Technical Background Note:
2015 Refinements to the External Balance Assessment (EBA) Methodology[1]

This technical background note describes the two key refinements to the EBA methodology introduced since the inception of the model (Phillips et al., 2013): the addition of non-linear demographic effects in the current account model and the introduction of a new Real Effective Exchange Rate (REER) level model. These refinements were developed by the IMF's Research Department, in consultation with country teams and authorities, and are now part of the current EBA toolkit used for conducting external assessments in a group of 49 economies.

I. Introduction

1. **Since its inception in 2013, the EBA methodology has been the basis for external assessments conducted by Fund Staff**. The 2013 EBA version covered three models: Current account (CA), REER index, and external sustainability (ES). The first two methods are panel-based regression analyses while the third method focuses on the Net Foreign Assets (NFA) position sustainability. The three methods provide quantitative inputs that, in combination with judgement and country-specific information, underpin the assessment of external positions of a group of 49 countries, a subset of which are covered by the ESR.

2. **In 2015 the EBA methodology was revamped in three areas**: (i) a refinement of the CA model was implemented to capture non-linear effects of demographics; (ii) a new REER level model was introduced as part of the EBA toolkit; and (iii) all model coefficients were re-estimated by extending the sample period by three years (currently covering 1986-2013).

3. **This note summarizes the methodological updates of the CA and REER level models**.

- **Demographic refinements**: The CA model was refined to account for non-linear effects of demographic variables on the CA balance (Section II). These effects proved particularly important in regions where population are expected to age rapidly (South East Asia, Europe). The revised CA regression also exhibits a better model fit relative to the 2013 specification, and shows that demographic effects of aging depend positively on initial conditions (aging speed and old-age dependency ratio).

- **Level-based REER model**. A new model (Section III) that exploits cross-country information on PPP exchange rate levels, was introduced to better identify the drivers (policies and fundamentals) of the REER. The REER level model also exhibits a better fit than the REER index model for most countries and provides valuable cross-country information for REER assessments.

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[1] The note expands on the documentation already presented to the IMF Executive Board and made public in Annex I of the 2015 External Sector Report (ESR). The note was prepared by Mai Chi Dao, Daniel Garcia-Macia, Ruy Lama, and Rui Mano. Jair Rodriguez and Hongrui Zhang provided excellent research assistance. The note was completed on July 25, 2017.

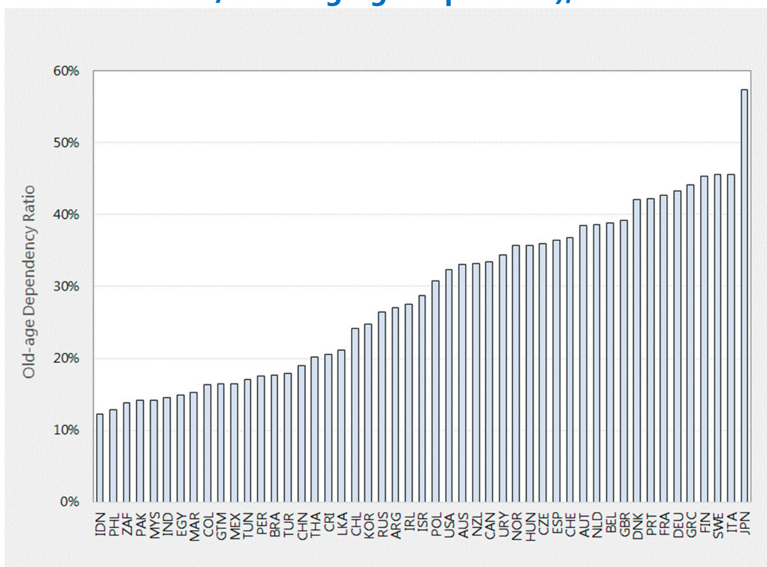
II. Demographic Refinements[2]

This section summarizes the rationale and theoretical underpinnings for the recent refinement to the demographic components of the EBA CA model, and presents the empirical results of the revised EBA CA model.

A. Background on Demographics and Savings

4. Demographic structures vary substantially across country and over time. There is a strong correlation between a country's demographic structure and its overall stage of development, with advanced economies being considerably older on average than emerging and developing economies (See Figure 1). This reflects both lower fertility as well as higher life expectancy in advanced economies. However, the demographic transition (or population aging process) differs substantially across countries. As shown in Figure 2, demographic transition can occur smoothly (e.g. Japan), or it can display large temporary shifts: for example, due to baby booms and baby busts following wars (United States) or migration waves following external events and/or opening of borders (Spain, Eastern Europe).

Figure 1. Old-Age Dependency Ratio (Population 65 and Older/Working Age Population), 2015



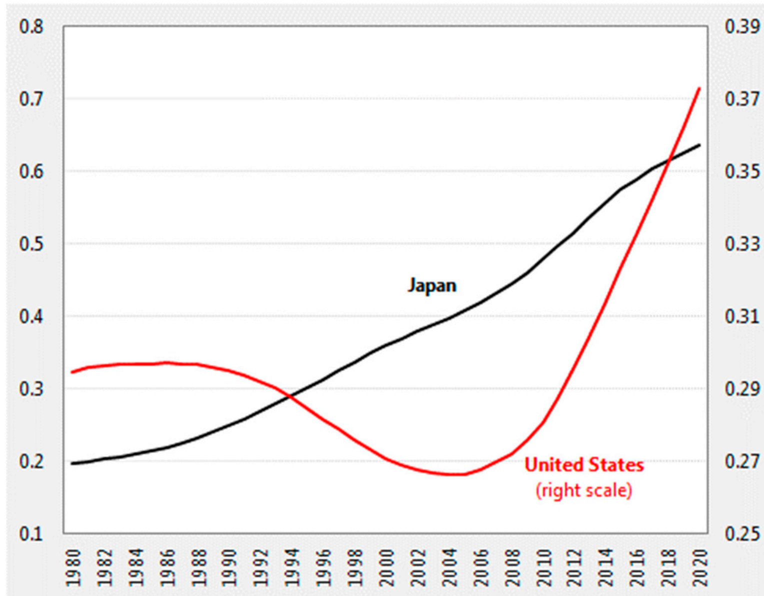
Source: UN (2015)

5. These demographic differences across countries and over time can have significant implications for savings, investment, and the current account, although the mechanisms are complex and not always fully supported by the data.

[2] Recent work at the Fund has increasingly paid attention to demographics as a global megatrend which is influencing macroeconomic evolution in complex, interconnected ways, from the boon of the "demographic dividend" in some countries, to the distributional effects of trade in others (IMF, 2013a), and the effect of aging on future potential growth worldwide (2015 WEO Chapter 3). Understanding and properly gauging the impact of demographics on current account dynamics is therefore an important component of such analyses, and occupies an essential role in the context of the Fund's EBA model and ESR exercise.

- According to the **standard Life Cycle Hypothesis (LCH)**, a rise in the dependency ratio is assumed to reduce savings through the compositional effect, as the share of dissavers relative to savers in the economy increases. However, and despite its intuitive appeal, the composition effect is not found to be empirically robust across countries (Masson et al. (1998), CEPII (2012), IMF (2013b)). The correlation is weak conditional on other key macro determinants such as GDP per capita or GDP growth, which may absorb much of the variation in demographic variables themselves, but is also weak unconditionally across countries, and may be in fact be of opposite signs within countries (Figure 3).

Figure 2. Old-Age Dependency Ratio in U.S. vs. Japan



Source: UN (2015).

