

Kim, Sujin

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The nexus of safe asset shortage, credit growth, and financial instability

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ADB Working Paper Series

**THE NEXUS OF SAFE ASSET
SHORTAGE, CREDIT GROWTH,
AND FINANCIAL INSTABILITY**

Sujin Kim

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Sujin Kim is economic advisor at the New Economic Approach Lab in Sejong, Republic of Korea.

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Please contact the authors for information about this paper.

Email: aqua.sujin.kim@gmail.com

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Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

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Abstract

Does a shortage of safe assets sow the seeds of instability in a financial system? This paper empirically explores the hypothesis of safe asset shortage-induced excess credit booms and financial instability. As an alternative step forward from the assumption of growth- or wealth-based demands for safe assets, the study underlines demographic factors as a key determinant of safe asset demands. Based on the long-run trends of aging and government debt, I construct a new safe asset shortage index. Using the index, consecutive empirical exercises confirm the positive relationship of safe asset shortage-credit expansion-aggregate risks of a financial system. The estimation of the crisis probabilistic model for 17 advanced economies in 1960–2013 presents new evidence that the (high) level of private credit at a time of increasing safe asset shortage is the major predictor of financial crises. The fixed-effect panel analysis results for 18 advanced countries in 1980–2016 also show a significant, positive contribution of a safe asset shortage to credit growth. The total effect of the shortage depends positively on securitization growth and negatively on net capital outflows. The latter effect is considerably dominant.

Keywords: safe asset shortage index, demographics, credit, financial crises, financial stability, government debts, capital flows

JEL Classification: E21, E62, G00, G01, J10

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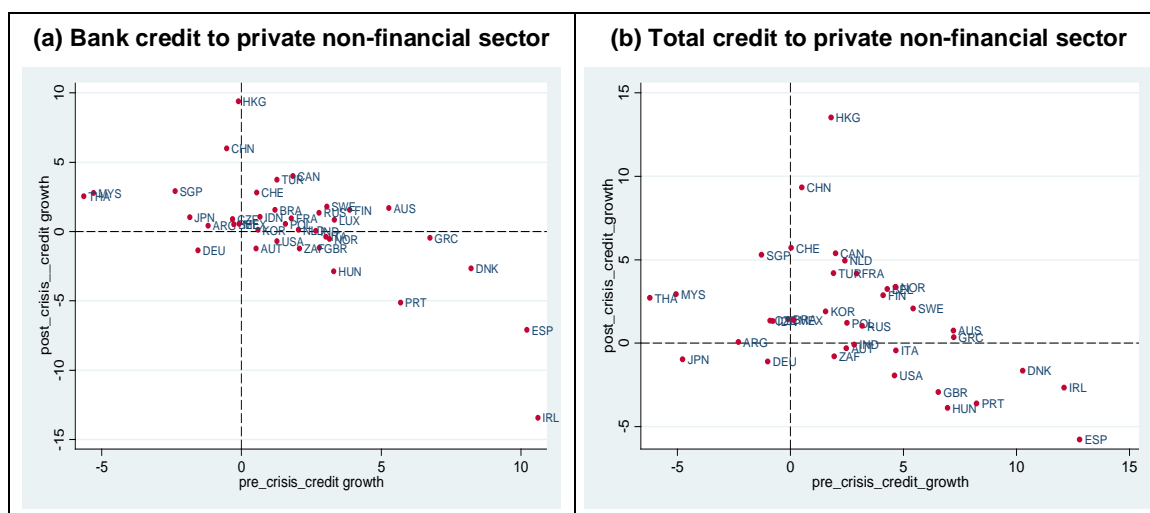
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1. INTRODUCTION

Does a safe asset shortage sow the seeds of financial instability? This is an important and timely question given the resurgence of credit booms during the subdued global recovery¹ since the 2008 global financial crisis (hereafter GFC). Despite fully fledged macroprudential measures² implemented to moderate excessive credit creation, rapid credit growth in economies such as the People’s Republic of China (including Hong Kong, China)³ is deepening policy makers’ woes.

In terms of bank credit flows to the private non-bank sector (Figure 1 (a)), a simple comparison of the average annual increase in credit-to-GDP ratios in 38 countries⁴ in the post-crisis period (2009–2017) against the pre-crisis (2000–2007) reveals that only 32% of the sample countries, most of which were hit by the GFC, resumed to deleverage after the crisis. In the sub-group of eighteen that experienced the 2007–2008 banking crisis (according to Laeven and Valencia 2018), only 60% saw a drop in terms of credit-to-GDP, whereas the credit level in the rest⁵ reached a record high. Moreover, 26% of the sample countries, mainly emerging economies,⁶ swung from a deleverage to a leverage position after the crisis.

