assets.

From the lenses of the spreads, see Table 5, during the intervals with normal market conditions, when Kamin and Kleist (1999) approach is consistent with our empirical findings, only slightly positive response of spreads to the risk-free IR is observed. I.e., the changes in the UST risk-free rate are passed through to the yield of EM sovereigns becoming slightly augmented.

On the other hand, during the distressed EM turbulence and the global crisis intervals when structural model based on contingent claims analysis is consistent with our empirical findings, spreads exhibit negative sensitivity to the risk-free IRs. When the risk-free rates decrease spread values increase

TABLE 5.

Theoretical models and observed sensitivities subjacent to different regimes

Model	**Source**	**Dominance**	**Capital gain-wise average sensitivity**	**Spread-to-rate average sensitivity**	**PD vs. interest rate dynamics**
Transfer of changes in risk-free rates through to risky yields	Kamin & Kleist (1999)	42.6%	≥ 1, i.e., positive with augmented response	Null or slightly positive	PD not affected or slightly augmented by rate increases
Structural model based on contingent claims analysis	Merton (1974); Gray et al. (2007); François et al. (2011)	57.4%	< 1, positive or negative; reduced or inverted response	Negative	PD reduced by rate increases and vice versa

and vice versa. So, under such conditions the changes in risk-free IRs quite strongly impact creditworthiness of sovereign obligors, which suffer/benefit from deterioration/recovery of global economic conditions reflected by decreasing/increasing risk-free IRs, defined in their turn by prices of the UST securities.

So, if the window of analysis covers both types of regimes, one when prevails Kamin and Kleist (1999) approach (implying null or slightly positive spread sensitivity) and the other when prevails the structural model (resulting in negative sensitivity of spread to risk-free rate) one finds himself observing on average a slightly negative spread-to-rate sensitivity. It is so, because under such analysis arrangements strong negative sensitivity during the structural model dominance is diluted by the null or slightly positive spread sensitivity within the regimes of applicability of Kamin and Kliest (1999) approach.

5.2. The business cycle and interest rate sensitivity

Differently from corporates involved in production activities, governments are mostly in the business of promises and delivery. They collect taxes, borrow money, and expend funds on social benefits, goods and services. The EM governments also can print money.

Nevertheless, sovereign risk is tightly connected to the development of global macro imbalances. In fact, the EM government assets, on one hand, consist of domestic and foreign currency reserves, deposits in banks and receivables, commodities reserves, and other assets. In plus, the EM government assets are also composed by projected long-term stream of taxes, fees, tariffs, and exploration rights, all discounted to the present moment.

Thus, the aggregate performance of sovereign debt in general and of EM in particular must be in line with the state of global economy.

Below, based on our analysis we propose an explanation for both positive and negative capital gain-based IR sensitivities of the EM Sovereigns observed along rising and falling global economic conjuncture.

Each business cycle is different from any other, but certain patterns in growth rates have tendency to repeat over time. For a typical cycle we analyze four critical stages: (i) early-cycle phase, (ii) mid-cycle phase, (iii) late-cycle phase, and (iv) a recession. Alternatively, the business cycle is also frequently sliced into expansion, peak, contraction, and trough.

(i) The typical early-cycle phase represents a sharp recovery from recession, a resumption of economic activity, an inflection from negative to positive economic growth, and then an accelerating growth rate. During this relatively short phase, the accelerating economic activity drives the recovery from the recession bottom until the full exit is reached.

(ii) The typical mid-cycle phase usually is the longest among the stages of the business cycle. The economy passes from recovery into expansion. This phase is characterized by a positive but diminishing rate of economic growth while compared to the early-cycle. Growth is peaking, as inventories and sales grow. But inflationary pressures upsurge.

(iii) During the late-cycle phase, taking place prior to recession, the economy build-up gradually becomes saturated. Inflation threats keep rising. Inventories increase while sales drop. Economic growth is severely restrained and ready to slip into a recession free fall.

(iv) Typically the recession is the shortest of the stages of the business cycle. This phase represents a contraction in economic activity. Economic growth stalls. Corporate profits decline and credit is scarce. Inventories gradually fall despite low sales levels. In this way, the recession phase prepares a set up for a recovery during the early phase of the next cycle.