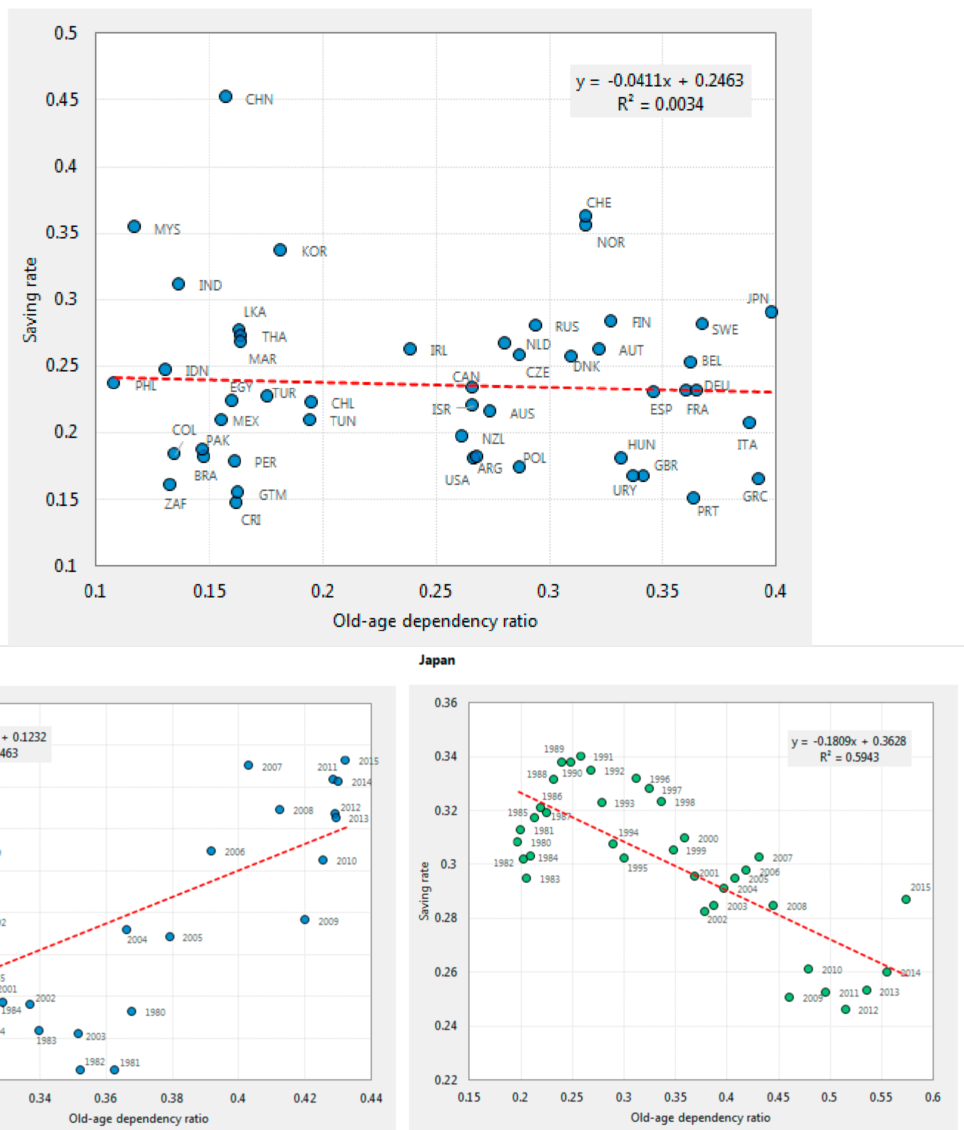
- The weak correlation could be related to the fact that (old-age and youth) dependency ratios do not capture other (possibly offsetting) aspects of population aging crucial for determining saving and investment rates. An aging population structure is often accompanied by increasing life expectancy at retirement, which by itself raises saving at all ages since individuals need to save more to support themselves at old age. As a result, an increase in longevity risk can presumably offset the negative compositional effect of higher old-age dependency. Indeed, as shown below, it is important to distinguish between static and dynamic aspects of aging to properly capture the impact of demographics on saving and the current account.

6. **Data suggest that in certain circumstances the dynamic aspects of aging (longevity risk) could outweigh the static and compositional effects**. For example, many European economies which already have a high share of elderly, are expected to age further in the future, reflecting both lower fertility and higher life expectancy trends that have been ongoing for several decades (Figure 4). In these countries, the negative composition effect on saving coming from the high old age dependency ratio could be offset by the positive effect on saving coming from increasing survival risk in old age, overall leading to an ambiguous net effect on the saving rate. Meanwhile, there are some emerging and developing economies (EMDEs), notably China and Thailand, who are still relatively young, but are facing a sharp acceleration in its old age dependency ratio in the coming years. In these cases, both the compositional and the dynamic effect of aging point toward higher desired saving rates. In contrast, in other EMDEs like India, Philippines, high

fertility rates and its still young population will help to keep saving rates low relative to other countries.

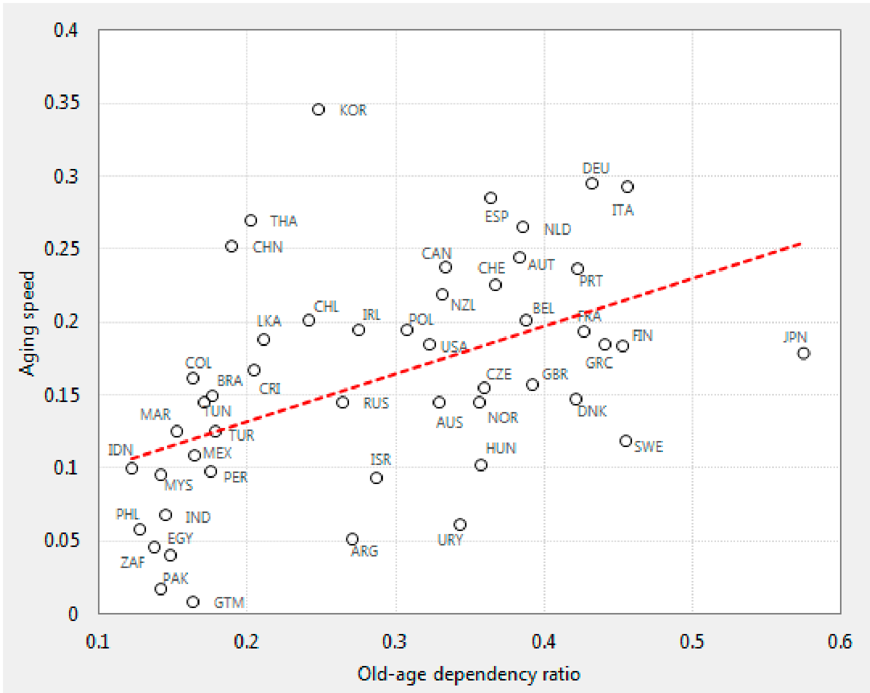
7. To arrive at a better understanding of these complex relationships, a theoretical framework is developed to ascertain the precise role static and dynamic demographics features play. In contrast to the empirical results relying solely on the old-age dependency ratio, the framework shows that demographics affect aggregate the savings rates through multiple channels, involving interactions between the dependency ratio and the speed of aging (change in the dependency ratio). The empirical implications of the predictions of the framework are also studied, and compared to the previous model specification.

Figure 3. Savings Rates and Old-Age Dependency Ratio



Sources: WEO. UN (2015).

Figure 4. Correlation Between Current Old-Age Dependency Ratio and Aging Speed (2015)



Source: UN (2015).

Note: aging speed is defined as the change in old-age dependency in the next 20 years.

