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The Impact of Euro Adoption on Sovereign Credit Ratings and Long-term Rates

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Abstract

The paper investigates the impact of euro adoption on sovereign credit ratings and on long-term rates experienced until the 20th anniversary of the euro. The three pillars of the research are (1) the analysis of the scoring methodology of Credit Rating Agencies, (2) the empirical investigation of the 'euro privilege' in the ratings of Fitch, Moody's and S&P, and (3) in the long-term rates. We find that the methodology of ratings allows an upgrade up to 2 rating notches from admission to the Exchange Rate Mechanism II to joining the euro. The euro privilege was estimated with the Arellano-Bond generalized method of moments (GMM) and the difference-in-difference (DD) estimators. The euro privilege fluctuated in the range of 0-1 notch before the financial crisis, and reached its 1.5 notch maximum at the peak of the crisis and disappeared during the euro crisis. The benefits from euro adoption for long-term rates are more difficult to justify empirically in general. Although improved credit quality, lower liquidity and FX risk and access to ECB operations played a role in case of some later euro adopters in lowering funding costs, for some Member States euro privilege was not confirmed in long-term rates. Results are relevant for current and candidate euro area members, as they allow an estimate of some of the benefits and sometimes costs of euro adoption and may shed light on the importance of deepening the Economic and Monetary Union and strengthening the international role of the euro further.

JEL classification: G24, E58, E61, E62

1 Introduction

This paper reconsiders the impact of euro adoption on sovereign credit ratings and long-term bond rates. New candidates (Bulgaria and Croatia) announced their intention in 2019 to enter the Exchange Rate Mechanism (ERM II), the so-called waiting room of the European single currency. Hence, our results are useful to show benefits and possible costs of euro area membership for both existing members and candidates thus provide incentives for deepening the Economic and Monetary Union (EMU).

A key advantage of euro adoption remains to be the improved country risk profile from integrating deeper in the euro area's institutional framework that may support compressing funding costs, and the elimination of currency mismatches for euro entrants. According to the methodology of CRAs, the adoption of the euro directly influences the reserve currency status (see further discussion of this issue in Section 2). Moreover, credit rating agencies value the indirect and second order economic, fiscal and institutional impacts of the euro adoption, as it may help finance the fiscal deficit and debt, improve institutional and structural qualities of debtors, synchronize business cycles and decrease the probability of asymmetric shocks.

On 1 March 2017, the European Commission published a White Paper on the future of Europe. The Commission (2017) paper finds that safe assets are essential for modern financial systems and the euro area needs a common safe asset that would be comparable to the US Treasury bond. With the Rome Declaration signed on 25 March 2017, EU leaders committed to "working towards completing the Economic and Monetary Union; a Union where economies converge".

Wiegand (2017) gives evidence of a significant euro privilege in International Investor Country Credit Ratings (IICCR) in the 2000s, but not in S&P ratings. His study showed that the premium in ICCR disappeared in the wake of the euro crisis in 2010, it has recently returned, although at a reduced size. Nominal convergence in candidate Member States of the euro area was supported by the establishment of the European Central Bank (ECB) and by the acceptance of euro area members' government bonds as eligible collateral. It strengthened and confirmed expectations about the benefits from euro adoption especially for economies exposed to higher interest rates before the introduction of the euro Ehrmann et al. (2011). Although the gravity force of the euro area on non-euro EU Member States decreased due to the euro area crisis, the author finds that euro adoption continues to hold advantages for highly euroized economies.

Kunovac and Panic (2017) show the existence of a euro privilege – after controlling for the dynamics in the macroeconomic fundamentals and market sentiment. The euro area members have been enjoying on average lower borrowing costs and higher credit ratings than other EU Member States. The euro area Member States' CDSs spreads were, on average, 10% lower than in other countries in the sample from 2007 to 2016. This estimate is equivalent of a 1-2 notch lower credit rating. Aizenman et al. (2013) estimate the pricing of sovereign risk for sixty countries based on fiscal space (debt/tax; deficits/tax) and other economic fundamentals over 2005-10. Their dynamic panel estimates of the model suggest that fiscal space and other macroeconomic factors are statistically significant and economically important determinants of market-based sovereign risk.

Bartels and Weiser (2015) study whether the euro area is treated differently by institutional investors compared to other sovereign debtors outside the euro area. They find that core euro area members do not seem to be held responsible for the bail-out of other members. However, credit assessment of GIIPS (Greece, Ireland, Italy, Portugal and Spain) economies could have overrated creditworthiness in the 2000s, and this bias was corrected during the crisis. These countries could have enjoyed a large but not significant privilege before the onset of the crisis and a large and significant debt penalty after 2008.

Engels (2020), Maggiori (2013) showed that the US dollar earns a safety premium versus foreign currencies and that this premium is particularly high in times of global financial stress. During such periods, investors are willing to earn negative expected returns as compensation for holding safe assets. Fagan and McNelis (2020) found that the availability of external financing from the common central bank reflected in TARGET balances greatly mitigates the collapse in GDP, consumption and investment during sudden stops (relative to a regime in which such financing is notavailable).

Wolswijk and de Haan (2005) argued that the euro introduction eliminated the exchange rate risks of issuers and helped the achievement of sovereign debt managers goals in Member States to finance public debt at low costs and risk in the early years of euro area establishment.

Several Credit Rating Agencies (CRAs) communicated both before and after the 2008-9 global financial crisis that euro adoption improves the credit worthiness of sovereign issuers and hence their ratings, Barriga Salazar et al. (2019), Kraemer and Mrsnik (2014). The access to the reserve currency status of the euro and plausible drop of the weight of foreign currency (FC) debt in public sector debt eliminates the risk of self-fulfilling currency crises, supports foreign demand for domestic financial assets and adds to fiscal and external financing flexibility.

Eichengreen (2007), however, argued that the euro area disintegration could have never been excluded, not even before the single currency existed. Neither then was it likely that one or more members of the euro area would leave in the next ten years nor it is likely now, complete disintegration of the euro area was even less likely. Still, in some euro area member states, where slow growth was combined with high and unsustainable debt burdens, policy makers and politicians might be tempted from time to time to reintroduce their former national currency to generate inflation and depreciate debt value. However, doing so would result in credit-rating downgrades, higher sovereign spreads and an increase in interest costs, as investors foresee and react to the government's actions.

Euro adoption has an indirect impact on long-term bond rates too. Long-term rates are subject to changes in risk-premia, expected future real rate and expected future inflation, Amisano and Tristani (2019). Kucera et al. (2017) argued that some investors prefer sovereign bonds to other assets, mainly because of their low credit risk, their relatively high market liquidity, their low haircuts when used as financial collateral, and their preferential regulatory treatment. Euro adoption may influence several of these factors, especially the risk-premia component (credit risk, country risk, liquidity risk, ECB collateral eligibility and haircuts) and expected future inflation.

Building upon the aforementioned literature, this paper examines the significance of the euro privilege for the sovereign credit risk and funding cost dynamics. The empirical analysis is based on panel regressions and two types of estimators: (i) the Arellano-Bond generalized methods of moments (GMM) estimator and (ii) the difference-in-difference (DD) estimator. The advantage of the GMM estimator is that it builds on the entire dataset and is less subject to effects of particular events related to the 2008-2011 crisis, as these may overlap with the euro adoption and hence bias the case study type of DD estimation results. On the other hand, the advantage of the difference-in-difference (DD) estimator is that it is less influenced by the problem of time-varying treatment/control group (euro adopters/non-euro countries). Using both estimators can be interpreted as a two-way robustness check of findings.

Our regression results are more certain in case of the credit rating regressions compared to the long-term rate regressions. Both the GMM estimator and the DD estimator supports the conclusion that euro adoption was likely to improve the credit worthiness of sovereign issuers and hence their ratings before the 2009 financial crisis, and in some Member States even afterwards. Hence, it confirms the methodology and communication of credit rating agencies that the membership in the monetary union is "credit positive". The euro privilege varied in the range of 0-1 notch before the financial crisis, reached its 1.5 notch maximum at the peak of the crisis and disappeared during the euro crisis.

Benefits of euro adoption for funding costs are more difficult to justify empirically in general. Although improved credit quality, lower liquidity and FX risk and access to ECB operations play a role in case of some later euro adopters in lowering funding costs, for other Member states euro privilege was not confirmed in long-term rates. The GMM estimator suggests a euro privilege except for the period of the euro debt crisis in 2011-12. The estimated coefficients of the euro adoption, e.g. the difference in difference parameters show, however, large dispersion from minus 5 percentage points (Latvia, long-term real rates) to plus 2 percentage points (Cyprus and Malta, long-term government bond rates). Perhaps breaching the DD estimator's parallel trend assumption in some cases caused the great variation in results of the DD estimators. As a matter of fact, the time period of the treatment (euro adoption) overlapped with the economic surveillance and financial assistance programs in some Member States which make it difficult to clearly separate the effects of the crisis from the euro adoption on small case-by-case euro adoption samples. Although we attempted to solve these problems by broadening our dataset (time, control variables) the short period of experience with the euro and the large variation in results leads us not to draw general conclusion on long-term rates similarly to sovereign credit ratings. The only exemption is the case of the 1999 euro introduction in 11 EU Member States. This period did not overlap with global crisis events of the currency zone. The 1999 adoption suggests that there was neither immediate funding benefit for the EMU11 nor significant funding disadvantage compared to Denmark, Sweden and the United Kingdom. It should be noted however, that the countries in the control group could have benefited from the euro area creation too, especially Denmark which conducts a fixed exchange rate policy and closely follows the ECB's monetary policy. Hence, the euro privilege could be partly priced in Danish long-term rates without adopting the common currency, and our results may reflect the credibility of the Danmarks Nationalbank rather the (lack of) euro privilege in the rating of euro adopters.

The contribution of our study to the current debate is morefold. First, as a starting point we investigate the inputs, outputs and outcomes of sovereign ratings: the indicators and methodology of major CRAs (inputs), the actual ratings (outputs) and their impact on government bond rates and economic costs of government debt (outcomes). Earlier studies focused on outputs (ratings) and not on outcomes (financial consequences of ratings). Second, we investigate all three major CRAs case-by-case. Third, our analysis is carried out on a panel data set that is richer than those used by previous studies and covers a wider set of indicators used by CRAs for all EU28 Members States. Finally, we applied an improved empirical set-up for the identification of the euro privilege by using both the Arellano-Bond generalized methods of moments (GMM) estimator and the difference-in-difference (DD) estimator. Our paper can also provide evidence on the impacts of the common EU approach to regulate and supervise Credit Rating Agencies. The CRA Regulation was introduced in 2009 and aims at enhancing the integrity, responsibility, good governance and independence of credit rating activities to ensure quality ratings and high levels of investor protection.

The rest of the paper is structured as follows. Section 2 describes the indicators and rating methodology of Credit Rating Agencies, in particular how CRAs take into account the adoption of the euro. Section 3 summarizes the determinants of long-term rates. Section 4 presents our empirical model and data. Section 5 discusses the results. Section 6 concludes.

2 Euro Adoption in the Methodology of the Credit Rating Agencies

This chapter investigates how Fitch, Moody's and S&P take into account various credit risk factors and in particular euro adoption in their methodology.

Ratings have been based mostly on scorecards in the past and more and more on models recently. These evaluate sovereigns by four to six different pillars of credit risk (I. Economic, II. Fiscal, III. Institutional/Structural, IV. External assessment, V. Monetary Assessment, VI. "Event risk"). The pillars of credit rating agencies include more or less the same indicators, grouping of them is however different. (see the detailed list of indicators used by Fitch, Moody's and S&P in Appendix - A).

Table 1. Pillars of credit ratings

PILLARS		**S&P**	**Fitch**	**Moody's**
I.	Economic	X	X	X
II.	Fiscal	X	X	X
III.	Institutional/Structural	X	X	X
IV.	External	X	X	
V.	Monetary	X		
VI.	"Event risk"			X

Source: Credit Rating Agencies, 2020.

The adoption of the euro directly influences the reserve currency status. Earlier rating actions often highlighted the benefits of the euro, in particular reduced exchange rate risks and access to ECB liquidity and institutional support, Eglitis et al. (2014). Moreover, credit rating agencies value the indirect and second order economic, fiscal and institutional impacts of the euro adoption, as it may help finance the fiscal deficit and debt, improve institutional and structural qualities of debtors, synchronize business cycles and decrease the probability of asymmetric shocks. There are, however, significant differences how Fitch, S&P and Moody's value euro adoption, especially the reserve currency status (See the next subsections of this section for further details).

The I. Economic pillar of the rating methodology includes indicators measuring the general conditions in the economy influencing debt-bearing capacity and resilience of sovereigns, e.g. the economic growth indicators (real GDP growth, per capita GDP growth, etc.), metrics of inflation and credit boom indicators etc..

The II. Fiscal pillar consists of the key fiscal analysis indicators capturing the overall health of government finances (general government's balance, its assets, liabilities and debt, interest payments, sovereign exposure to the banking sector, foreign currency denominated debt, etc.).