Below we provide an economic explanation of why IR sensitivity switches in line with phases of the business cycle. We present the discussions on IR sensitivity dependence on the business cycle in the following sub-sections.

5.2.1. "Normal" interest rate sensitivity: the mid-cycle and late-cycle

Under the "normal" regime of the mid-cycle and late-cycle, the sensitivity of the capital gains/losses of the EM Sovereigns portfolios to the capital gains/losses of the corresponding UST portfolios is positive.

I.e., the ups and downs in the risk-free IR are passed through to the respective bond yields unchanged or slightly augmented. Therefore, we posit that moderate gradual changes in the risk-free IR do not affect the level of financial hardship of sovereign entities if considered from the point of view of government operations.

It is a plausible statement as creditworthiness of a government could be equated to the aggregate creditworthiness of the corporate and financial sectors of the economy, plus its own tax collection and borrowing capacity, both not supposed to be considerably influenced by moderate changes in such macroeconomic variable as IR.

This is especially true for both, the "old normal" pre-crisis regime, March 2004 — June 2007, and the "new normal" post-crisis regime, April 2013 — June 2017, as the capital gains/losses of EM Sovereigns are related to the capital gains/losses in the corresponding UST portfolio as 1.07 to 1 and 1.09 to 1, respectively. The fact that the capital gains sensitivity is slightly above 1 signifies that sovereign government creditworthiness is slightly reduced/improved by an increase/decrease in IRs. This could be attributed to the embedded leverage inherent in sovereign debt, mainly due to the EM governments' propensity to borrow, among other factors. Still, as sensitivity coefficients are quite close to 1, it means that market participants interpret the creditworthiness of the governments rather as not depending on the risk-free IRs.

We ascribe "normal" regime of IR sensitivity to periods of a normal to moderate economic growth. This is a plausible statement as both, the mid-cycle phase and the late-cycle phase, feature the economic expansion, its initial and saturating phases respectively. Changes in the risk-free IR do not considerably affect the perception of the probability of default. The spreads remain quasi-unaffected, and the capital gains sensitivity is positive.

Discussing the EM Sovereigns portfolios, we certainly refer to global economic growth dynamics. Still, we posit that our reasoning also holds for the regional scale analyses as well as for the studies of sovereign debt behavior in isolated geographies.

5.2.2. "Distressed" interest rate sensitivity: recession and sharp early-cycle recovery

Now we discuss the negative capital gain-based sensitivities of the EM Sovereigns portfolio under the "distressed" regime, i.e., the sharp contraction and recovery of the economy. In other words, the "distressed" regime is but a passage through a bust of a bubble to the economic bottom and then back to economy as usual.

“Distressed” interest rate sensitivity during a recession-driven downturn: During the vicious cycle of a recession phase, markets enter into the risk-off mode and the risk-free IR behavior exhibits a downtrend dynamics due to the increasing demand for the safe assets. To stimulate the investment necessary to turn things around, central banks usually adopt a policy of reducing IRs. Hence, yields on risk-free assets drop and capital gains are registered in portfolios consisting of UST securities.

In parallel, the overall worsening of the economy augments the credit risk of the EM governments through several mechanisms. Tax collection perspectives get worse due to the lower demand for products and services as uncertainty increases, which adversely impacts individuals, corporations, and financial institutions.

Regarding the financial side, governments’ ability to service their debts potentially becomes undermined due to the eventual necessity to bailout systemically important financial institutions in order to keep the banking sector operational. Otherwise, the collapsing financial sector implies stalling economy, and decaying tax revenues. Thus, sovereign default risk keep growing and governments’ capacity to obtain external financing worsens. Financing costs of Sovereigns keep augmenting.

Under such conditions, there is a lot of uncertainty in the EM sovereign debt market. On the contrary, the demand for safe UST securities causes their yields to drop and prices to rise. Simultaneously, because of flight-to-quality phenomena investors withdraw their funds from relatively risky EM Sovereigns investments (Gubareva and Borges, 2016). Thus, the yields on the EM sovereign bonds rise and the prices drop. Risk-free rates are falling, but the EM sovereign spreads are widening.