B. Theoretical Framework: Demographics and Saving

8. **A simple Overlapping Generations (OLG) model, with varying survival probabilities is developed to study the implications of demographics on saving.** Key assumptions and features of the model follow:

Assumptions:

- Every period, *N* young individuals are born, and with probability *p*, they survive into the second period. All surviving individuals die at the end of period 2.
- During period 1, each individual is endowed with income *y* which they can consume and/or save for the old age.
- Individuals who do not survive into the second period consume all their saving immediately prior to dying at the end of period 1. This avoids redistributing unused income.

Individual intertemporal optimization problem

A person born in period *t* has the following utility function:

$$U(c_t^y, c_{t+1}^o) = \log(c_t^y) + p_t\beta\log(c_{t+1}^o),$$

where c_t^y and c_{t+1}^o denote consumption when young and consumption when old respectively.

The consumption saving decision of the young individual is subject to the inter-temporal budget constraint, with r being the interest rate on savings:

$$c_t^y + \frac{c_{t+1}^o}{1+r} = y$$

Aggregate saving

The saving rate of each young individual is obtained by combining the first order condition and the budget constraint:

$$s_t^y = s^y = \frac{\beta p_t}{1+\beta p_t} y$$

which implies the following aggregate saving rate:

$$s_t = \frac{S_t}{Y_t} = \frac{N_t s_t^y + N_{t-1} s_t^o}{N_t y} = \frac{N_t s_t^y - N_{t-1} s_{t-1}^y p_{t-1}}{N_t y}$$

$$= \underbrace{\frac{\beta p_t}{1+\beta p_t}}_{Life-cycle\ effect} - \underbrace{\frac{1}{1+n_t}\frac{\beta p_{t-1}^2}{1+\beta p_{t-1}}}_{Composition\ effect} \qquad (1)$$

where the dissaving of the old is $s_t^o = -s_{t-1}^y$, and the population growth rate is n_t.

9. The simple OLG model suggest there are two basic demographic forces influencing the saving rate:

- **Life-cycle effect,** reflects the positive life-cycle saving through which individuals' smooth consumption between youth and old age, and it is stronger the higher the probability of surviving into old-age.

- **Composition effect,** the higher the share of old relative to young population, the lower the overall saving rate. This old-age dependency ratio, in turn, is positively related to the past survival rate p_{t-1} , and negatively related to the current growth rate of the young population n_t. Without loss of generality, the saving rate is pinned down by the evolution of the survival probability *p* over time assuming the size of the overall population is unchanged (n=0).

10. These demographic forces can be summarized into a few variables, that can be obtained from the data.

- **Dependency Ratio (DR),** which is defined as the ratio of the old to young population at a given time, and can be expressed as follows:

$$DR_t = \frac{N_{t-1}p_{t-1}}{N_t} = \frac{p_{t-1}}{(1+n_t)} = p_{t-1}$$

- **Aging Speed (AS),** which is defined as the expected growth of the DR (with one period here corresponding to the span of prime saving period, i.e. about 20 years), and expressed as follow:[3]

$$AS_t = \frac{DR_{t+1}}{DR_t} = \frac{p_t}{p_{t-1}}$$

- This allows the **survival risk** *p* to be decomposed as the product between the dependency ratio and the aging speed. In this formulation, the survival risk is a proxy of the life expectancy of all cohorts present in the working-age population.

$$p_t = DR_t AS_t \tag{2}$$

11. In fact, aggregate saving can be expressed as non-linear functions of the current and future dependency ratios (by plugging (2) into (1)), The dependency ratio affects the saving rate both through the negative composition effect and the positive life-cycle effect, the latter resulting from its interaction with the aging speed

$$s_t = \frac{\beta AS_t * DR_t}{1 + \beta AS_t * DR_t} - \frac{\beta DR_t^2}{1 + \beta DR_t}$$

Taking the partial derivative relative to dependency ratio (and dropping the time index for brevity) the following equation is obtained:

$$\frac{\partial s}{\partial DR} = \frac{\beta}{(1 + \beta DR * AS)^2} * AS - \frac{\beta DR(2 + \beta DR)}{(1 + \beta DR)^2}$$

- The **first term** shows the positive effect of a higher dependency ratio on saving through its effect on the survival probability of the current young population. The higher the aging speed, the larger the increase in the survival probability p that comes with a given increase in the dependency ratio (per *p=AS*DR*), hence the stronger the life-cycle saving channel.

- **The second term** shows the negative composition effect of a higher dependency ratio on the saving rate.

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[3] Similar results are obtained with the aging speed being defined as the difference between future and current dependency ratio, but the closed-form solutions are algebraically more complex.

A similar interaction occurs with the partial derivative relative to the aging speed. That is, a given increase in the aging speed raises the survival probability more the higher is the current dependency ratio:

$$\frac{\partial s}{\partial AS} = \frac{\beta}{(1 + \beta DR * AS)^2} * DR$$

12. To sum up, the theoretical model predicts that demographic variables have important non-linear effects on saving. Expressed in terms of the existing variables, an OLG model with varying survival probability would imply that, while the dependency ratio has a negative effect on overall saving due to the composition effect, this effect is attenuated by the higher the aging speed. This is because with higher aging speeds, a given increase in the dependency ratio implies a higher future dependency ratio, hence a higher survival probability of the young cohort, increasing the need for life-cycle saving. At the same time, the positive effect of aging speed on saving is stronger, the higher the current dependency ratio. The reason is similar to the aforementioned interaction: for a given change in aging speed, a higher current dependency ratio implies a higher dependency ratio in the future, and hence a higher survival probability of the current young cohort. Therefore, it is critical to understand what demographic variables imply for the survival risk of the current working-age population and the need for life-cycle saving.

C. Empirical Results: Demographics and Saving

13. Results from a panel data regression model suggests a strong non-linear relationship between demographics and saving rates (Table 1). In line with previous findings, the conventional measure of age composition, the old-age dependency ratio, does not have a strong linear relationship with the overall saving rate (columns 1 and 3). This lack of systematic relationship, however, masks a strong non-linear pattern, consistent with the theoretically identified interaction effects. When adding an interaction term between aging speed and old-age dependency ratio, both the interaction term and the old-age dependency ratio become statistically significant and with the right sign. Moreover, the estimated non-linear effects are robust for alternative model specifications and after including different control variables. Results holds both for annual data as well as for 5-year averages (columns 2 and 4), and when further covariates are introduced (column 5), including the share of public health expenditure (which affects the level of precautionary saving) and the overall quality of institutions (proxied by the political risk indicator, ICRG).

Table 1. non-linear effects of demographic variables on saving

	Dependent variable: aggregate saving/GDP				
VARIABLES	annual data		5-year averages		
Old-age dependency	-0.0390	-0.148***	-0.0560	-0.148***	-0.0394
	(0.0294)	(0.0233)	(0.0447)	(0.0528)	(0.136)
Old-age dep.*Aging speed		0.602***		0.749***	0.987***
		(0.0775)		(0.176)	(0.223)
Youth dependency					-0.174***
					(0.0217)
Public health exp/GDP					-5.765***
					(0.528)
ICRG political risk					0.157***
					(0.0530)
Constant	0.231***	0.245***	0.235***	0.244***	0.575***
	(0.0112)	(0.00585)	(0.0130)	(0.0133)	(0.0672)
Observations	1355	1,355	241	241	220

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: IMF Staff Estimates.

D. Demographics and the Saving-Investment Balance

14. The impact of demographic forces on the saving-investment balance is largely an empirical question.

- A country's saving is an important source of financing for its investment, especially where access to external financing is more limited, as has been the case for many EMDEs. That said, this positive correlation between saving and investment both within and between countries (Feldstein-Horioka puzzle) is not limited to EMDEs and has applied also to advanced economies (Obstfeld and Rogoff, 2000). Whatever the reason, the fact that there is some degree of co-movement suggests that demographic forces that determine the saving rate could also determine the investment rate of a given country (saving channel).