The III. Institutional pillar covers indicators to measure the effectiveness and transparency of political institutions which support the government conduct sound economic policies fostering economic prosperity to refinance debt. Most CRAs follow indicators like GDP per capita, broad money supply, track record of debt payment, inflation volatility, the Worldwide Rule of Law Index, the Worldwide Control of Corruption Index, etc.

The IV. External pillar and VI. Event risk pillar (Moody's) are based on the reserve currency flexibility, official reserve metrics, and balance of payment indicators (current account balance, net foreign direct investment, foreign reserves, terms of trade, etc.). Erhart (2019) gave evidence of the importance of external indicators in early recognition of sovereign debt crisis situations.

The V. Monetary pillar (S&P) results from the analysis of the credibility of the sovereign's monetary policy achievements, as measured, among other factors, by inflation and from the assessment of the exchange rate arrangement.

2.1 Fitch

Fitch recently assessed euro adoption in central and eastern European (CEE) countries for sovereign creditworthiness and concluded that the benefits of euro area membership outweigh the costs and therefore have positive rating impacts, Barriga Salazar et al. (2019). The key benefit is the access to the reserve currency status of the euro and a likely reduction of the share of public sector debt denominated in foreign currency (FC). Therefore, everything else being equal, Fitch would be likely to upgrade Long-Term FC Issuer Default Ratings (IDRs) of new euro area entrants by two notches from admission to the Exchange Rate Mechanism (ERM II) to joining the euro.

Fitch considers that the risk of self-fulfilling currency crisis is eliminated with reserve currency status. The reserve currency status supports foreign demand for domestic financial assets and adds to fiscal and external financing flexibility. Further advantages are the lower risk of foreign currency debt in "euroised" economies, the access to the credible monetary policy framework and liquidity facilities of the European Central Bank (ECB).

The reserve currency flexibility (RCF) score in Fitch's Sovereign Rating Model (SRM) is based on the share of a country's currency in global reserves (in the IMF COFER, Currency Composition of Official Foreign Exchange database). Euro membership is currently worth 1.8 notches. If a country has a "reserve currency" status, the official foreign reserves no longer adds to its score in the SRM, which can reduce partly the positive "reserve currency" effect by about 0.1-0.2 notches. However, the overall net effect of a "reserve currency" in the SRM is largely positive.

The SRM score of a sovereign with 100% of its debt denominated in euros would improve by 0.57 notches on joining the euro. In sum, Fitch's SRM would suggest a two-notch uplift of the FC Issuer Default Rating over the process from admission to ERM II to joining the euro in almost all scenarios. Fitch furthermore highlighted the potential second-order positive effects of euro adoption on public finances and macro-economy without naming them. Fitch has also acknowledged that no model can fully understand all factors of sovereign creditworthiness. Therefore, the agency conducts its assessment of euro adoption case by case.

As the SRM does not reflect the benefits of euro area accession until the date the country formally adopts the euro, Fitch raises the rating via adjustments to its Qualitative Overlay. Fitch revises the outlook of the long-term (LT) foreign currency (FC) rating to Positive once the sovereign formally submits its letter of intent on joining the ERM II and Fitch deems the prospect of joining the ERM II and EMU to be credible, Barriga Salazar et al. (2019). If the country is formally admitted into ERM II, the LT FC rating would be upgraded by one notch, if Fitch expects the country to stay in the ERM II will be short and joining EMU to be credible. Furthermore, the LT FC rating would be upgraded by one notch, if the European Council's Economic and Financial Affairs Council (ECOFIN) formally agrees for the country to join the EMU (following a recommendation from both the European Commission and the ECB). The above mentioned changes would be likely to be implemented in the External Finances category, as Fitch sees this area where euro adoption could have the highest positive impact.

The most recent EU Member States which adopted euro were the Baltic countries: Estonia in January 2011, Latvia in January 2014 and Lithuania in January 2015. Fitch took a number of positive rating actions in the run-up and accession to EMU. The FC ratings for the three countries were raised by one to two notches, Barriga Salazar et al. (2019).

2.2 Standard and Poor's (S&P)

Standard & Poor's views membership in a monetary union as "credit positive", Kraemer and Mrsnik (2014). Similarly to Fitch, S&P raises sovereign ratings already on envisaged euro adoption. Eurorzone membership is seen likely to directly benefit in most cases the monetary and external scores of sovereigns, the two key rating factors in the methodology of S&P with reference explicitly to monetary union membership.

S&P's monetary assessment for sovereigns in monetary unions is a two-step process, Standard and Poor's (2017). The first step assigns an initial assessment for the monetary union as a whole. The second step of the monetary assessment can lower the initial assessment by one category to reflect if members of monetary unions generally have less flexibility, other things being equal, relative to sovereigns having an independent central bank. S&P also considers how much the economy of a monetary union member is (un)synchronized with the zone as a whole. However, these adjustments are not taken if members account for more than 50% of the zone's GDP. In sum, a final assessment of a monetary union member can be up to four categories away from an initial assessment of the monetary zone.

Standard and Poor's also deems that external risks are lessened in situations where the respective monetary authority issues a widely used international currency. The control over an "actively traded currency" supports the sovereign's access to funding sources in domestic currency outside the national jurisdiction. Such sovereign issuers may be less exposed to shifts in investors' portfolios, especially in cases where the common currency is used as an official foreign exchange reserves ("reserve currency").

Standard & Poor's defines an "actively traded currency" if it accounts for more than 1% of global foreign exchange turnover (based on the Bank for International Settlements' Triennial Central Bank Survey). The "reserve currency" status is given if a currency's share is more than 3% of the world's total allocated foreign exchange reserves based on the IMF's data (Currency Composition of Official Foreign Exchange Reserves).

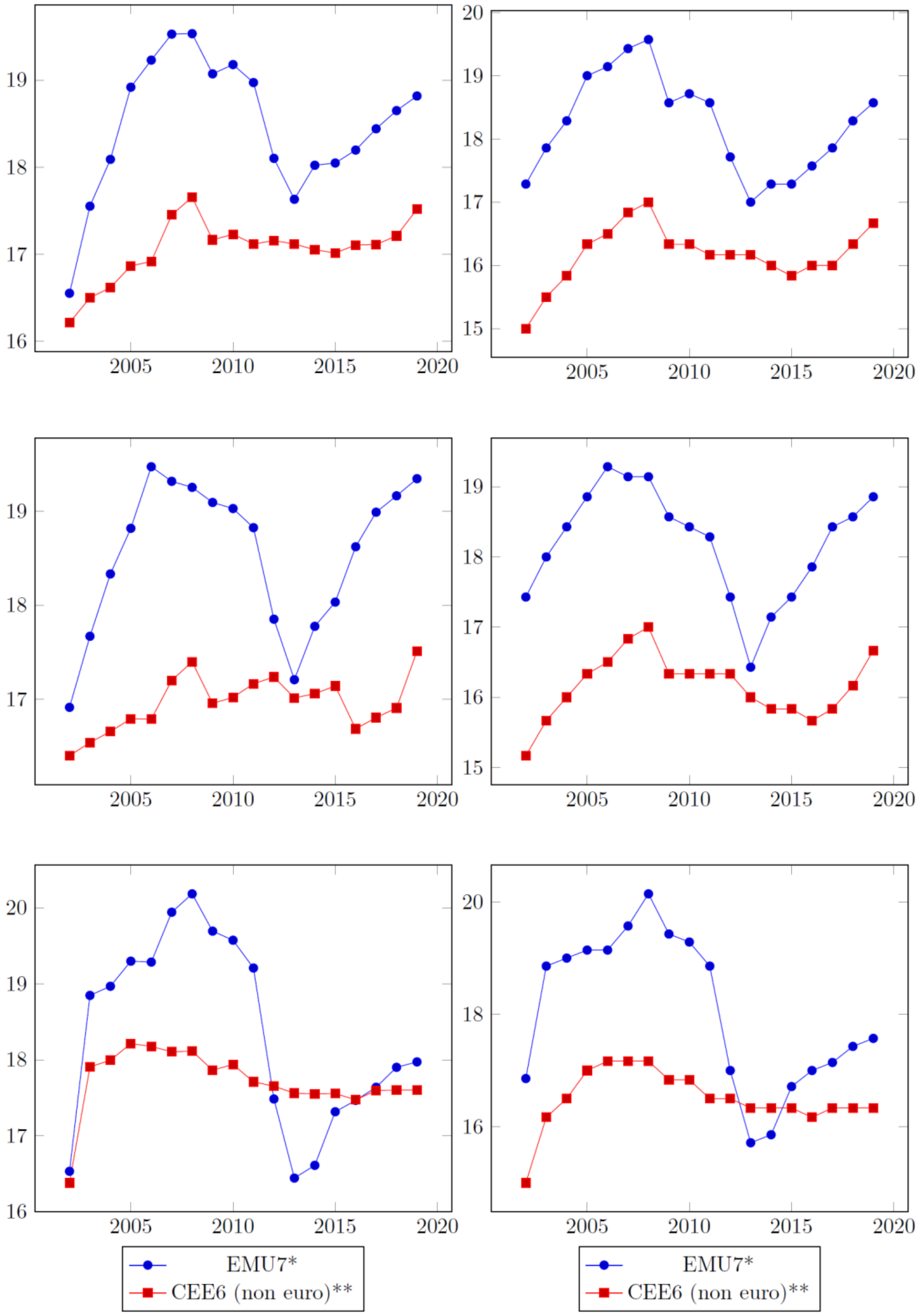
According to S&P, the world's monetary authorities view sovereign bonds issued by France and Germany as preferred euro-denominated instruments as they are (a) issued by highly rated sovereigns and (b) benefit from a deep and liquid secondary market. Therefore, S&P deems that no other sovereigns in the euro area enjoy the same two advantages to the same extent. The monetary score of sovereign issuers comprises two subscores, the nature of the exchange rate regime, and the assessment of monetary policy's credibility and effectiveness as well as inflation trends.

S&P starts scoring monetary flexibility at the monetary union level, which in the case of the euro area is "1", the highest (on a scale from 1 to 6). This score is based on "the ECB's monetary policy flexibility supported by the euro's role as a reserve currency, the euro's free-floating exchange rate regime, and the credibility of the ECB's monetary policy". The union-wide monetary score is applied to each sovereign member, but then lowered for each sovereign's monetary score by one (to "2") to reflect that the ECB's policy can not perfectly match the need of individual sovereigns, but of the euro area overall. Furthermore, if the economic conditions are unsynchronized with the euro area, an additional negative adjustment is applied (to "3").

S&P evaluated that its theoretical framework was consistent with its rating record of sovereigns joining EMU, both for founding members and later adopters. It typically raised the ratings, if it viewed that euro adoption was becoming highly likely.

S&P also communicated that their methodology assigns no value to EU membership per se. However, the accompanying economic benefits of membership can be a rating factor, Standard and Poor's (2015). S&P stressed that abandoning EU membership would be negative for creditworthiness, both for the exiting member states and for the EU itself.

Figure 1. Ratings in EMU7* and CEE6** countries, GDP weighted average (right panel) and arithmetic average (left panel) (linearized scale, top Fitch, middle S&P, bottom Moody's)



Notes: *EMU7 = Cyprus, Estonia, Lithuania, Latvia, Malta, Slovakia, Slovenia. **CEE6 (non euro) = Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania.

Ratings are converted into a linear numerical scale, where at one end AAA rating equals 24 and default equals 1.

2.3 Moody's

Moody's (2018) gives preferential weight for reserve currency countries. The weights of Debt Burden and Debt Affordability for reserve currency countries are 10% and 90%, respectively, while for Highly Indebted Poor Countries (HIPC) and IDA countries (supported by the International Development Association), the weights are 100% and 0%, respectively.

According to Moody's a reserve currency is a currency that is held in significant quantities by central banks as part of their foreign exchange reserves. Japan, Switzerland, United Kingdom and the US are considered as reserve currency countries by Moody's. The euro is seen as a reserve currency, only in case of Germany and France as the two largest member states have the extent of influence over the ECB's monetary policy to support analysis as 'reserve currencies'.

Like other CRAs Moody's assigned some credit enhancement after stable ERM II experience, adequate policy discipline of the involved governments. Elimination of currency risk results in an upward adjustment of country ceilings at the time of euro adoption.

3 Euro adoption and long-term rates

The behaviour of interest rates and the background determinants are thoroughly discussed in the literature on finance and monetary policy. The policy importance of interest rates is manifested in the 1993 Maastricht Treaty, which defined five convergence criteria, to measure progress in Member States readiness to adopt the euro, including a criteria on long-term interest rate stability.

The convergence criteria stipulate that: interest rates observed over a period of one year before the examination should not exceed by more than two percentage points that of the three best performing Member States in terms of price stability. Interest rates shall be measured on the basis of long-term government bonds or comparable securities.