The increase in the EM sovereign default risk, provoked by the above-mentioned factors, makes the EM sovereign spreads get wider in such a manner that yields on these relatively risky assets grow even though yields on risk-free assets drop. I.e., the EM sovereign spread widens more than the risk-free rates drop. Hence, capital losses occur in risky EM Sovereigns portfolios. Therefore, capital gain-based IR sensitivity of the EM Sovereigns reveals itself as negative under the sharp downturn deterioration of economic conditions.

Therefore, IRs decrease, the sovereign risk premia rise in such a manner that the EM Sovereigns spreads widening is superior to the drop in the risk-free rates, determined by the prices of the UST securities. It is but the well-known flight-to-quality phenomenon described here through the prism of a global economy impact on the EM governments, on one hand, and the US state, on the other. This phenomenon results in capital losses in risky EM Sovereigns portfolios, and simultaneously leads to capital gains of portfolios composed by the UST instruments.

"Distressed" interest rate sensitivity during a sharp recovery from recession:

During the early-cycle phase, which is but a recovery from a flight-to-quality, i.e., during a "flight-from-quality", markets enter into the risk-on mode. As the economy sharply recovers the demand for the safe assets drops. Decaying prices for risk-free assets make the risk-free IR rise. Capital losses are registered in UST portfolios.

Simultaneously, this economic recovery results in a decrease in the EM sovereign default risk. Tax collection perspectives become more optimistic due to the higher demand for products and services as uncertainty decreases and consumer confidence improves. Thus, individuals, corporations, and financial institutions are positively impacted by the early-cycle recovery.

Regarding the financial side, governments' ability to service its debt potentially gets better due to the reduced risk of eventual bailouts of systemically important financial institutions. The banking sector returns to fully operational conditions. This helps to accelerate economy, results in more stable expectations regarding future tax revenues. Thus, sovereign default risk keep decreasing and governments' capacity to obtain external financing improves. Financing costs of sovereigns are falling.

Credit spreads of the EM Sovereigns tighten so that the yields on risk assets drop even though the yields on risk-free assets grow and, hence, capital gains occur in the EM sovereign debt portfolios.

Capital gain-wise IR sensitivity of the EM Sovereigns, as during the recession phase, remains negative also during the phase of an early-cycle sharp recovery from the recession.

Wrapping up, during the early-cycle phase, when the risk-free IRs increase, the sovereign risk premia decline in such a manner that the spreads are tightening faster than the risk-free yields widening. That is but a recovery from the well-known flight-to-quality phenomenon. This "flight-from-quality" leads to capital gains experienced by the relatively risky EM Sovereigns portfolios and to capital losses of portfolios composed by the UST instruments.

It is worth noting, that in the present research the "distressed" regime is considered to contain only the two following phases of the business cycle: the recession and a sharp early-cycle recovery. For the "distressed" regime our results are somewhat in line with the findings of Dupoyet et al. (2016), which state that the average change in IRs (credit spreads) is negative (positive) during periods of recession while the average change in IRs (credit spreads) is positive (negative) during periods of economic expansion.

However, the caution is needed. In contrast to Dupoyet et al (2016), where all the business cycle is used to explain the alleged consistent negative relation between credit spread and IRs observed over 1973-2014, the present paper evidences such negative relation only for the two phases of the business cycle: the recession and a sharp early-cycle recovery.

For the two other stages of the business cycle, which features normal to moderate economic growth, namely, the mid-cycle and the late-cycle phases, our results deeply contrast with the above-cited research. We evidence that under the "normal" regime of the mid-cycle and the late-cycle expansion, the negative relation between IRs and credit spreads disappears and turns to be null or slightly positive.

Note, that under the "normal" regime of the mid-cycle and the late-cycle we observe positive, superior to 1, sensitivity of the capital gains of the EM Sovereigns portfolios to the capital gains of the UST portfolios. On the contrary, under the distressed regime of the EM turbulence at the beginning of the century and during the global crisis-driven recession and the following sharp recovery from the recession, we observe switching of a capital gain-based sensitivity to negative values. This finding can add value to the intermediate-term hedge strategies by considering a business cycle in the development of IR hedging mechanisms.