- Demographics could influence investment through other channels. For example, a high (old-age and youth) dependency ratio would imply a smaller share of working age population, and over time a lower investment rate to achieve the optimal or desired capital-to-labor ratio (Cutler et al., 1990). Similarly, a rise in the share of old-age population and/or faster aging population could reduce the demand for future housing stock as the profile of housing consumption flattens in old-age, thus lowering the optimal rate of housing investment (Yang, 2009).

- Therefore, taken together, how demographic variables affect the overall saving-investment balance requires an empirical examination, which is performed through the EBA model.

E. The EBA Model with a Demographic Refinement

15. The 2013 EBA CA regression featured three demographic variables: the old-age dependency ratio, population growth, and aging speed.[4] The old-age dependency ratio (DR) is expected to have a negative effect on the CA, as it reflects a higher share of consumers relative to savers. Population growth, if mainly driven by birth rates, should also exert a negative impact by increasing the youth dependency ratio and therefore the share of non-savers.[5] If driven by growth in working-age population, higher population growth may also imply more investment to stabilize the capital-to-labor ratio, which also affects the CA negatively. Finally, aging speed, defined as the expected increase in old-age dependency ratio 20 years forward, should exert a positive effect on saving and the current account, driven by higher life expectancy and resulting need for more life-cycle saving. All three variables were expressed in deviations from world average since only the relative magnitude of each variable should affect the overall saving investment balance (see further details in Phillips, 2013). Of the three variables, only the aging speed variable had a statistically significant effect on the CA in the previous EBA model.

16. The CA EBA model was refined by adding interaction terms implied by the theoretical framework, resulting in an improvement in the overall fit of the model. Specifically, relative aging speed is interacted with the dependency ratio and relative dependency ratio is interacted with aging speed, in addition to the stand-alone dependency ratio term as implied by the model (see Table 2). Consistent with theoretical framework, regression results show that both variables have the correct positive sign and are statistically significant. In particular, while the dependency ratio has a negative effect on overall saving due to the composition effect, this effect is attenuated if current aging speed is high, which in turn implies higher old-age survival risk and thus stronger need for life-cycle saving. Meanwhile, the positive effect of aging speed on saving is stronger, the higher the current dependency ratio, as this predicts an even higher survival risk in the future. Moreover, the coefficient on population growth and dependency ratio, while still not statistically significant (due to collinearity with the interaction terms), are larger in magnitude and negative as expected.[6]

17. Summary. Demographic variables influence aggregate savings, investment and the current account through multiple channels. The EBA demographic refinement was implemented to better capture the impact of old-age survival risk on the current account. Since survival risk is a variable not directly observed, this is proxied by a non-linear interaction of dependency ratio and aging speed. The interaction terms in the new specification are statistically significant in the latest version of the CA EBA model, and are consistent with the predictions a theoretical OLG framework. The other non-

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[4] This version of the current account model was estimated for the sample period 1986-2013. The 2013 EBA model was estimated for the sample 1986-2010.The data source for demographic variables is World Population Prospects (UN, 2015).

[5] The youth dependency ratio is the population ages 0-15 divided by the population ages 16-64.

[6] A cross-country comparison of the fitted value of CA EBA models is reported in Annex I. The new specification tends to show a higher CA norm in countries with both relatively high dependency ratio and aging speed.

demographic coefficients are statistically significant and similar in magnitude to the previous two versions of the CA EBA model based on different sample periods (1986-2010 and 1986-2013).

Table 2. EBA CA regression Coefficients

VARIABLES	Benchmark 1986-2010	Baseline 1986-2013	Demography 1986-2013
L. NFA/Y	0.016**	0.018***	0.015**
	(0.019)	(0.003)	(0.016)
L. NFA/Y*(dummy if NFA/Y < -60%)	-0.012	-0.014	-0.009
	(0.378)	(0.287)	(0.493)
Financial Center Dummy	0.033***	0.028***	0.027***
	0.000	(0.000)	(0.000)
L.Output per worker, relative to top 3 economies	0.007	0.018	0.033
	(0.730)	(0.398)	(0.143)
L.Relative output per worker*K openness	0.065***	0.052**	0.046**
	(0.003)	(0.021)	(0.043)
Oil and Natural Gas Trade Balance * resource temporarir	0.615***	0.406***	0.410***
	(0.000)	(0.000)	(0.000)
Dependency Ratio #	-0.03	0.000	-0.057
	(0.476)	(0.993)	(0.312)
Population Growth #	-0.629	-0.269	-0.565
	(0.107)	(0.503)	(0.168)
Aging Speed (proj. change in old age dependency ratio)	0.156***	0.117***	.
	(0.000)	(0.001)	.
GDP growth, forecast in 5 years #	-0.471***	-0.465***	-0.425***
	(0.000)	(0.000)	(0.000)
L.Public Health Spending/GDP #	-0.551***	-0.508***	-0.503***
	(0.000)	(0.000)	(0.000)
L.demeaned VIX*K openness	0.068***	0.042***	0.040**
	(0.000)	(0.007)	(0.011)
L.demeaned VIX*K openness*share in world reserves	-0.136*	-0.099	-0.093
	(0.056)	(0.157)	(0.177)
Own currency's share in world reserves	-0.045***	-0.034***	-0.041***
	(0.000)	(0.006)	(0.000)
Output Gap #	-0.400***	-0.386***	-0.385***
	(0.000)	(0.000)	(0.000)
Commodity ToTgap*Trade Openness	0.230***	0.199***	0.197***
	(0.000)	(0.000)	(0.000)
Safer Institutional/Political Environment (index) #	-0.109***	-0.108***	-0.109***
	(0.000)	(0.000)	(0.000)
Demeaned Private Credit/GDP #	-0.026***	-0.023***	-0.021***
	(0.002)	(0.004)	(0.005)
Cyclically adjusted Fiscal Balance, instrumented #	0.324***	0.430***	0.470***
	(0.001)	(0.000)	(0.000)
(ΔReserves)/GDP* K controls, instrumented #	0.346**	0.414**	0.449**
	(0.040)	(0.038)	(0.024)
rel. Dependency Ratio*Aging Speed	.	.	0.130***
	.	.	(0.000)
rel. Aging Speed * Dependency Ratio	.	.	0.088**
	.	.	(0.039)
Constant	-0.014***	-0.012***	-0.014***
	0	(0.000)	(0.000)
Observations	1080	1,197	1,197
Number of countries	49	49	49
Root MSE	0.033	0.032	0.032

P-values of Het-corrected z-statistics in brackets

* significant at 10%; ** significant at 5%; *** significant at 1% "L." denotes one year lag.

Note: variables denoted with # are constructed relative to a (GDP-weighted) country sample average, in each year.

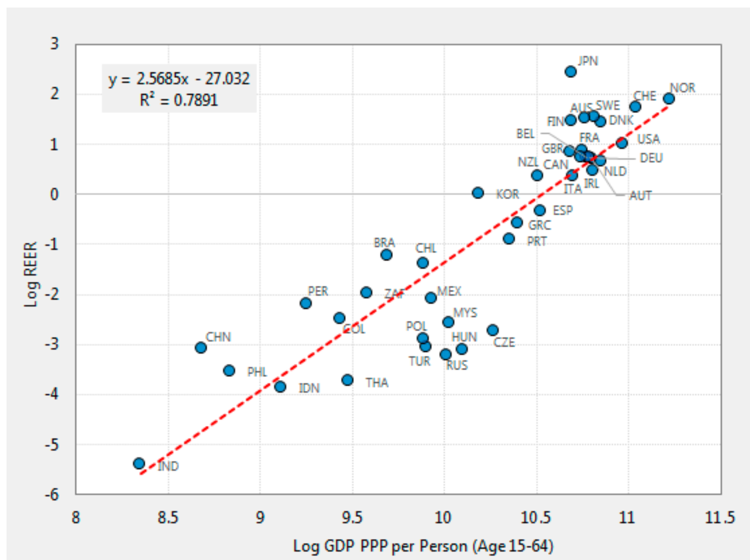
Source: IMF Staff Estimates.