Fulfilment of the Maastricht-criteria is mandatory ex-ante the euro adoption, still the sustainability of convergence has been an issue since the 2008-2009 crisis, del Hoyo et al. (2017) Here, we investigate empirically whether the euro adoption had a favourable impact on long-term rates ex-post. Therefore, we back-test the theory of endogeneity of currency areas and whether sharing a single currency may set in motion forces bringing countries closer together, De Grauwe and Mongelli (2005).

Euro adoption has an indirect impact on long-term bond rates. Long-term rates are subject to changes in risk-premia, expected future real rate and expected future inflation, Amisano and Tristani (2019). Kucera et al. (2017) argued that some investors prefer sovereign bonds to other assets, mainly because of their low credit risk, their relatively high market liquidity, their low haircuts when used as financial collateral, and their preferential regulatory treatment. Euro adoption may influence several of these factors, especially the risk-premia component (credit risk, country risk, liquidity risk, ECB collateral eligibility and haircuts) and expected future inflation. Borio et al. (2018) summarize the recent strand of literature on further determinants of long-term interest rates (productivity, output growth, monetary policy, risk premia, return on capital, monetary policy variables, etc.) which were built in our empirical set-up.

4 Empirical assessment of earlier euro adoptions

4.1 Empirical set-up

Our workhorse regression is based on a linear dynamic equation (1) similarly to Wiegand (2017), D'Agostino and Lennkh (2016).

$$R_{it} = \rho R_{it-1} + X'_{it}\beta + \theta_t + \delta_i + \lambda_t EUR_{it} + \gamma ERM_{it} + \mu EU_{it} + u_{it} \quad (1)$$

R_{it} is the sovereign credit rating of country (i) in year (t), X'_{it} a vector of input indicators of CRAs (see in Appendix A), θ_t and δ_i are a country/time-dummies that control for unobserved country characteristics and common macro-economic shocks, and u_{it} is an independently distributed error term. λ_t, γ and μ are the coefficients of euro zone dummy (EUR_{it}), EU membership dummy (EU_{it}) and the European Exchange Rate Mechanism dummy (ERM_{it}) to measure euro, EU and ERM 'privilege' beyond what is explained by macroeconomic fundamentals. We allowed λ_t to vary across years to control for the possibility that the euro privilege granted by rating agencies changes over time. We did not use similar time-varying coefficients for the EU and ERM dummies to simplify our estimation and its interpretation.

Sovereign credit ratings show strong persistence, hence Equation (1) includes lagged ratings. This could lead to correlation between the unobserved panel-level effects and the lagged dependent variables, making standard estimators inconsistent. Therefore, we estimated Equation (1) with the Arellano-Bond generalized methods of moments (GMM) estimator.

Furthermore, we apply another commonly used method, the difference-in-difference (DD) method to compare the euro effect in the 'treatment' group (EU Member States which adopted the euro) to a control group (EU Member States, which never adopted the euro) as suggested by Conti (2014). We choose the CEE6 countries in case of later adopters as a control group, and the country group of Denmark, Sweden and the United Kingdom as a control group for the 1999 adopters. The goal of this alternative empirical approach is to reduce the problem of the time-varying nature of the euro area and the control group of non-euro countries. The DD estimator compares ratings, and long-term rates in the euro area before and after the euro adoption with the characteristics in the control group.

$$R_{it} = \alpha_t + \varphi_1 dPost_{it} + \varphi_2 dTreat_{it} + \varphi_3 dPost_{it} dTreat_{it} + X'_{it}\beta + u_{it} \quad (2)$$

In Equation 2 variable R_{it} denotes either the sovereign credit rating or the long-term rate, variable $dPost_{it}$ is a time dummy which take the value of one after the euro introduction and zero otherwise, $dTreat_{it}$ is another dummy that equals one in euro area member $country_{it}$ and zero otherwise. Finally, X'_{it} is a vector of control variables based on CRA's input variables to reduce the bias from potential differences in time trends (see the variables in the Appendix), and u_{it} is the independently distributed error term. Goodman-Bacon (2018) gave evidence that if treatment effects are not constant over time, which is very likely in case of euro adoption, the use of already treated units as controls necessarily biases estimates of the treatment effect. Hence, the control group (non-euro CEE 6 countries, e.g. Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania) was kept unchanged in the DD specification for later euro adopters and we used the DK, SE and the UK as a control group for the original big-bang euro adoption in the EMU11 in 1999.

Both the GMM estimator and the DD estimators have advantages and disadvantages. The former takes into account the persistence of the outcome variable and uses a larger sample to identify the euro adoption impact. The latter, the DD estimator is more precise but exposed to the risk that some of its assumptions are not held. For example, the partial overlap of euro adoption periods with the 2008-2009 crisis and with the euro debt crisis (2011-2012) may have negative effect on the precision of the DD estimator in countries which needed financial assistance and economic surveillance.

4.2 Data

The analysis is carried out on a panel dataset that is richer than those used by previous studies and covers a wider set of input indicators used by CRAs for all EU28 Members States. Bruha et al. (2017) identified on the basis of a broad empirical literature review that GDP growth, inflation, external and public debt, external reserves, level of economic development, and country's default history as most important variables. The fundamentals vector X'_{it} includes indicators of credit rating pillars (I. Economic, II. Fiscal, III. Institutional/Structural, IV. External assessment, V. Monetary Assessment, VI. "Event risk")[1].

Equation (1) and (2) are estimated with annual data for 28 EU Member States with a time span of 2002–2018. Equation (2) was estimated on a longer time span (1999-2018) in case of the original EMU11 Member States. Ratings were linearized similarly to earlier studies (1 - default to 24 AAA rating).

The data sources of our panel estimations are the IMF World Economic Outlook database, World Bank, Bloomberg, Eurostat, AMECO database, the Fitch Ratings Interactive Sovereign Rating Model's (SRM) input database, the Bank of Canada and the Bank of England Credit Rating Assessment Group (CRAG) sovereign default database, the database of the European Commission on members of the EU, euro area and Exchange Rate Mechanism, the Trading Economics Database. As a robustness check, we compared our data collected from official and other statistical sources to the input indicators of Fitch Ratings's Interactive (SRM) Sovereign Rating Model's database and we found no discrepancy.

Credit ratings of the three CRAs exhibit high correlations, which suggest that the CRAs measure the same fundamental concept of sovereign credit quality similarly at large (Table 2).

Table 2. Pairwise correlation of CRA's sovereign credit ratings

	Fitch	Moody's	S&P
Fitch	1.00		
Moody's	0.98	1.00	
S&P	0.98	0.97	1.00

[The data can be downloaded as a Mendeley dataset: https://data.mendeley.com/datasets/ymjbffrnrm/1]

Changing membership in the EU and euro area provides an opportunity to identify and measure the value of EU, euro area membership and ERM participation. New countries joined the European Union recently in 2004 (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia), in 2007 (Bulgaria and Romania) and Croatia in 2013. Euro was adopted by Slovenia (2007), Cyprus (2008), Malta (2008), Slovakia (2009), Estonia (2011), Latvia (2014) and Lithuania (2015) in the sample.

[1] ECONOMIC PILLAR: Real GDP growth (%), CPI (%), Unemployment rate (%), Investment ratio (% of GDP), GDP volatility (%), II. FISCAL PILLAR: General Government Debt (% of GDP), General government deficit (% of GDP), BoC-BoE CRAG sovereign default value (% of GDP), Foreign Currency Debt (% of GG debt), Recent default (0-1), Sovereign Net Foreign Assets (% of GDP), III. INSTITUTIONAL PILLAR: Share in World GDP (ln), Worldwide Governance Indicator (percentile rank), Broad money (% of GDP), ERM Member State (dummy), EU Member State (dummy), IV. EXTERNAL/EVENT RISK PILLAR: Current account + net FDI (% of GDP), External Interest Service (% of CXR), Net International Investment Position (% of GDP), V. MONETARY PILLAR: Eurozone Member State (dummy)

5 Results

Table 3 and Figure 2 report the workhorse regression results with Equation (1) for CRAs (column (1) - Fitch, column (2) S&P, column (3) Moody's in Table 3).

5.1 Fundamental pillars of sovereign ratings

Ratings show strong stickiness, the coefficient of the lagged ratings is large (0.4) and statistically highly significant for all three CRAs. Our results also help to draw a clear picture about the key indicators driving sovereign credit ratings. Credit Rating Agencies seem to agree on the importance of fiscal indicators: indebtedness and default history variables have significant explanatory power in case of all CRAs. This finding confirms the results of Aizenman et al. (2013).

Table 3. Regression results with Equation 1 on sovereign credit ratings (Arellano-Bond GMM estimator)

	(1) Fitch	(2) S&P	(3) Moody's
L.Sovereign Credit Rating	0.439***	0.395	0.416
Share in World GDP (ln)	1.227***	0.300	0.644
Worldwide Governance Indicator (percentile rank)	0.0683***	0.0869***	0.0910***
Real GDP growth (%)	0.0438***	0.0446***	0.0374**
CPI (%)	-0.0483***	-0.0446**	-0.101***
Unemployment (%)	-0.0736***	-0.104***	-0.0712***
Investment (% of GDP)	0.00257	-0.00461	-0.00293
GDP volatility (%)	-0.00640	0.0332	-0.0944
Current account + net FDI (% of GDP)	0.000151	0.00127	-0.000885
Net International Investment Position (% of GDP)	0.000427	-0.00193	-0.00827**
External Interest Service (% of CXR)	-0.00592	0.00501	0.0157
Sovereign Net Foreign Assets (% of GDP)	0.00386	0.00214	0.0103***
Broad money (% of GDP)	-0.00293	-0.00124	0.000160
General Government Debt (% of GDP)	-0.0282***	-0.0404***	-0.0502***
Foreign Currency Debt (% of GG debt)	-0.0111**	0.000146	-0.00597
General government deficit (% of GDP)	-0.0235	-0.0258*	-0.0655***
Recent default	-2.797***	-0.968*	-1.421*
BoC-BoE CRAG sovereign default value (% of GDP)	0.315	-2.179***	-2.869***
EU Member State (dummy)	-0.0185	0.102	-0.0740
ERM Member State (dummy)	-0.173	0.0732	-0.306
Eurozone Member State (dummy)	0.345	0.244	0.558
Constant	15.67***	9.422**	11.65***
Observations	435	436	434

Notes: This table reports the sign, value and significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$) of the estimated parameters of Equation 1 for the model specifications on sovereign credit ratings of (1) Fitch, (2) S&P and (3) Moody's. Equation 1 is estimated with the Arellano-Bond general methods of moments (GMM) estimator. The lag operator is denoted L. in the first row of the table and operates on the ratings.

As for other pillars of the rating methodology, the Worldwide Governance Indicator turned out to be the key institutional indicator and the real GDP growth, CPI and unemployment rate as the major economic indicators, all having the expected sign (better governance, stronger growth, lower unemployment and inflation all result in improved ratings). More surprisingly, external imbalance indicators were mostly insignificant, except for the Net International Investment Position in case of Moody's.

Our basic results confirm the results of other authors Wiegand (2017), D'Agostino and Lennkh (2016) about the stickiness of ratings, and the importance of basic economic, fiscal variables.

5.2 Euro privilege in ratings

Table 3 presents the average coefficient of the Euro area membership and Figure 2 shows how the estimated euro privilege changed over time. The average euro privilege parameters are estimated to be positive for the entire sample, although insignificant. The time-varying euro area coefficient was in the range of 0.3-0.6 notch and significantly higher than zero in most years and for all three CRA's before the financial crisis after controlling for macroeconomic and institutional indicators of ratings. The euro privilege coefficient reached its maximum in case of all rating agencies at the outburst of the financial crisis in 2008-9 (1.0-1.5 notches). Most likely, credit rating agencies valued the eligibility of sovereign bonds issued by euro area member state governments to ECB operations most at the time of the extreme levels of market stress and liquidity squeeze in government bond markets.