5.3. Additional Considerations

At the end, does it make an economic sense to hedge interest risk of the USD-denominated EM sovereign debt by short positions in UST bonds? As we have evidenced, such hedge makes sense only over the periods of normal to moderate economic expansion: during the mid-cycle and the late-cycle phases.

On the contrary, in times of economic turmoil, it is advisable even to augment exposure to IRR in order to hedge against downside risk. In sum, we argue that the hedging of IRR and downside risk should not be mechanical, but ought to be a dynamic process linked to phases of the business cycles.

If the capital gain-based sensitivity is negative, hedging IRR would not reduce the volatility of the profit and loss. Thus, a business cycle approach to IR hedging can add value as part of intermediate-term hedge strategies.

6. CONCLUDING REMARKS

We develop the framework to assess an IR sensitivity of the EM sovereign bond portfolios based on the EM blended yield index. Our research advances well beyond the widely performed studies of the relation between IRs and risk spreads as we investigate the bottom line profit and losses of risky and risk-free modeled portfolios. The proposed technique of capital gain-based IR sensitivities assessment provides new insights into the IR risk hedging and the downside risk protection mechanisms.

The historical span of our research covers the period 1999-2017, which enables us to assess IR sensitivity of the EM sovereign debt during the EM turbulence around the beginning of the century, and also during the development, apogee, and the aftermath of the recent global financial and economic crisis. Our results contrast with the results of previous empirical works and their theoretical interpretations, as previously all phases of business cycle were used to explain negative responses of credit spreads to IRs while we show that in fact it is not so.

We explicitly indicate that the mid-cycle and the late-cycle phases of a moderate to restrained global economic growth correspond to the insensitivities or slightly positive sensitivities of spreads to IRs, i.e. null or slightly positive response of credit spreads to risk-free IRs. We observe negative responses of credit spreads to IRs only during the recession and a sharp recovery from the bottom. In terms of capital gain-based IR sensitivities during the mid-cycle and the late-cycle phases, we observe positive IR sensitivity of the relatively risky portfolios containing EM sovereign bonds to the capital gains of the risk-free UST bond portfolios.

During recession and a sharp early-cycle recovery from recession we observe switching from positive to negative capital gain-based IR sensitivities and demonstrate that IR sensitivity rotates in accordance with different phases of the business cycle. We evidence a phenomenon of a binarity of IR sensitivity along phases of the business cycle and observe regime dependent behavior of sensitivity documenting three switches between different positive and negative ranges. Thus our findings suggest that the hedging of downside risk ought to be a dynamic process linked to phases of the business cycle.

Our approach permits to solve an apparent controversy between structural model applied to the sovereign issuers, (Merton, 1974; Gray et al. 2007; and François et al. 2011) and Kamin and Kleist (1999) approach. The former model advocates that the level of IRs influences creditworthiness of obligors approach, while the latter argues that changes in the risk-free rates are passed through entirely or even slightly augmented to the yields of the relatively risky EM assets, maintaining creditworthiness of obligors practically unchanged.

On one hand, we demonstrate that for the mid-cycle and late-cycle phases of a moderate to restrained growth, the capital gain-based IR sensitivity is positive. Hence, the Kamin and Kleist (1999) approach fits better our empirical observations.

On the other hand, it is shown that during the EM related turbulence as well as during the distressed conditions of the global recession and the sharp recovery from the recession the structural model considerations provide a better theoretical explanation of the observed negative sensitivities. Thus, the clue to the solution of this controversy resides in a binary behavior of IR sensitivities of risky assets "privileging" either one or another model along the cycle.

Examining behavior of asset sensitivity to IR along the phases of the business cycles we corroborate with our idea presented in our parallel research, see Gubaeva and Borges (2016 and 2017a), that an integrated treatment of the IRR and credit risk allows improving risk assessment and optimizing economic capital of banks and financial institutions.

Looking ahead, we can affirm that the applicability of the developed herein index-based methodology to gauge IR sensitivity is considerably wider than the EM sovereign debt. Depending on availability of blended yield and average coupon indices and/or average price indices, it can be applied to diverse portfolios containing fixed-income assets from diverse geographies, sectors, and rating categories.

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