Figure 1: Private Credit Growth: Pre- and Post-Crisis Comparison



Note: (a)(b) plots a simple annual average percentage point increase of bank credit (total credit) to private non-financial sector relative to nominal GDP level in the post crisis period 2009–2017 in comparison to records in the pre-crisis period 2000–2007. There are 38 sample countries (37 without Luxembourg).

Source: Bank for International Settlements (BIS); author’s calculation.

¹ At the time of writing in 2018.

² Refer to Alam et al. (2019) for the extensive use of macroprudential policies after the GFC.

³ In terms of total credit to the private non-financial sector, Canada, the Netherlands, Singapore, and Switzerland. See also the even more rapid surge of credit growth in the post-crisis period (see Figure 1b).

⁴ See Appendix A1 Country List.

⁵ Including France, Luxembourg, the Netherlands, the Russian Federation, Sweden, and Switzerland.

⁶ Specifically, the PRC; Hong Kong, China; Singapore; Malaysia; and Thailand.

The surging credit volume in some advanced economies does not seem to be in tune with secularly low private investment. Moreover, it is surprising to observe a sudden switch to leverage in emerging economies after the GFC, especially some leverage at an alarming pace,⁷ given that the economic structure might not crave greater credits in a period of weakened economic growth. A suspicion emerges that an endogenous credit supply within a financial system is at play. What is the key factor or condition in triggering risky upturns in credit cycles? Is a safe asset shortage playing a role? This is a pivotal question that might help account for the GFC as well as prevent a future one.

A growing strand of literature on safe assets has argued for (macroeconomic) shortages of safe assets as a potential root of (global) financial instability (Gourinchas and Jeanne 2012; Gorton and Ordonez 2013; Gorton 2016; Gourinchas and Rey 2016; Caballero, Farhi, and Gourinchas 2017; Golec and Perotti 2017; Kacperczyk, Perignon, and Vuillemeys 2017). To read its main view, with a focus on the question of this paper,⁸ the demand for safe assets is generally assumed to increase proportionally with output or wealth (Caballero, Farhi, and Gourinchas 2017),⁹ with a search for a reliable store of value, liquid collaterals for banks, key components of prudential regulation, and capital preservation in portfolio construction (Gorton and Ordonez 2013). On the other hand, the supply of safe assets can be constrained by the level of financial development, the fiscal capacity of the sovereign, the track record of the central bank for inflation and exchange rate stability, and the willingness of central banks to “backstop” government debts (Gourinchas and Jeanne. 2012). The origins of financial instability are sowed when excessive (insufficient) demand (supply) arises for safe assets. Such a shock to safe asset shortages distorts an incentive of the financial system to issue “private label safe assets”¹⁰ by utilizing the input of excessive risky claims on firms and households (Gourinchas and Jeanne 2012).¹¹ The whole process consequently spurs the volume of credits independently from real factors (Golec and Perotti 2017).

Despite empirical evidence attesting to the presence of safe asset shortage either in the form of safety premiums¹² or a fall in natural interest rates,¹³ the economic growth-based

⁷ The credit-to-GDP in the PRC, China (Hong Kong, China) has escalated to 156% (245%) in 2017 from 106% (151%) in 2007.

⁸ The issue has been discussed in the separate fields of international macro and finance. Accordingly, macro shortage is more closely related to the real sector of households and firms, while its origin in the latter field is found in the financial system. However, recently, as in Golec and Perotti (2017), we have seen an increasing effort to understand the nexus of safe assets and financial stability in a more unified framework.

⁹ This has been assumed in the literature, such as for a model for “global” demand for safe assets, or in the context of foreign reserve accumulation by emerging economies and their demand for United States (US) treasury securities or international liquidity. For a critical review, see Bordo and McCauley (2017).

¹⁰ Bernanke et al. (2011) note that such private label safe assets are non-safe to a negative aggregate shock even though they are expected to be the most safe, as seen in Gourinchas and Jeanne (2012). Moreover, Kacperczyk, Perignon, and Vuillemeys (2017) empirically demonstrate that the supply of private safe assets fails during episodes of market stress.