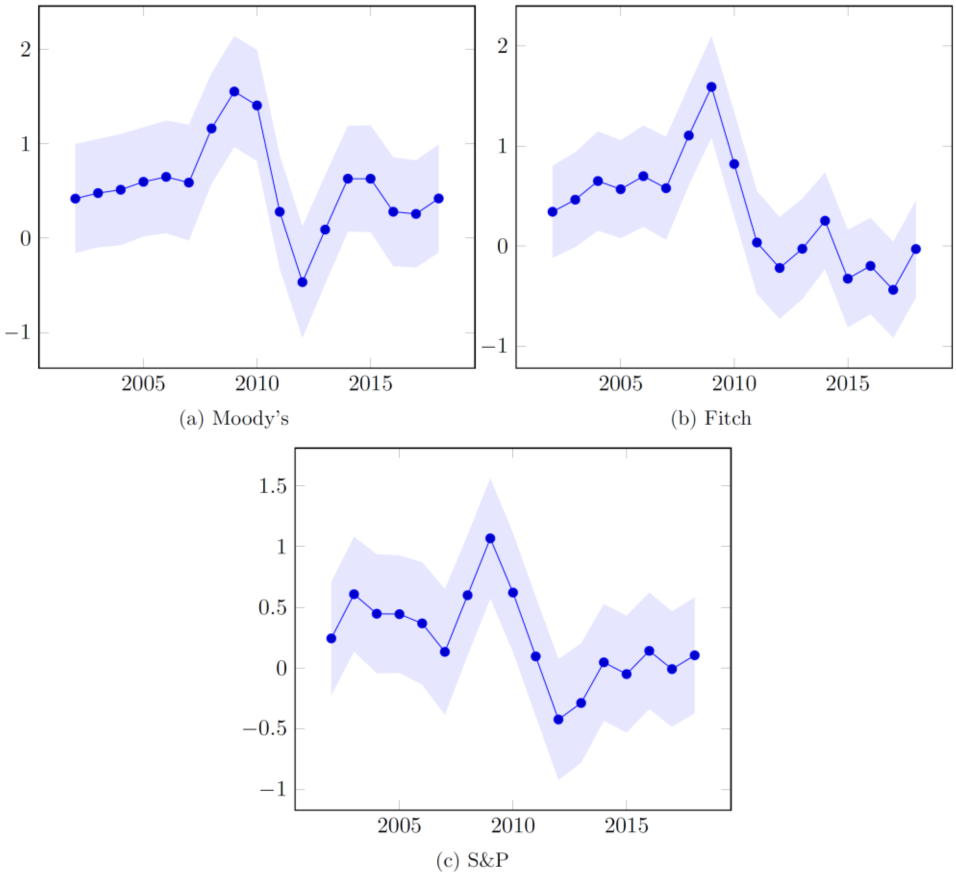
The estimated euro privilege fell sharply during the most severe years of the euro area debt crisis in 2011-2012, and remained not significantly different from zero afterwards. In case of Moody's, which seems to value the euro privilege most conservatively (see its methodology in Section 2), the privilege was estimated to fell lowest into the negative territory (-0.5 notch) in 2012 at the 10 percent significance level. This finding is in line with its methodology. Moody's grants reserve currency status only to Germany and France as these two largest member states have significant influence over the ECB's monetary policy.

Our results confirm the extreme risk aversion recorded by van Riet (2017) following the Franco-German Declaration of Deauville of October 2010. The declaration demanded a private sector involvement in resolving the Greek sovereign debt crisis and foreign official institutions drastically cut their reserve holdings of euro area government debt at the turn of 2011 and 2012 while keeping German bonds in their portfolios. Standard and Poor's (2015) placed all euro area sovereign ratings on CreditWatch with negative implications in December 2011, and downgraded nine of them the following month. One reason for the rating actions was the view "that the effectiveness, stability, and predictability of European policymaking and political institutions have not been as strong, Standard and Poor's (2012).

Our estimations are in line with the results of Wiegand (2017) finding, in general, no positive statistically significant premium for euro area membership for S&P ratings with the exception of only 2009. In sum, the euro privilege seems to become less important recently, but in extreme situations the privilege can become again significantly positive (in case of global shocks) or negative (in case of intra-euro area problems or shocks). In the former case, the euro adoption can be considered as an insurance, in the latter there is no advantage or disadvantage of the euro.

Also, our results corroborate the euro privilege communicated by CRAs, although its value is being somewhat smaller. An explanation could be that the weights of macroeconomic factors changed over time, as proposed by Bartels and Weiser (2015), Beirne and Fratscher (2013). Credit assessment of most vulnerable euro member states enjoyed debt privilege before the onset of the crisis (increasing the estimated value of euro privilege) and a large and significant debt penalty after 2008 (compressing the estimated euro privilege). Also, the privilege communicated by some CRAs referred to foreign currency ratings, which were significantly lower than local currency ratings for emerging countries although to a lesser extent recently, Amstad et al. (2018). One should interpret the estimated coefficient of the Euro area dummy with a pinch of salt, as the euro area and non-euro zone changed continuously in our sample, while CRAs rate the privilege ceteris paribus. In each year our estimated privilege is over a time varying non-euro area. Furthermore, the privilege may feed into the fundamental input variables of ratings which may bias the estimated euro area privilege. Conti (2014) for example showed that the euro adoption has a positive effect on growth rates.

Figure 2. Estimated euro privilege in sovereign credit ratings (in notches, and the 5-95% shaded confidence interval)



Notes: The figures show the time-varying coefficients of euro area membership for (a) Moody's, (b) Fitch and (c) S&P and the shaded 5-95% confidence interval by estimating Equation 1.

Table 4 presents the difference-in-difference (DD) estimation results with Equation 2. The DD estimator is the difference in average outcome (sovereign credit rating) in the EU Member States which adopted the euro recently (EMU11 in 1999, Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2014, Latvia in 2014, Lithuania in 2015). It shows the difference before and after treatment minus the difference in average outcome in the control group (CEE6 Member States which never adopted the euro for later euro adopters and Denmark, Sweden and the United Kingdom for the core euro area, EMU11 countries) before and after treatment. Goodman-Bacon (2018) gave evidence that if treatment effects are not constant over time, which is very likely in case of euro adoption, the use of already treated units as controls necessarily biases estimates of the treatment effect. Hence, the control group (non-euro CEE 6 countries, e.g. Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania) was kept unchanged in the DD specification for later euro adopters.

The estimated coefficients of the euro adoption, e.g. the difference in difference parameters (φ3 in Equation 2) are mostly positive although only significant in case of Slovakia and Estonia. The euro privilege is measured by the DD estimator confirms the results of the Arellano-Bond GMM estimator. In both cases euro privilege in sovereign ratings varied in the range between -0.3 and 1.5 notches for those countries where the DD estimation results are less influenced by crisis events of the Member States.

Table 4. Regression results on sovereign credit ratings with Equation 2 by euro adopter countries and the EMU11 group (difference-in-difference DD estimator)

	(1) Fitch	(2) S&P	(3) Moody's	(CG) Control Group
EMU11 (1999)	0.61	0.34	0.77	DK, SE, UK
	[-0.450,1.659]	[-0.696,1.369]	[-0.521,2.052]	
Slovenia (2007)	-0.13	0.33	-1.26	CEE6
	[-1.352,1.100]	[-1.072,1.725]	[-2.875,0.364]	
Cyprus, Malta (2008)	0.31	-1.23	1.41	CEE6
	[-0.920,1.533]	[-2.614,0.151]	[-0.0701,2.894]	
Slovakia (2009)	1.59***	1.39*	0.33	CEE6
	[0.675,2.495]	[0.224,2.560]	[-0.735,1.406]	
Estonia (2011)	0.87	1.65**	0.35	CEE6
	[-0.0417,1.779]	[0.564,2.733]	[-0.783,1.479]	
Latvia (2014)	0.91	0.34	0.66	CEE6
	[-0.0188,1.834]	[-0.832,1.502]	[-0.471,1.787]	
Lithuania (2015)	-0.27	1.06	0.08	CEE6
	[-1.596,1.064]	[-0.558,2.673]	[-1.464,1.632]	

Notes: This table reports the sign, value and significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$) of the estimated euro privilege parameters of Equation 2 for the model specifications on sovereign credit ratings of (1) Fitch, (2) S&P and (3) Moody's by euro adopter countries and the EMU11 group. Equation 2 is estimated with the difference-in-difference (DD) estimator. The table reports the φ3 parameters and the 5-95% confidence intervals of the estimated parameter in square brackets [] below each parameter.

5.3 Time-varying coefficients

As our sample covered the complete life-cycle of the recent financial crisis (boom, crisis and bust) which may have influenced the CRA's sensitivity to input variables, we test whether parameters have changed in time.

Equation (3) is similar to Equation (1) with two exceptions: (i) coefficients of input indicators are allowed to vary in time, but (ii) λ, the coefficient of euro zone membership (EUR) is not allowed. X'_{1it} and X'_{2it} include the same indicators but are always complementary. X'_{2it} allows always the parameter of only one regressor to vary in time, which is left out from X'_{1it}. D_t is a dummy that takes on value 1 if an observation falls in a specific year (t).

$$R_{it} = \rho R_{it-1} + X'_{1it}\beta_1 + D_t X'_{2it}\beta_{2t} + \theta_t + \delta_i + \lambda EUR_{it} + \gamma ERM_{it} + \mu EU_{it} + u_{it} \quad (3)$$

Figures of time varying coefficients can be found in Appendix.

The coefficient of the real GDP growth has almost always a positive impact on credit ratings. Its explanatory power increased significantly in the period of 2010-2014, e.g. in the most serious years of the euro debt crisis, when debt-bearing capacity became more of a concern in the euro area. The coefficient of the government debt is significant and negative for the entire period with an increase in the period of 2011-2012. Another indicator of fiscal stance, the sovereign net foreign assets became significant in 2011-2012. The negative coefficient of the CPI dropped slightly over time, however its confidence interval became also wider, suggesting increased uncertainty about the inflation outlook recently. Interestingly, the current account coefficient fluctuated in the negative range except for 2011, meaning that CRA's did not value negatively higher deficits in the good times before the euro crisis, and in times of macroeconomic adjustments after the crisis. The coefficient of the NIIP (Net International Investment Position) tells a similar story, CRAs ordered negative value to this indicator of external vulnerability in 2011-2012, but in other years the indicator was insignificant. Darvas (2019) argued that current-account surpluses, or close to balanced positions, helped to reduce external vulnerability, however further convergence would require current-account deficits, which can boost domestic investment. This argument could be an explanation why the parameter of the current account balance increased in the crisis, but fell below zero recently.

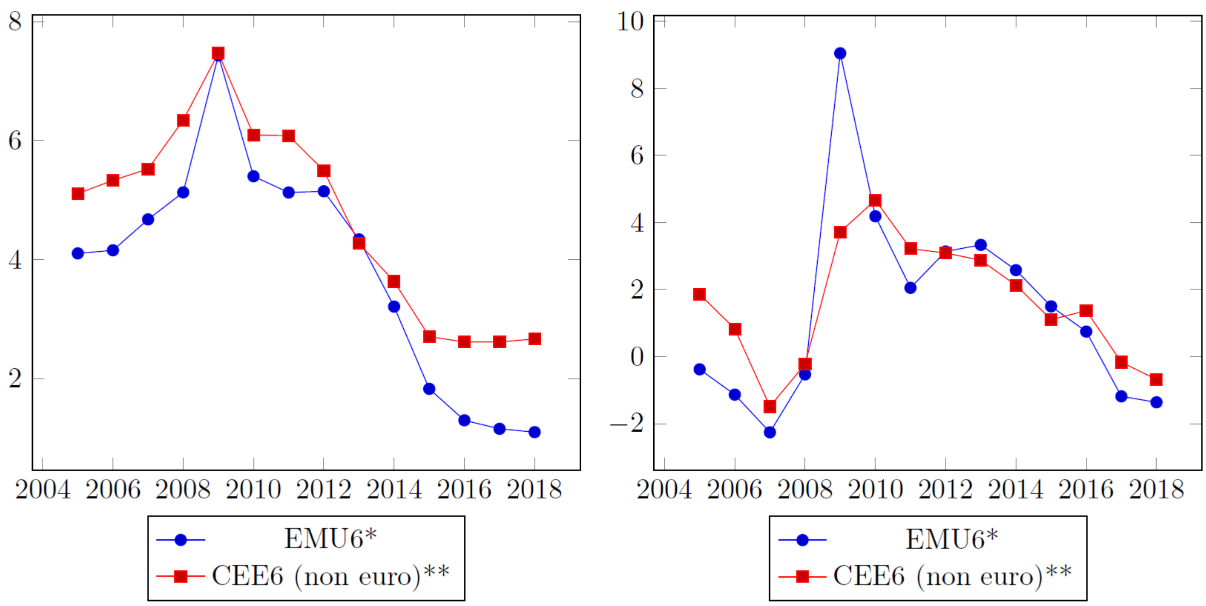
Overall, our results confirm the findings of D'Agostino and Lennkh (2016), Wiegand (2017) that the crisis changed some of the underlying parameters of CRA's sovereign ratings.

5.4 Euro privilege in long-term government bond rates

Long-term bond rates manifest several factors from risk-premia and expected future real rate to expected future inflation, Amisano and Tristani (2019). Hence, bond rates are excellent candidates for the analysis of the euro privilege. Most investors prefer sovereign bonds to other assets, mainly because of their low credit risk and because of their relatively high market liquidity, their low haircuts when used as financial collateral, and their preferential regulatory treatment (Kucera et al. (2017)). Euro adoption may influence several of the above mentioned factors, especially the risk components (credit risk, foreign exchange risk, country risk, liquidity risk) and expected future inflation. Euro area sovereign bonds are eligible to the European Central Bank operations as a collateral or as an eligible security to the asset purchase program, which influence their usability, value and pricing.