II. EBA REER Level Model

The REER level model was introduced in 2015 to complement the original CA and REER-index EBA models. This section explains the rationale for introducing the REER-level model, compares its performance to the REER-index model, and provides guidance on its use for conducting external assessments.

18. The specification of the REER-level model is motivated by a large literature aimed at understanding differences in real exchange rate levels across countries and over time. Bergstrand (1991) explored the extent the positive cross-country correlation between REER levels and GDP per capita (also known as the Penn effect, see Figure 6), reflected productivity differentials (higher productivity raises wages and thus the price of non-tradables), relative factor endowments or preferences.[7] Other studies have looked at the within-country variation in the REER level. Frankel (2005) analyzed the evolution of factors driving the REER level and the extent of undervaluation in China over time. Based on panel data methods, the EBA REER-level-model exploits both within-and between-country information, and quantifies the real exchange rate level consistent with country fundamentals (beyond income per-capita) and policies.

Figure 6. Penn Effect: REER Level vs GDP per Capita (1990-2016)



Source: WEO, WDI. IMF Staff Estimates

19. The REER-level model relies on country fundamentals and policies as regressors, yet unlike the REER-index model excludes country fixed effects. The inclusion of country fixed effects into the REER-*index* model imposes the condition that the exchange rate is on average in equilibrium over the sample period in each country.[8] Instead, the REER-level model, by excluding fixed effects, allows for the possibility of persistent deviations of the exchange rate from the level consistent with fundamentals and desired policies. Furthermore, the residuals in the REER-level model can

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[7] See Cheung et al. (2016) for a recent empirical review on the Penn Effect.

[8] With country-fixed effects, the sum of the residuals for each country is equal to zero, so any long-run distortions in the REER is absorbed by the country dummy.

potentially reflect unidentified policy distortions which, by construction, are not manifested in the REER-index model.

20. Measurement issues may complicate the interpretation of estimates of the REER-level model. Empirically, the level of the REER is constructed with data on purchasing power parity (PPP) exchange rates from the World Bank International Comparison Program (ICP). Given that data on international relative prices is particularly noisy, errors in the measurement of REER levels could bias the exchange rate assessment.[9] Moreover, errors in model specification can lead to sizeable deviations between fitted and actual REER levels that might not reflect overall policy distortions. In these cases, the external assessments should assign greater weight to the other EBA models and judgement, as explained in Section II.B.

A. Regression Specification and Results

21. The REER level variable is constructed in a two-step process combing PPP exchange rates and REER indices. First, REER level cross-country data for the base year (2011) are obtained from the World Bank International Comparison Program (ICP)—which computes a price level index relative to that of the United States. After, to create a panel dataset (i.e., with time-series variation), the REER level data are extended for the sample period (e.g. 1990-2016) for each country using the IMF-INS country-specific REER indices, which are re-scaled to the value of the base-year price index. Rescaling the REER index ensures that the basket of goods used to compute the REER level is comparable over time and that the model is generally consistent with the REER-index model estimates. [10]

22. The REER-level regression has a linear specification and excludes country fixed effects. The REER-level regression model specifies the (log) REER level of a country i at time t as a linear function of a constant α, fundamentals X_{it}, policies P_{it} and a mean-zero independently distributed error term, ε_{it}:

$$REER_{it} = \alpha + \beta X_{it} + \gamma P_{it} + \varepsilon_{it} \ .$$

[9] See Deaton and Heston (2010) for a discussion of the inherent challenges to accuracy of the ICP.

[10] The PPP exchange rates from ICP use a different basket of goods each year, which makes it difficult to interpret changes over time. By splicing the PPP exchange rates with the country-specific REER indices, a fixed consumption basket over time is assumed.

23. Relative to the REER Index and CA models, the REER level model includes three new supply-side factors as regressors:[11,12]

- **Relative labor productivity:** This variable—obtained from the Penn World Table 8.0—captures the traditional Balassa-Samuelson effect, by which higher labor productivity in the tradable goods sector pushes domestic wages up and the price of non-tradable goods, leading to a REER appreciation. A positive coefficient is expected.

- **Capital-to-labor ratio:** This variable—also obtained from Penn World Table 8.0—captures the Bhagwati-Kravis-Lipsey effect, by which larger capital-to-labor ratios in a country, coupled with the higher labor-intensive nature of the non-tradable sector, leads to higher non-tradable prices and a more appreciated REER. The associated coefficient is also expected to be positive.

- **VAT revenue:** VAT revenue as a share of GDP—obtained from OECD statistics and national statics agencies— proxies for the effective tax rate of indirect taxation. Indirect taxes introduce a wedge between domestic and foreign prices, thereby resulting in a more appreciated REER. This variable is also expected to enter the regression with a positive coefficient.

24. The REER-level model exhibits a higher fitted value and more statistically significant coefficients than the REER-index model. The R^2 of the REER level model is very high (0.91) indicating a better fit than the REER-index model (See Table 3).[13] In addition, most regressors included in both the REER-index and REER-level specifications have the same sign and similar magnitude. Moroever, and consistent with the theory, all three new variables—relative labor productivity, capital-to-labor ratio and VAT revenue—have statistically significant and positive coefficients. Estimates suggest that a one percent increase in the capital-to-labor ratio and relative labor productivity would appreciate the REER by 0.08 and 0.23 percent, respectively. Meanwhile, a one percent of GDP increase in VAT to GDP ratio appreciates the REER by 1.21 percent.

25. The fit of the REER-level model, however, varies greatly across countries. For all countries, the fitted value of the REER-index model closely mimics the level of the observed REER due to the presence of country fixed effects. On the contrary, the REER-level regression model shows persistent deviations, especially in commodity-exporting countries. For example, while for the United Kingdom and the United States, the REER-level and REER-index models have generally similar fitted values, for Chile and New Zealand, the REER-level model generates much larger residuals (Figure 7). This likely reflects an omission of variables (including policy variables) that might be relevant in commodity exporting countries.