As a first descriptive approach we compared the long-term bond rates and long-term real rates of those EU members, which joined the EU in 2004 and afterwards, by dividing them into two groups (Figure 3). Exploring the real rates as an alternative interest rate may be appropriate as it is the real rate that matters for the government in the end. In the (i) first group those countries were selected which have later adopted the euro (Cyprus, Lithuania, Latvia, Malta, Slovakia, Slovenia), (ii) in the second group those which have not (Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania). These countries together can be seen as a homogeneous group otherwise, they are all emerging countries, with increasingly independent monetary policy, and have been progressing with structural reforms. Estonia was left out, because no long-term rate data for Estonia is available. Euro privilege can be observed except the most severe years of the crisis, in particular after the asset purchase program of the ECB.

Figure 3. Long-term government bond rates and real rates in EMU6 and CEE6 countries (%)



(a) 10 year gov. bond rates (b) Long-term real rates

Notes:
*EMU6 = Cyprus, Lithuania, Latvia, Malta, Slovakia, Slovenia. (No long-term rate data for Estonia is available.)
**CEE6 (non euro) = Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania

Our more advanced empirical approach was based on Equation (4), a linear dynamic equation, similar in nature to Equation (1) estimated on ratings:

$$y_{it} = \kappa y_{it-1} + X'_{it}\,\beta + \theta_t + \delta_i + \lambda tEUR_{it} + \gamma ERMit + \mu EU_{it} + u_{it} \quad (4)$$

y_{it} is the long-term rate in country (i) (proxied by the nominal 10 year government bond rate or by the long term real rates or by the private sector long-term rates) in year (t), interpretation of all other variables and parameters are similar to those in Equation (1) except for regressors of further fundamental determinants of interest rates. We augmented Equation (1) by adding (i) the short-term rate, (ii) a dummy variable of the zero lower bound and (iii) the inflation expectations to control for differences in monetary policy and (iv) labour productivity per employed persons, (v) net return on non-financial corporations' capital to the X'_{it} vector of explanatory variables. The short-term rate data was downloaded from the European Commission's AMECO database and the zero-lower dummy was given the value of one if short-term rates were below zero and zero otherwise. The IMF World Economic Outlook inflation forecasts were used to measure the inflation outlook. The data source of labour productivity per employed persons, and the net return on capital was the Eurostat. Our long-term rate data source was the ECB's statistics on long-term bond rates and on long-term private sector borrowing costs, the European Commission AMECO database (long-term real rates).

Table 5. Regression results on long-term rates with Equation 4 (Arellano-Bond GMM estimator)

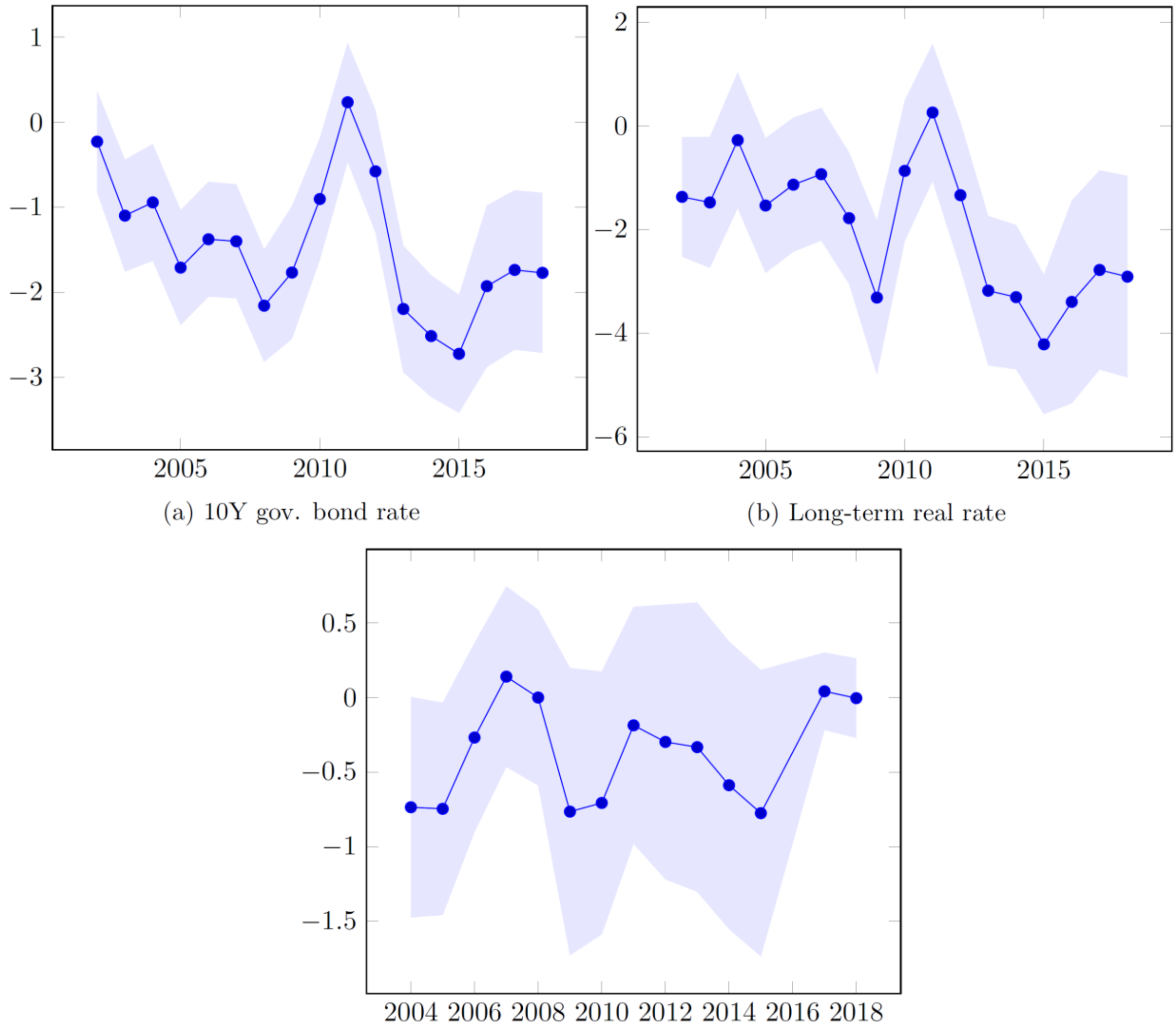
	(1) 10Y gov. b. rate (%)	(2) Priv. sect. (%)	(3) Real rate (%)
L.10Y gov. b. rate/Priv.sect. rate/Real rate (%)	0.0997*	0.605***	-0.03
Short-term rate (%)	0.441***	0.0436	0.572***
Zero lower bound (dummy)	-0.736*	-0.944	0.0630
CPI forecast (%)	-0.579***	0.117	-0.621*
Labour productivity (real, per person employed)	0.101**	-0.0489	0.275***
Return on capital (net, %)	0.000823	0.000183	0.00477*
GDP forecast (%)	0.113	-0.00196	0.152
Share in World GDP (ln)	2.237**	2.222**	-1.400
Worldwide Governance Indicator (percentile rank)	-0.110***	-0.0841***	0.0133
Real GDP growth (%)	-0.202***	0.0464	-0.522***
CPI (%)	0.153***	0.0659	-0.463***
Unemployment (%)	0.0965**	0.0210	0.0992
Investment (% of GDP)	-0.0343	-0.0275	-0.136**
GDP volatility (%)	0.139*	-0.117*	0.513***
Current account + net FDI (% of GDP)	-0.00488*	-0.000740	-0.00831*
Net International Investment Position (% of GDP)	0.00153	0.00247	-0.00226
External Interest Service (% of CXR)	0.0409*	-0.0325*	0.0793*
Sovereign Net Foreign Assets (% of GDP)	-0.0118***	0.00149	-0.0119*
Broad money (% of GDP)	-0.00599*	0.00137	-0.00451
General Government Debt (% of GDP)	0.00863	0.00476	0.00503
Foreign Currency Debt (% of GG debt)	-0.00255	-0.0298***	0.0108
General government deficit (% of GDP)	0.0533**	-0.00884	-0.0176
Recent default	0.709	1.250*	2.235
BoC-BoE CRAG sovereign default value (% of GDP)	4.506***	-1.773***	4.117**
EU Member State (dummy)	-0.354		0.174
ERM Member State (dummy)	-0.547*		-1.149*
Eurozone (dummy)	-1.45	-0.37	-1.97*
Constant	24.90***	21.21***	-4.944
Observations	407	200	419

Notes: This table reports the sign, value and significance (* p < 0.05, ** p < 0.01, *** p < 0.001) of the estimated parameters of Equation 4 for the model specifications on long-term rates, e.g. on (1) 10 year government bond rate, (2) long-term private sector borrowing costs (3) long-term real rates. Equation 4 is estimated with the Arellano-Bond general methods of moments (GMM) estimator. The lag operator is denoted L. in the first row of the table and operates on the long-term rates.

Estimating Equation 4 with the GMM method reveals that long term rates are persistent, albeit less than ratings except for the private sector long-term borrowing costs. The monetary policy control variables and few macroeconomic regressors have significant explanatory power (share in the World GDP, the Worldwide Governance Indicator, real GDP growth rate, consumer price inflation, GDP volatility, general government debt, sovereign net foreign assets, broad money and the BoC-BoE CRAG default value). The sign of some important macroeconomic and monetary policy variables are surprising (negative coefficient of inflationary and economic growth variables), though may be a consequence of unconventional monetary policy actions recently. The ERM Membership dummy had a significant negative coefficient in case of both the nominal and real rates, but EU membership dummy had no significant impact.

Figure 4 presents the time-varying euro privilege coefficient. The privilege was estimated to be negative for almost the entire sample period, e.g. lower financing costs for eurzone members is estimated in the range from 0 to 2 percentage points at the longer end of the yield curve compared to non-euro area EU countries. The euro privilege, although disappeared temporarily at the time of the euro debt crisis from long-term rates similarly to its disappearance from ratings, it appeared again after 2012 at the 5 % significance level, especially after the interventions of the ECB.

Figure 4. Euro privilege estimates in long-term rates (in percentage points, and the 5-95% confidence interval)



Notes: The figures show the time-varying coefficients of euro area membership for (a) 10 y government bond rate, (b) long-term real rates (c) long-term private sector borrowing costs and the 5-95% shaded confidence interval by estimating Equation 4.

The above results seem to corroborate the finding of Lemke et al. (2019) that the contemporaneous impact of the ECB asset purchase programs flattens the yield curve and amounts to around 95 bps for the 10y maturity. This impact may have added to the increasing spread between euro zone and non-euro zone countries and is comparable to the estimates for the Federal Reserve's asset purchase programmes.

Our empirical analysis with the Arellano-Bond GMM estimator finds that the long-term real rates (inflation adjusted 10 year government bond rate), which matter the most for debt management, may benefit the most from euro adoption (-2 pp lower long-term real rate of euro adopters on average). Although the government bond rate can be interpreted as a bottom or lower threshold for otherwise similar interest rates in the private sector, the transmission of euro privilege from the government rates to private rates is influenced by further risk characteristics of the private sector. The estimated euro privilege is, hence and not surprisingly, the smallest in case of the long-term private borrowing costs compared to long-term nominal and real rates.

Similarly to the rating analysis we cross-checked the workhorse regression results of the GMM estimator with Equation 4 by estimating Equation 2 with the difference-in-difference method. This helps lessen the possible problem of biases due to the time-varying nature of the euro area and the control group. Table 6 presents the DD estimation results with Equation 2. The DD estimator here is the difference in average outcome (long-term bond rates or long-term real rates or long-term private borrowing costs) in the EU Member States which adopted the euro (EMU11 countries in 1999, Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2014, Latvia in 2014, Lithuania in 2015).

Table 6. Regression results on long-term rates with Equation 4 by euro adopter countries and the EMU11 group (difference-in-difference DD estimator)

	(1) 10y gov. bond rate	(2) Long-term real rate	(3) Control Group
EMU11 (1999)	0.369	0.0478	DK, SE, UK
	[-0.915,1.653]	[-1.884,1.980]	
Slovenia (2007)	0.431	-3.235	CEE6
	[-0.942,1.804]	[-6.956,0.486]	
Cyprus, Malta (2008)	2.064	0.501	CEE6
	[-1.572,5.700]	[-9.106,10.11]	
Slovakia (2009)	0.729	-1.791	CEE6
	[-0.154,1.612]	[-4.524,0.943]	
Estonia (2011)	-	-	-
Latvia (2014)	-1.270	-5.066*	CEE6
	[-2.900,0.360]	[-9.709,-0.422]	
Lithuania (2015)	0.0808	0.775	CEE6
	[-1.885,2.047]	[-4.794,6.344]	

Notes: This table reports the sign, value and significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$) of the estimated euro privilege parameters of Equation 2 for the model specifications on long-term rates (1) 10 year government rate, (2) long-term real rate by euro adopter countries and the EMU11 group. Equation 2 is estimated with the difference-in-difference (DD) estimator. The table reports the $\varphi 3$ parameters and the 5-95% confidence intervals of the estimated parameter in square brackets [] below each parameter. No long-term rate data for Estonia is available, hence its row is left blank in the table.

The estimated coefficients of the euro adoption, e.g. the difference in difference parameters ($\varphi 3$ in Equation 2) show large dispersion from minus 5 percentage points (Latvia, long-term real rates) to plus 2 percentage points (Cyprus and Malta, long-term rates). Perhaps breaching the DD estimator's parallel trend assumption in some cases caused the great variation in results on long-term bond rates. As a matter of fact, the time period of the treatment (euro adoption) overlapped with the economic surveillance and financial assistance programs in some Member States which makes it difficult to clearly identify the effects of the crisis from the euro adoption in the same period. Although we attempted to solve this problem by broadening our dataset (time, control variables) the short period of experience with the euro and the large variation in results leads us not to draw general conclusion on long-term rates similarly to sovereign credit ratings. The only exemption is the case of the 1999 euro introduction in 11 EU Member States. This period did not overlap with global crisis events of the currency zone. The 1999 adoption suggest that there was neither immediate funding benefit for the EMU11 nor significant funding disadvantage compared to Denmark, Sweden and the United Kingdom. It should be noted however, that the countries in the control group could have benefited from the euro area creation indirectly too, especially Denmark which conducts a fixed exchange rate policy and closely follows the ECB's monetary policy.

Hence, the euro privilege could be partly imported by Denmark and priced in by compressing Danish long-term rates too without adopting the common currency, and our results may reflect the credibility of the Danmarks Nationalbank rather the (lack of) euro privilege in the euro area.

Results with the DD estimator are less mixed for the long-term real rate. The estimated effect varied in the negative range and on average were comparable to the 2 percentage point gain estimated by the GMM method, although the estimated 5-95% confidence intervals are rather wide.

Understanding better the relationship between euro adoption and funding costs in future may help to find the best debt management strategy and to optimally schedule the euro adoption in accordance. At the current level of general government debt (80-90 % of the GDP in the EU on average) every percentage point drop in funding costs is equivalent of 0.8-0.9 percent saving of the GDP for the governmental sector. Most vulnerable countries may benefit even more.

6 Conclusions

In this paper we investigated the impact of euro adoption on the sovereign issuers in three steps: (1) first, we analysed the scoring methodology of Credit Rating Agencies and the role of the euro adoption in the methodology, (2) second, we investigated the euro privilege in the sovereign credit ratings of Moody's, S&P and Fitch, and (3) third we estimated the euro privilege in long-term rates.

We find that the methodology of rating agencies allows an upgrade of credit ratings from the admission to the Exchange Rate Mechanism (ERM II) to joining the euro. Credit rating agencies value especially the reserve currency status of the euro. The reserve currency flexibility score in Fitch's model is currently worth 1.8 rating notches in case of euro zone membership. The S&P starts scoring monetary flexibility at the monetary union level, but scores each euro area member differently. Moody's is the most conservative, it sees euro as a reserve currency, only in case of Germany and France as the two largest member states have the extent of influence over the ECB's monetary policy.

Our panel econometric analysis strategy applied two estimation methods to identify the impact of euro adoption on sovereign ratings and funding costs (i) the Arellano-Bond general methods of moments (GMM) estimator and (ii) the difference-in-difference (DD) method. Both the GMM estimator and the DD estimator have advantages and disadvantages. The former takes into account the persistence of the outcome variable and uses a larger sample to identify the euro adoption impact. The latter, the DD estimator is less exposed to the problem of time-varying euro area and its control group, but may result in imperfect estimates if its assumptions are not held.

Our workhorse GMM regression analysis finds that the euro privilege varied in the range of 0.3-0.6 notch before the financial crisis after controlling for macroeconomic and institutional indicators of ratings in case of Fitch, but remained insignificant in case of Moody's. The euro privilege coefficient reached its maximum in case of all rating agencies at the outburst of the financial crisis in 2008-9 (1-1.5 notches). Most likely, credit rating agencies valued the eligibility of sovereign bonds issued by euro zone member state governments to ECB operations most at the height of market stress and liquidity squeeze in government bond markets. Our results corroborate the findings of Maggiori (2013) that reserve currency status pays-off especially in times of global financial stress. The estimated euro privilege fell sharply in case of all credit rating agencies during the most severe years of the euro zone debt crisis in 2011-2012, and remained not significantly different from zero afterwards.

Our results corroborate the euro privilege communicated by CRAs, although our estimated value of the privilege is being somewhat smaller. An explanation could be that the weights of macroeconomic factors changed over time, as proposed by Bartels and Weiser (2015). Also, the privilege communicated by some CRAs referred to foreign currency ratings, which were significantly lower than local currency ratings for emerging countries although to a lesser extent recently, Amstad et al. (2018). One should also interpret the estimated coefficient of the euro zone dummy with a pinch of salt, as the euro zone and non-euro zone changed continuously in the sample of the Arellano-Bond GMM estimations, while CRAs rate the privilege ceteris paribus. Finally, the privilege may feed into the fundamental input variables of ratings which may change the estimated euro area privilege. Conti (2014) for example showed that the euro adoption has a positive effect on growth rates. In other words, the estimated euro privilege coefficient could be also affected, if the privilege transmits through better/worse macroeconomic performance.

As for the key input indicators of ratings, not surprisingly CRAs seem to agree most on the importance of economic and fiscal indicators, these have significant explanatory power in case of all CRAs.

The euro privilege as measured by the DD estimator confirms the results of the Arellano-Bond GMM estimator. In both cases euro privilege in sovereign ratings varied in the range between -0.3 and 1.5 notches on average and have been varying across years.

Benefits from euro adoption for long-term rates are more difficult to justify empirically in general. Although improved credit quality, lower liquidity and FX risk and access to ECB operations played a role in case of some later euro adopters in lowering funding costs, for some Member States euro privilege was not confirmed in long-term rates. The privilege was estimated to be negative for almost the entire sample period with the Arellano-Bond GMM method, e.g. lower financing costs for euro area members in the range from 0 to 2 percentage points at the longer end of the yield curve compared to non-euro area EU countries. The euro privilege, although disappeared temporarily at the time of the euro debt crisis from long-term rates similarly to its disappearance from ratings, it appeared again after 2012 at the 5 % significance level, especially after the interventions of the ECB. Our empirical analysis finds that the long-term real rates, which matter the most for debt management, may benefit the most from euro adoption (-2 pp lower long-term real rate of euro adopters on average).

The difference in difference estimation results for the euro privilege in long-term rates show large dispersion across countries from minus 5 percentage points (Latvia, long-term real rates) to plus 2 percentage points (Cyprus and Malta, long-term rates). Perhaps breaching the DD estimator's parallel trend assumption in some cases caused the great variation in results on long-term bond rates. As a matter of fact, the time period of the treatment (euro adoption) overlapped with the economic surveillance and financial assistance programs in some Member States which makes it difficult to clearly identify the euro adoption and separate them from the effects of the crisis. It should be also noted however, that the countries in the control group could have benefited from the euro area creation indirectly too, especially Denmark which conducts a fixed exchange rate policy and closely follows the ECB's monetary policy.

Our results confirm the findings of D'Agostino and Lennkh (2016), Wiegand (2017) that the crisis changed some of the underlying parameters of CRA's sovereign ratings. When controlling for the time-varying nature of input indicators, the explanatory power of the real GDP growth increased significantly in the period of 2010-2014, e.g. in the most serious years of the euro debt crisis, when debt-bearing capacity became more of a concern in the euro area. The estimated coefficient of the government indebtedness is significant and negative for the entire period with a big increase in the period of 2011-2012. Another indicator of fiscal stance, the sovereign net foreign assets became significant in 2011-2012 as well.

The euro privilege is estimated to become less important recently, but in extreme situations the privilege can become again significantly positive (in case global shocks) or negative (in case of intra-euro area problems or shocks). In the former case, the euro adoption can be considered as an insurance, in the latter there is no advantage or disadvantage of the euro.

Our findings are relevant for current and candidate euro area members, as they allow an estimate of some of the benefits and sometimes costs of euro adoption and may shed light on the importance of deepening the Economic and Monetary Union and strengthening the international role of the euro further.

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Annexes

Annex 1. Fitch sovereign rating indicators

PILLARS	Indicators (Fitch)
I. Economic	Real GDP growth volatility Consumer price inflation Real GDP growth
II. Fiscal	Gross govt debt/GDP General govt interest (% of revs) General govt fiscal balance/GDP Foreign Currency govt debt/GGD
III. Institutional/Structural	Governance indicators Nominal GDP (USD bn) GDP per capita Share in world GDP Year of most recent default Broad money supply (% of GDP)
IV. External	Reserve currency flexibility Sovereign net foreign assets (% of GDP) Commodity dependence FX reserves (months of CXP) External interest service (% of CXR) Current account balance + FDI (% of GDP)
V. Monetary	
VI. "Event risk"	

Source: Fitch(2019)

Annex 2. S&P sovereign rating indicators

PILLARS	Indicators (S&P)
I. Economic	GDP per capita (USD) Real GDP per capita (% change) Consumer price index (% change) Depository corporation claims (% change) Monetary base Diversification Credit boom
II. Fiscal	Change in general government debt (% of GDP) Net general government debt (% of GDP) Interest payment General government liquid financial assets Volatility of revenues Gross general government debt/GDP (%) Foreign currency government debt Remaining maturity Non-resident share of general government debt Flexibility of tax regime UN development index Demography Other public sector debt Sovereign exposure of banking sector
III. Institutional/Structural	Effectiveness, stability, predictability and transparency of policymaking and political institutions Geopolitical and external security risk Debt payment culture
IV. External	Current account receipts (CAR) Current account payments (CAP) Status of reserve currency Local currency in circulation Official reserves Usable reserves Narrow net external debt/CAR or CAP (%) Net Foreign Direct Investment (% of GDP) Gross external financing needs (% of CAR plus usable reserves) Current account balance/CAR (%). Net International Investment Position Net foreign direct investment (FDI/GDP,%) Net external liabilities/CAR (%). Terms of trade
V. Monetary	Exchange rate regime Credibility and effectiveness of monetary policy Inflation Real exchange rate stability Level of financial inter-mediation
VI. "Event risk"	

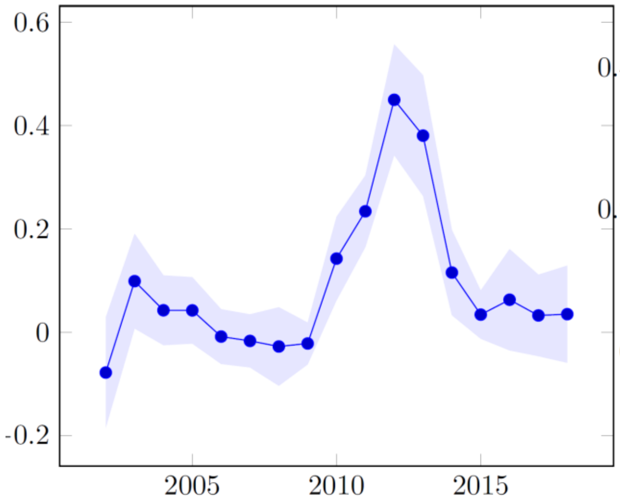
Source: S&P

Annex 3. Moody's sovereign rating indicators

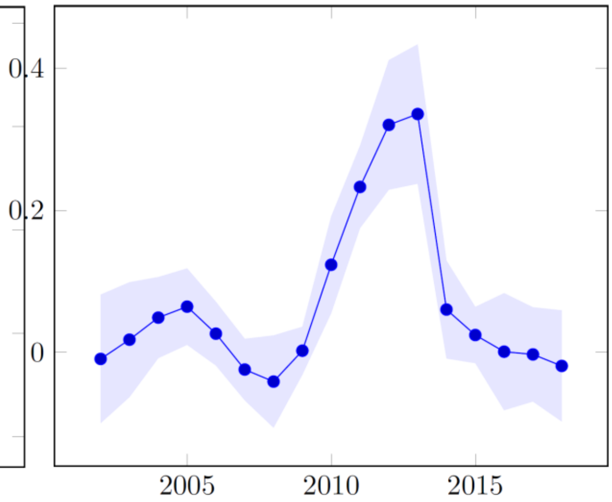
PILLARS	Indicators (Moody's)
I. Economic	Real GDP growth Real GDP growth volatility WEF Global Competitiveness Index Nominal GDP (USD) GDP per capita (USD, PPP) Credit growth compared to GDP growth rate
II. Fiscal	General Government Debt/GDP General Government Debt/Revenues General Government Interest Payments/Revenue General Government Interest Payments/GDP Debt Trend General Government Foreign Currency Debt/Total Debt Other Public Sector Debt/GDP Public Sector Financial Assets/General Government Debt Sovereign Wealth Funds/General Government Debt
III. Institutional/Structural	Worldwide Government Effectiveness Index Worldwide Rule of Law Index Worldwide Control of Corruption Index Inflation Level Inflation Volatility Track Record of Default
IV. External	
V. Monetary	
VI. "Event risk"	Worldwide Voice and Accountability Index GDP per capita Gross Borrowing Requirements/GDP (%) Non-Resident Share of General Government Debt (%) (Current Account Balance+FDI)/GDP Total Domestic Bank Assets/GDP Banking System Loan-to-Deposit Ratio (%) Moody's Market Implied Ratings External Vulnerability Indicator NIIP/GDP