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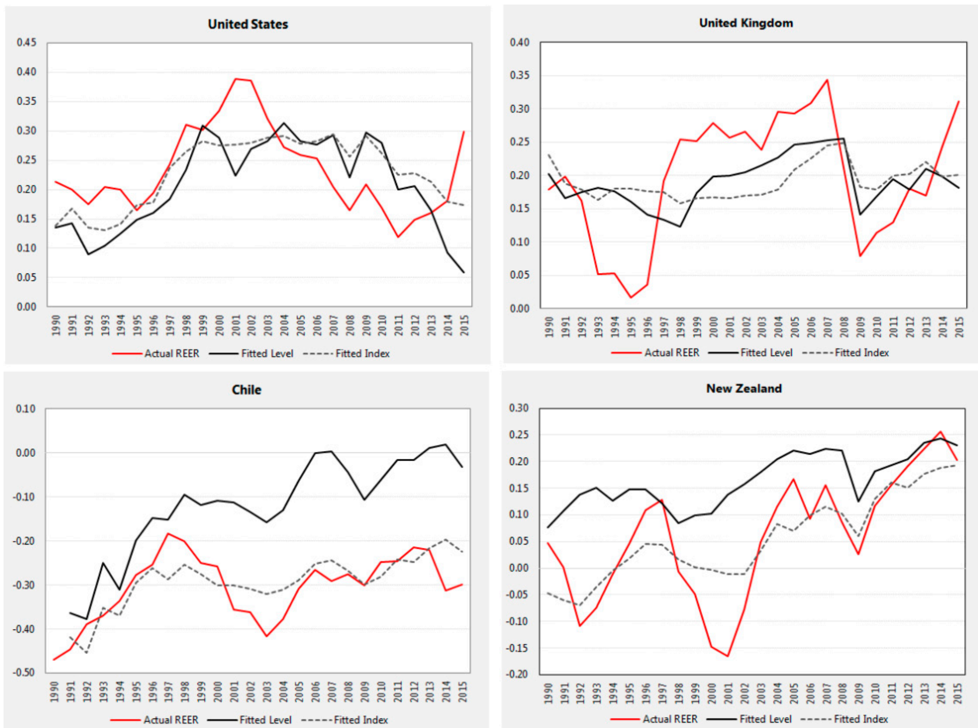
[11] See Krugman et al. (2014) for a description of these channels. The REER-level regression excludes some variables that are part of the REER-index model, such as the interaction of GDP per worker and capital account openness, financial home bias and a South African Apartheid dummy, as these were not statistically significant in the former case.

[12] Annex II provides the full list of explanatory variables.

[13] The model was estimated for the sample period 1990-2013.

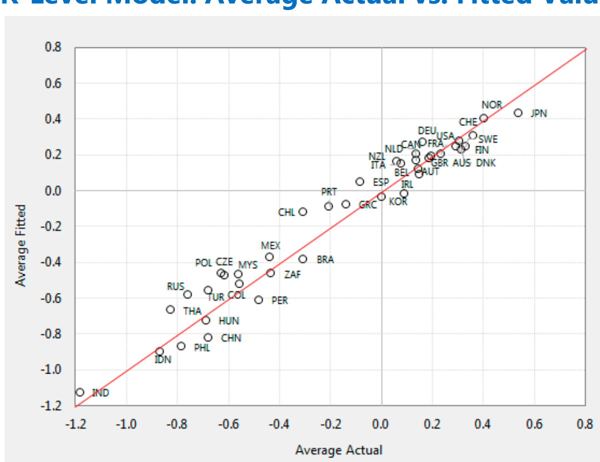
26. The REER-level model generally reproduces the cross-country differences in the REER levels observed in the data (Figure 8). Exceptions include some commodity exporters (Chile, Mexico, New Zealand, Russia), where the model over predicts the value of the REER, and countries with persistent surpluses (China, Japan, Sweden, and Switzerland), where the model under predicts the REER. In these cases, country-specific factors not included in the regression are likely at play, which requires the need to rely on the other EBA models and/or judgement.

Figure 7. REER Level and Index Models in Selected Economies



Source: IMF Staff Estimates.

Figure 8. REER-Level Model: Average Actual vs. Fitted Value (1990-2015)



Source: IMF Staff Estimates.

Table 3. Estimated Coefficients of the EBA REER Index and Level regressions (1990-2013)

VARIABLES	Index (1990-2010)	Index (1990-2013)	Level (1990-2013)
Change in reserves to GDP * cap controls (rel to TRD PRT)	-1.43***	-1.73***	-2.16*
	(0.00)	(0.00)	(0.08)
Lag of health expenditure to GDP (rel to TRD PRT)	1.78**	1.23	1.79**
	(0.03)	(0.11)	(0.04)
Real interest rate differential interacted with K openness (rel to TRD PRT)	0.71***	0.66***	0.94**
	(0.01)	(0.00)	(0.02)
Private credit/GDP (rel to TRD PRT)	0.13***	0.13***	0.12***
	(0.00)	(0.00)	(0.01)
Lag of Demeaned GDPpw/Top3GDPpw (PPP)	0.81***	0.70***	0.16***
	(0.00)	(0.00)	(0.00)
Lag of Demeaned GDPpw/Top3GDPpw (PPP)]* capital openness	-0.58***	-0.49***	.
	(0.00)	(0.00)	.
Lag of VIX * capital account openness	-0.24***	-0.26***	-0.33**
	(0.00)	(0.00)	(0.02)
Lag of VIX * capital account openness *share of own currency in global reserve	0.84**	0.84**	0.98
	(0.02)	(0.02)	(0.12)
Share of the country's currency held as FX reserve by central banks worldwide	0.03	0.04	-0.33***
	(0.69)	(0.54)	(0.00)
Lagged financial home bias (share of domestic debt owned by residents, rel to TR	0.34***	0.37***	.
	(0.00)	(0.00)	.
Log commodity Terms Of Trade	0.08	0.09*	0.06***
	(0.11)	(0.06)	(0.00)
Lag of Trade Openness (avg. of exports and imports to GDP) (rel to TRD PRT)	-0.36***	-0.30***	-0.31***
	(0.00)	(0.00)	(0.00)
Expected GDP growth of medium-term(5 years out), WEO project (rel to TRD PRT)	2.32***	1.86***	1.83**
	(0.00)	(0.00)	(0.05)
Population Growth (rel to TRD PRT)	3.50*	0.86	5.59**
	(0.07)	(0.61)	(0.02)
Share of administered prices	-1.86***	-2.12***	-2.62***
	(0.00)	(0.00)	(0.00)
Dummy south africa apartheid (pre-1994)	0.28***	0.31***	.
	(0.00)	(0.00)	.
Aging Speed (rel to TRD PRT)	.	.	0.68***
	.	.	(0.01)
Dependency Ratio (rel to TRD PRT)	.	.	0.89***
	.	.	(0.00)
ICRG political risk variable (rel to TRD PRT)	.	.	0.44***
	.	.	(0.00)
NFA/GDP	.	.	0.11***
	.	.	(0.00)
Lag Capital stock per emplyed person at current PPPs (2005US$) (rel to TRD PRT)	.	.	0.08***
	.	.	(0.00)
Lag Ratio Traded/Non Traded relative to trd part (in logs)	.	.	0.23***
	.	.	(0.00)
VAT Revenue, % of GDP (rel to TRD PRT)	.	.	1.21**
	.	.	(0.03)
Constant	4.30***	4.33***	0.19***
	(0.00)	(0.00)	(0.00)
Observations	769	882	838
R-squared	0.62	0.61	0.91
RMSE	0.08075	0.08271	0.1409

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

B. Comparison of Assessments Across Models

27. REER gaps derived from the REER level models are generally consistent with the REER-index and CA models.[14]

- With some key exceptions (e.g. China, euro area), gaps derived from the index and level-based models point in the same directions (Figure 9). Where discrepancies arise, they likely reflect the different dimensions that both models capture, since persistent deviations of the REER level (which incorporates additional cross-country information) will not be reflected in the REER-index model.

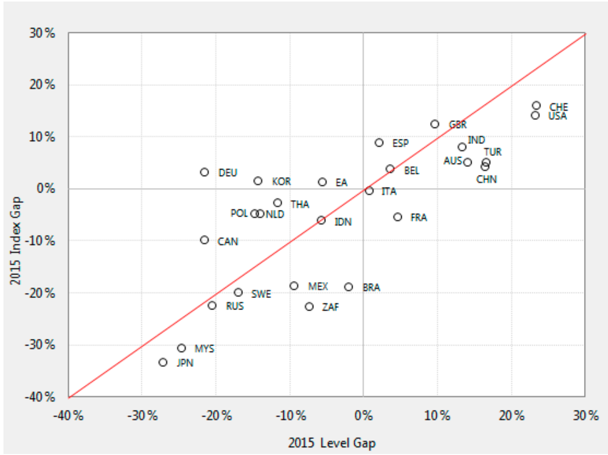
- Similarly, in most cases estimated gaps from the REER-level and CA models match (Figure 10). Countries with a strong external position (Sweden, Korea, Germany) feature a positive EBA CA gap (excessive CA surplus) and a negative REER-level gap (currency undervaluation), while countries with a weak external position (France, Belgium, United Kingdom) feature a negative EBA CA gap and a positive REER level gap. Exceptions include China, Switzerland, Canada, and South Africa, where the two gaps provide different external assessments.