Source: Moody's

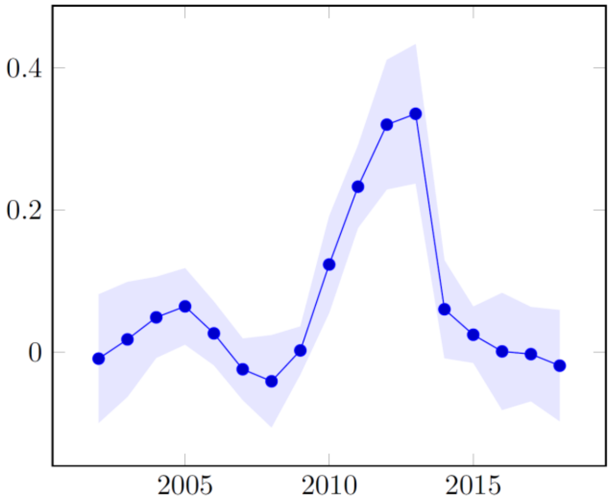
Annex 4. Real GDP growth coefficient estimates (in notches, and the 5-95% shaded confidence interval)



(a) Moody's



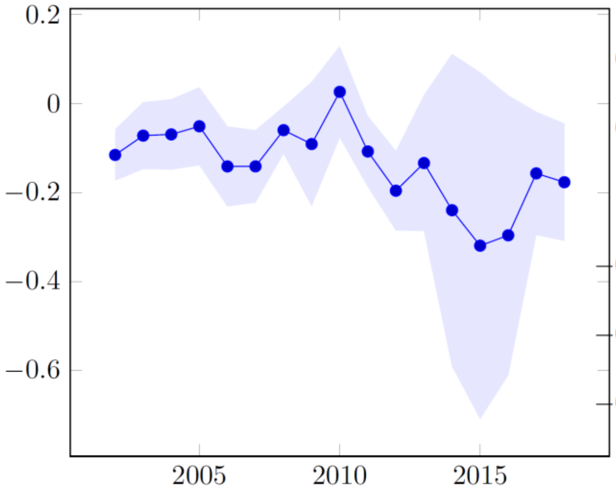
(b) Fitch



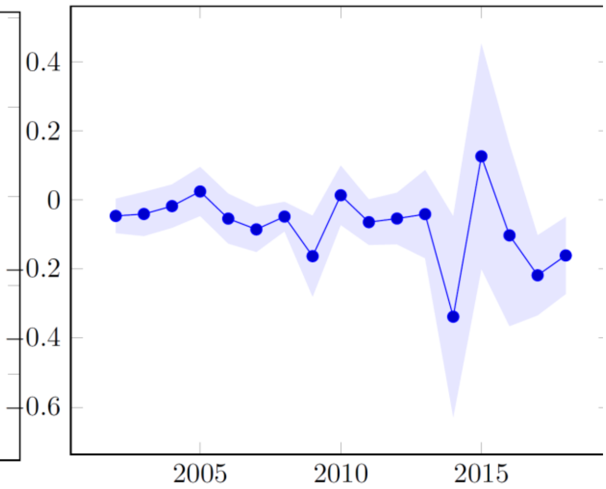
(c) S&P

Notes: The figures show the time-varying coefficients of the real GDP growth (%) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

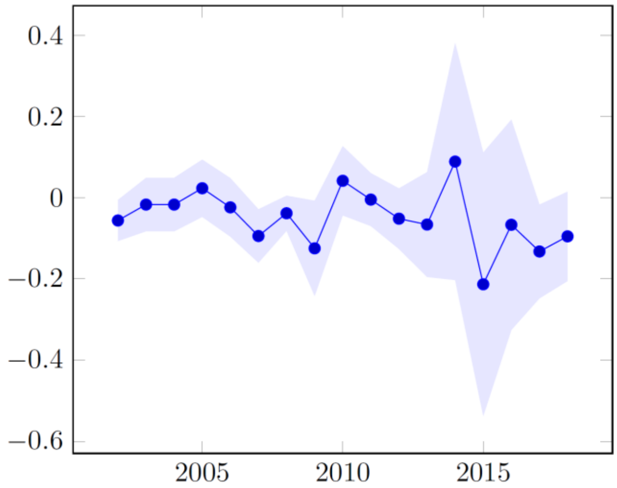
Annex 5. CPI coefficient estimates (in notches, and the 5-95% shaded confidence interval)



(a) Moody's



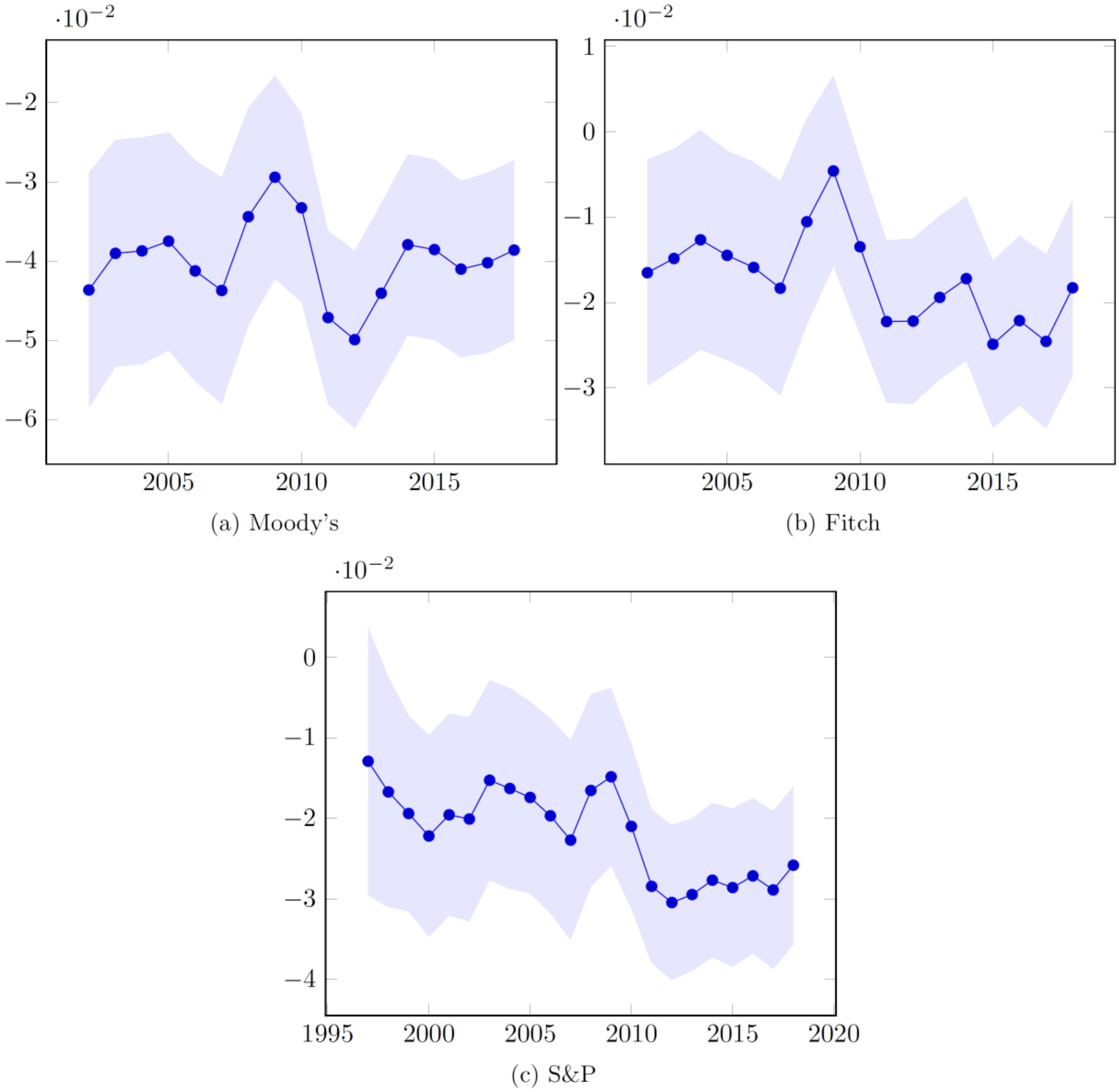
(b) Fitch



(c) S&P

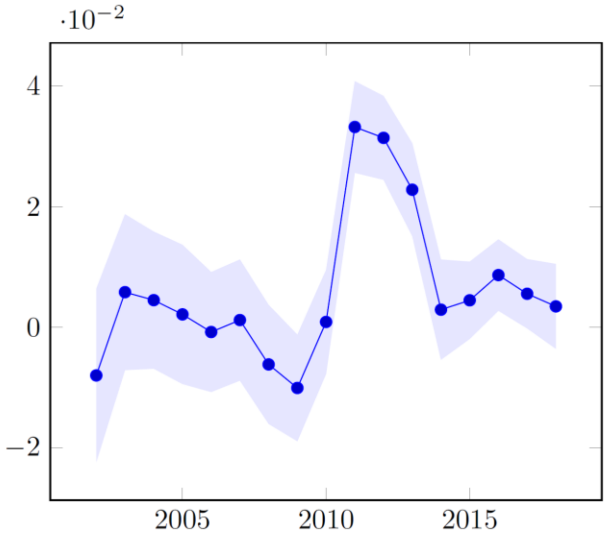
Notes: The figures show the time-varying coefficients of the CPI (%) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

Annex 6. General government debt coefficient estimates (in notches, and the 5-95% shaded confidence interval)

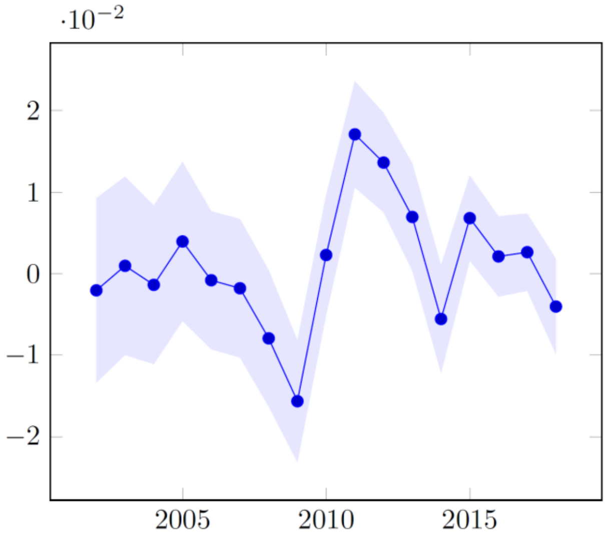


Notes: The figures show the time-varying coefficients of the General Government Debt (%) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

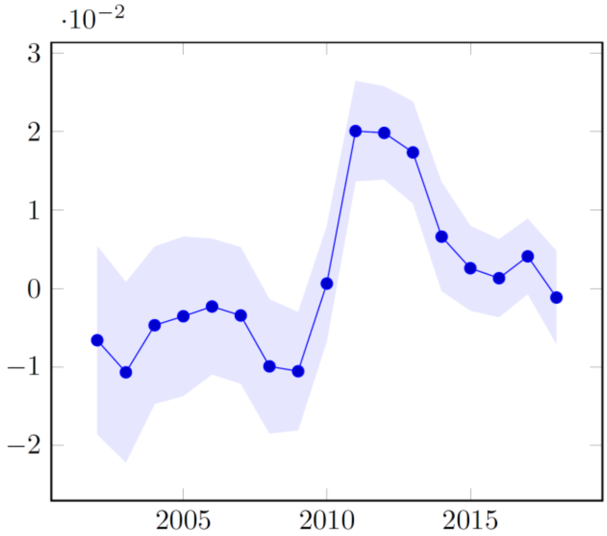
Annex 7. Sovereign Net Foreign Assets coefficient estimates (in notches, and the 5-95% shaded confidence interval)