28. When the REER models provide conflicting assessments, the REER assessment may be formulated by giving even more weight to the EBA CA model or other methods. In general, since the current account is a less volatile variable than the REER, it is preferable to base the overall assessment on the EBA CA model. In these cases, the REER gap can be estimated by multiplying the CA gap by the CA semi-elasticity, and acknowledging the uncertainty associated with the semi-elasticity estimates. In some cases, it might be appropriate to combine the results from the index and level-based models, together with judgement about country-specific factors not fully captured by the models.

29. Overall, the REER-level model enriches the set of EBA tools by shedding light on the drivers of cross-country differences in the level of the REER.

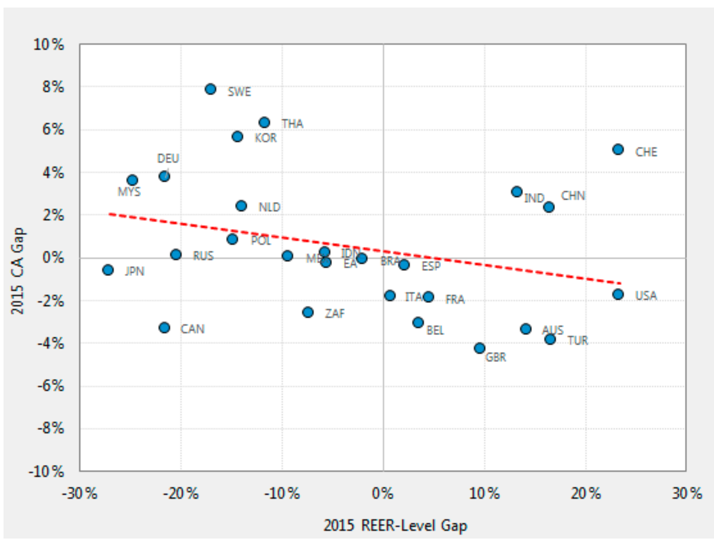
[14] The REER and CA gaps were calculated for 2015 using the EBA model.

Figure 9. 2015: REER Level and Index Gaps



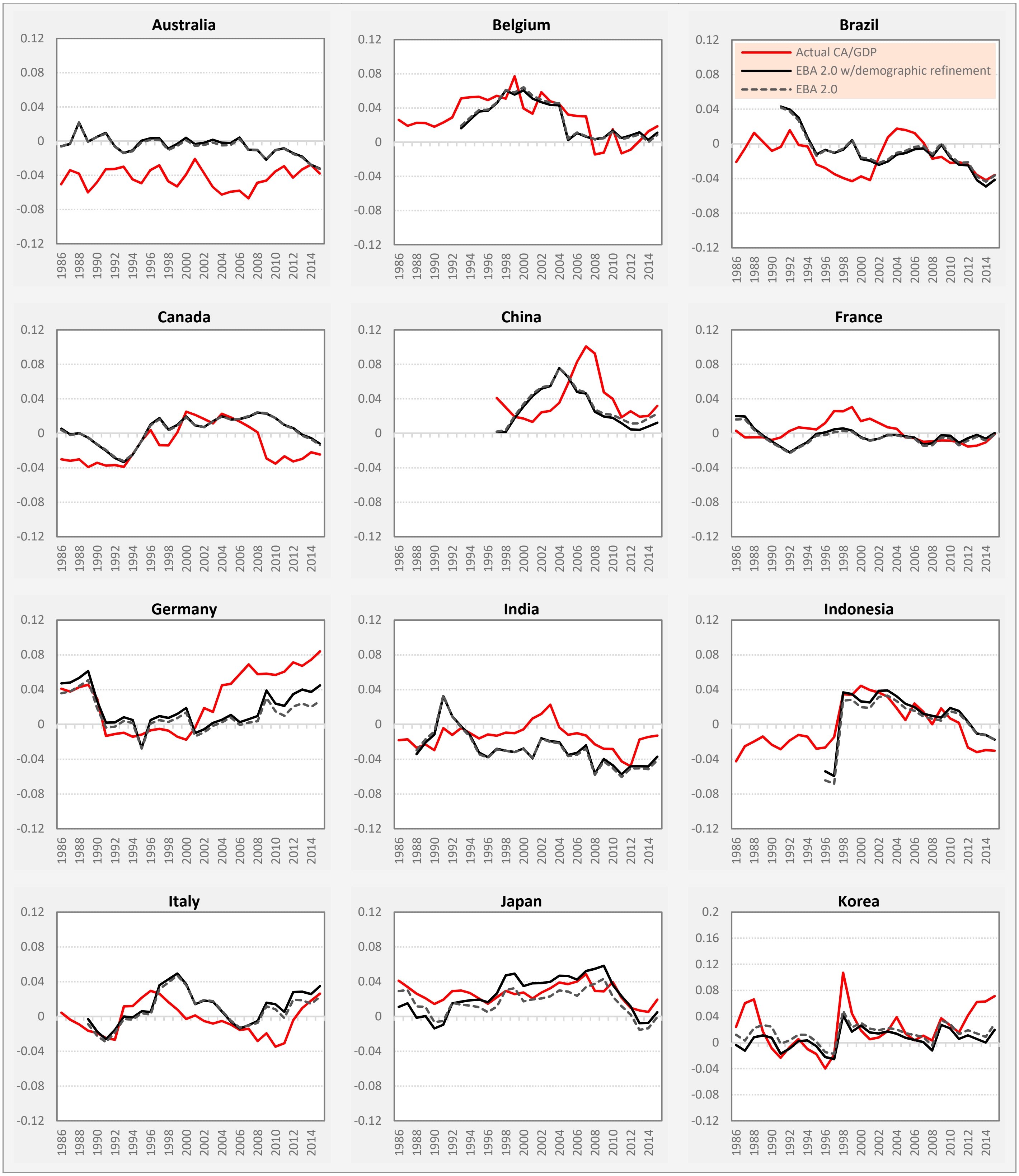
Source: ESR (2016)

Figure 10. 2015: REER Level and CA Gaps

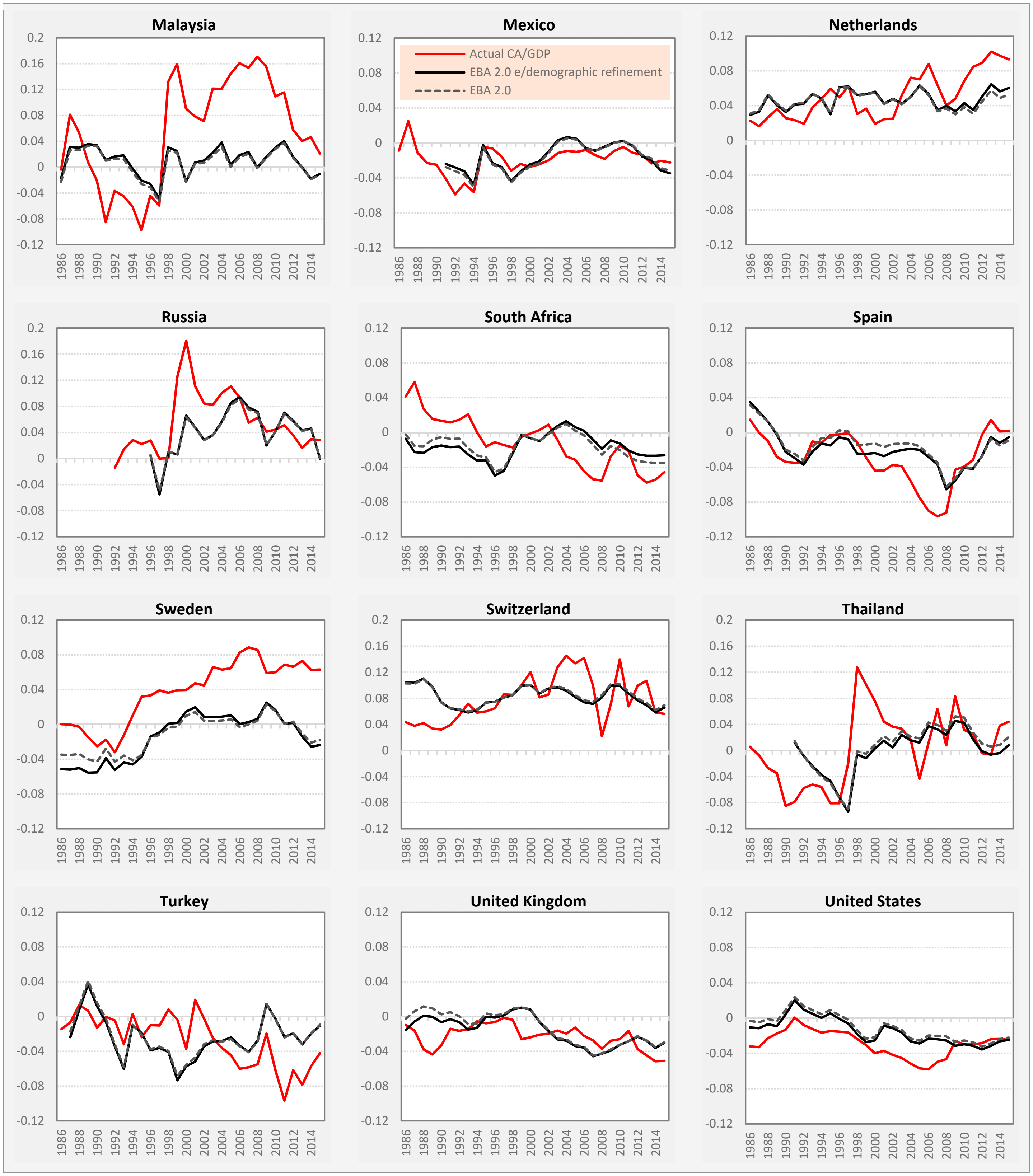


Source: ESR (2016)

Annex I: Fitted Values in EBA 2.0 and EBA 2.0 With Demographic Refinement



Annex I: Fitted Values in EBA 2.0 and EBA 2.0 With Demographic Refinement (Concluded)



Annex II: Variables in the REER level Model

Variable	Interpretation
Common fundamentals with the CA and REER-Index Model	
Productivity/level of development, both alone and interacted with capital account openness	This variable is calculated as the ratio of an economy's output (income measured in PPP terms) to the size of its working-age population relative to economies at the "frontier" of highest productivity. This ratio captures the Balassa-Samuelson effect, in which less-advanced economies have lower prices of non-tradable goods and lower real exchange rates.
VIX/VXO (indicator of global risk aversion), interacted with capital account openness (lagged)	As expected, this coefficient is generally negative for most countries (i.e. non-reserve currency countries), associated with the need to generate a CA surplus when global risk aversion increases and access to credit becomes more difficult. The effect is stronger the more open is the capital account. For reserve currency economies, the effect is in the opposite direction, and appreciates the currency (Entered as a separate regressor, the share of the own currency in global reserve holdings is also significant)
Demographic Factors	The REER level model considers three demographic variables: population growth, old age dependency ratio, and aging speed. Based on an OLG framework, higher population growth and dependency ratio reduce savings and appreciate the currency. Higher aging speed leads to a higher saving rate (life-cycle effect) and more depreciated REER through the aggregate demand channel. However, faster aging is also associated with higher life expectancy, which can have offsetting effect on the REER through aggregate supply channels (e.g. improved productivity).
Expected GDP growth (5-year ahead)	The coefficient has a positive coefficient consistent with the negative coefficient found in the CA regression (faster growth is associated with a weaker current account and a more appreciated real exchange rate).
Commodity terms of trade	The coefficient has a positive sign. In line with standard literature on real exchange rates, we use the ratio of real exports to imports prices of commodities. Higher terms of trade generate a real exchange rate appreciation.
Trade openness	This coefficient has a negative sign. Average exports and imports to GDP is a proxy for trade liberalization, which generally lowers the domestic price of tradable goods, thus depreciating the CPI-based real exchange rate. As a change in the exchange rate affects differently the numerator and denominator of openness, this is indicator is lagged.
The share of administered prices in the CPI	This coefficient has a negative sign (as administered prices are generally imposed to reduce prices). This variable is available only for a few transition economies (for the rest it is assumed to be 0), which experienced a significant reduction in the share of administered prices during the economic transition towards a market economy.
Lagged NFA/GDP	This coefficient has a positive sign. An improvement in the NFA position, increases the income balance an appreciates the currency.
ICRG (Risk associated with the institutional/political environment)	Greater risk—or the perception of such risk—is likely to be a disincentive to investment spending, and possibly an incentive to save more, and to that extent be reflected in a more positive CA balance and a more depreciated currency.

Annex II: Variables in the REER level Model (Concluded)

Variable	Interpretation
Fundamentals Specific to the REER-Level Model	
Relative labor productivity	This variable—obtained from the Penn World Table 8.0—captures the traditional Balassa-Samuelson effect, by which higher labor productivity in the tradable goods sector pushes domestic wages up and the price of non-tradable goods, leading to a REER appreciation. A positive coefficient is expected.
Capital-to-labor ratio	This variable—also obtained from Penn World Table 8.0—captures the Bhagwati-Kravis-Lipsey effect, by which larger capital-to-labor ratios in a country, coupled with the higher labor-intensive nature of the non-tradable sector, leads to higher non-tradable prices and a more appreciated REER. The associated coefficient is also expected to be positive.
VAT revenue	VAT revenue as a share of GDP—obtained from OECD statistics and national statics agencies— proxies for the effective tax rate of indirect taxation. Indirect taxes introduce a wedge between domestic and foreign prices, thereby resulting in a more appreciated REER. This variable is also expected to enter the regression with a positive coefficient
Policy Variables	
FX intervention, interacted with capital controls	Consistent with the finding that FX accumulation is associated with stronger CA balances, it is also associated with a weaker REER.
Health expenditure to GDP (lagged)	This coefficient has a positive sign, consistent with a negative sign in the CA regression. Higher public health spending reduces private savings, and appreciates the currency.
Monetary policy, interacted with capital account openness	The EBA REER regression uses short-term interest rate differentials, adjusted for inflation differentials to proxy for the effect of monetary policy on the exchange rate. The EBA model confirms that monetary policy helps explain movements of real exchange rates (a higher real interest rate differential induces a REER appreciation), but with the strength of that link depending on the degree of openness to capital flows.
Private credit to GDP (relative to an economy's own mean level)	This coefficient has a positive sign, consistent with the CA regression results. This variable aims at proxying for policies that help contain financial excesses. An increase in the ratio of private credit appreciates the currency.
Capital controls	As in the current account model, the REER level model takes account of the influences of capital controls via interaction terms, but it does not include the direct effect of capital controls since it is not statistically significant.

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