(a) Moody's



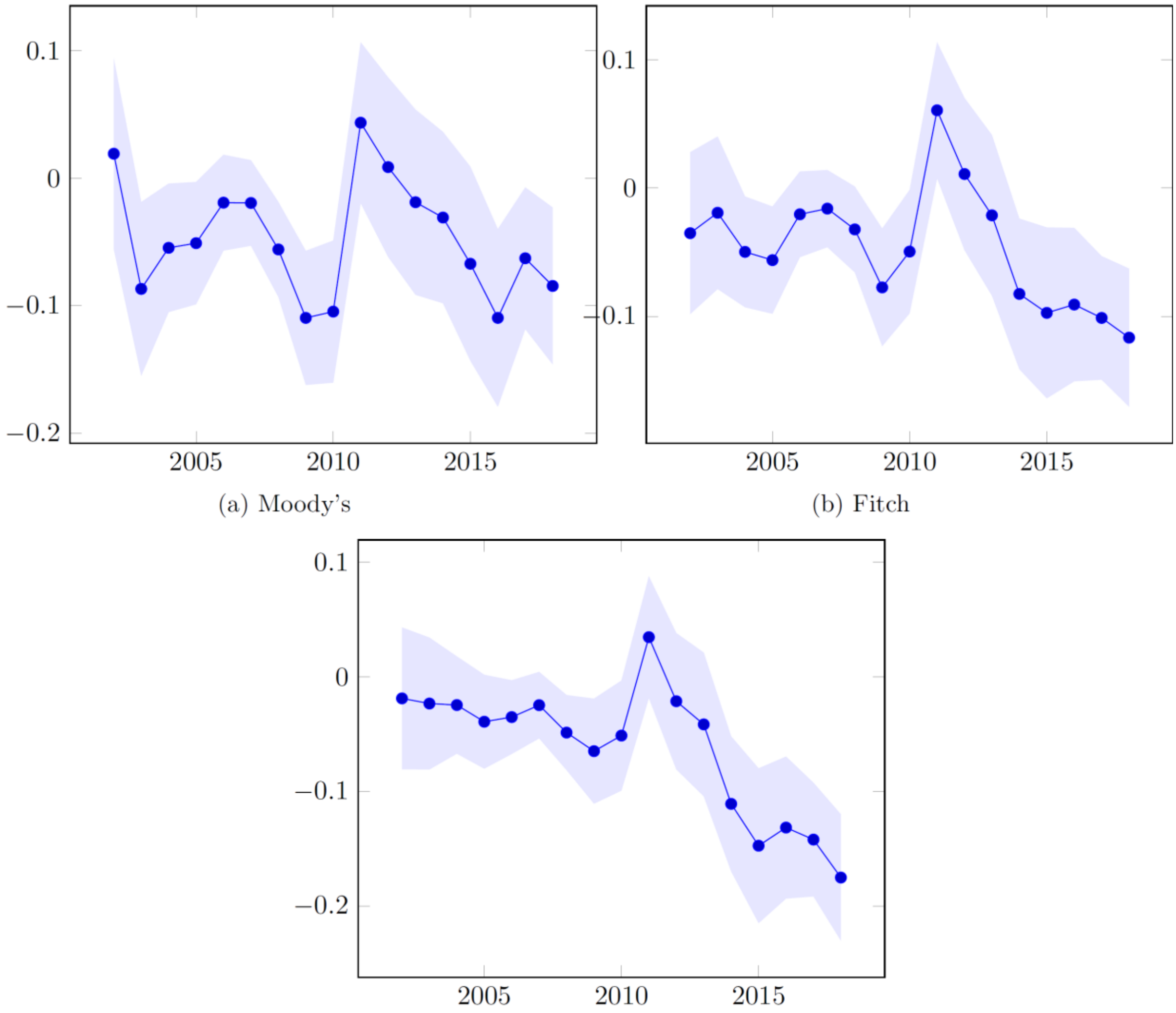
(b) Fitch



(c) S&P

Notes: The figures show the time-varying coefficients of the Sovereign Net Foreign Assets (in % of the GDP) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

Annex 8. Current account coefficient estimates (in notches, and the 5-95% shaded confidence interval)



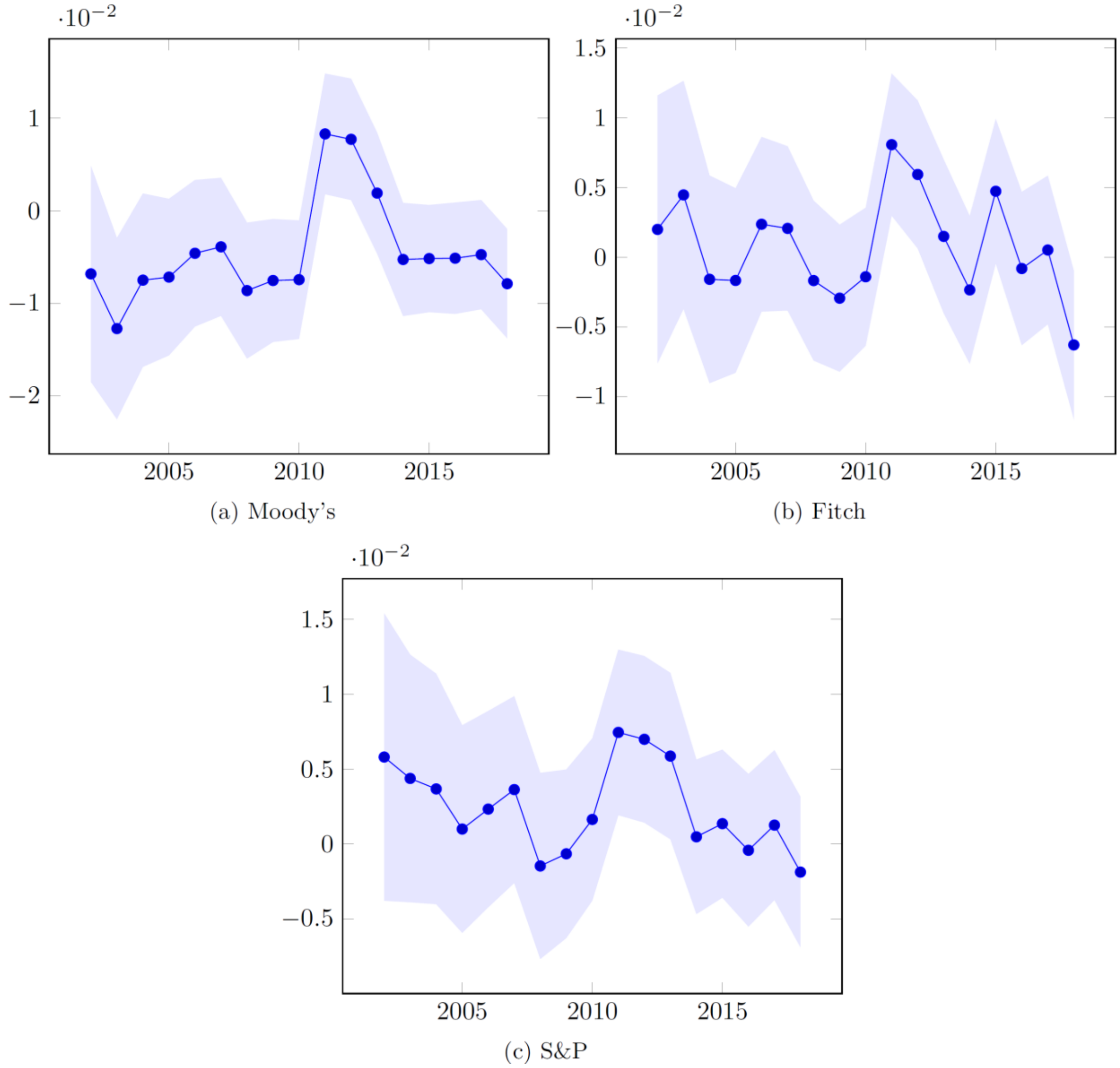
(a) Moody's

(b) Fitch

(c) S&P

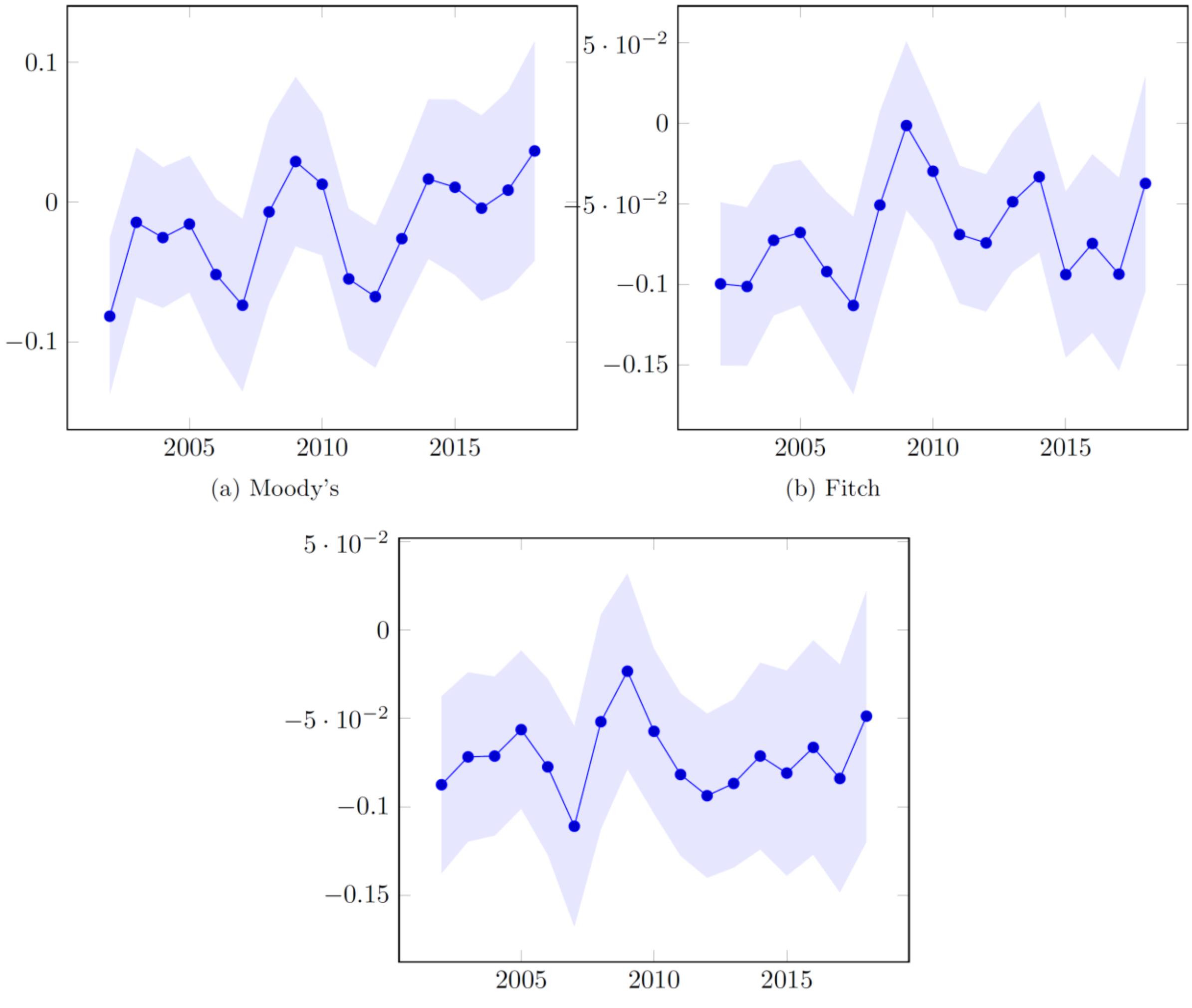
Notes: The figures show the time-varying coefficients of the Current Account + NET FDI (in % of the GDP) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

Annex 9. Net International Investment Position coefficient estimates (in notches, and the 5-95% shaded confidence interval)



Notes: The figures show the time-varying coefficients of the Net International Investment Position (in % of the GDP) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

Annex 10 Unemployment coefficient estimates (in notches, and the 5-95% shaded confidence interval)



(a) Moody's (b) Fitch (c) S&P

Notes: The figures show the time-varying coefficients of the Unemployment (%) for (a) Moody's, (b) Fitch and (c) S&P sovereign ratings and the 5-95% shaded confidence interval by estimating Equation 3. Further details of the estimation are discussed in Section 5.3 .

List of abbreviations and definitions

CA	Current Account
CIs	Composite Indicators
CEE	Central and Eastern Europe
CRA	Credit Rating Agency
DD	Difference-in-difference
ECFIN	Directorate-General for Economic and Financial Affairs of the EU Commission
EA	Euro Area
EC	European Commission
ECB	European Central Bank
EMU	Economic and Monetary Union
ERM II	Exchange Rate Mechanism II
EU	European Union
EUROSTAT	European Statistical Office
FC	Foreign Currency
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HIPC	Highly Indebted Poor Countries
IDA	International Development Association
IICCR	International Investor Country Credit Ratings
IMF	International Monetary Fund
LT	Long-term
MIP	Macroeconomic Imbalance Procedure
NEER	Nominal Effective Exchange Rate
NIIP	Net International Investment Position
REER	Real Effective Exchange Rate
ULC	Unit Labour Cost

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