¹¹ Gourinchas and Jeanne (2012) present the mechanism but argue that the demand for safe assets “primarily” comes from a precautionary motive from firms and households owing to financial frictions, not from within the financial system.

¹² See Gorton et al. (2012), Krishnamurthy and Vissing-Jorgensen (2012) and (2015), and Gorton (2016). On the other hand, Jordà et al (2019) have recently questioned the shortage of safe assets, documenting that risk premiums stay around their historical average. I will discuss the issue based on sample average correlation analysis in Chapter III.

¹³ Refer to Caballero, Farhi, and Gourinchas (2017) and Del Negro et al. (2017). The former additionally argue that real interest rates adjust to safe asset shortages in incomplete markets. The secular fall in natural or the real risk-free interest rates, measured as an equilibrium outcome of such safe asset shortages, puts an economy into still deeper recession at the near Zero Lower Bound. Only a reduction

safe asset demand, often adopted as a constant in the literature, remains an elusive concept to apply. For instance, why should changes in wealth (economic growth or savings) inflate a safe rather than risky asset demand, or why should we assume that the composition of demand for risky and riskless assets is fixed? As an alternative step forward to the real economy, I propose two long-run trends as key determinants of safe asset demand and supply. One is population aging, which has progressed globally in recent decades. The other is an increasing tendency to use some rule-based fiscal policy, at least in advanced economies, to manage the level of public debt around certain rates.¹⁴

Demographic factors affect demand through two channels. First, an increasing life expectancy stimulates precautionary savings that search for safe stores of value, providing a huge funding source on the liability side of balance sheet of banks and institutional investors, such as insurance and pension funds. As a consequence, financial institutions also need more “safe debt securities” as sound collateral, as well as to match their increasing asset liabilities (Greenwood and Vissing-Jorgensen 2018). Second, population aging shifts up an aggregate demand for safe assets in an economy (composition effects) via age-dependent or household life cycle portfolio choice on risky and riskless assets. Numerous empirical studies support a hump-shaped (an approximate U-shaped) age profile of risky (safe) share in household portfolios (see Cocco, Gomes, and Maenhout [2005] and Chang, Hong, and Karabarbounis [2018] for the US case; Brunetti and Torricelli [2010] for the Italian; and Fagereng, Gottlieb, and Guiso [2017] for the Norwegian). Therefore, in the case that government bonds are the only safe assets, a wave of aging, driving demand for safe assets, could constitute a potential contributor to financial vulnerability when it meets a specific condition, such as counter-cyclical fiscal policy.

The purpose of this paper is to empirically explore the hypothesis of safe asset shortage-induced excess credit booms and financial instability. Despite vigorous debates on the issue since the GFC, empirical evidence on how it works remains rather scarce. A domestic focus (excluding the US) is even rare. Against this backdrop, the study makes a couple of contributions. First, I construct a new safe asset shortage index (hereafter SAS index) that reflects the trends of aging and fiscal policies. To my knowledge, this is the first attempt of its kind at the time of writing. The index for each country is built on a data set for old-age dependency ratios and central government debt from 18 advanced economies in 1960–2017.¹⁵ The new stylized fact I found is that the sample average of the individual SAS index in terms of year-over-year differences depicts some cyclical behavior, specifically a deep shortage before crises (see Figure 4a). The cyclical feature has been mainly affected by the supply side (changes in government debt) up to year 2009, and then markedly driven by aging factors after the GFC (see Figure 4b).

Second, the paper adds new empirical evidence regarding the hypothesis. The SA shortage-financial instability hypothesis is assessed in two steps. In the first part I evaluate the validity of the SAS index, its link to bank credits and their interaction as a predictor of domestic banking crises. The empirical exercise uses the classification model of Jordà, Schularick, and Taylor (2016) (hereafter JST [2016]) and Schularick and Taylor (2012) (hereafter ST [2012]). The credit expansion in the private sector is adopted

in wealth decreases the shortage. These authors focused more on the consequences of deeper safe asset shortages since the crisis and on policy responses.

¹⁴ Jordà, Schularick, and Taylor (2016) describe the long-run evolution of public debts in advanced economies as counter-cyclical.

¹⁵ The observation period and the sizes of the sample countries vary slightly for here and each empirical analysis in the paper, owing to data availability. The time series of the shortage index used for empirical exercise is also slightly different in terms of range.

as a proxy for the endogenous build-up of aggregate risks in a financial system that could result in an extreme event like a financial crisis such as in ST (2012). The study provides a basic framework in which only government debt or securities are narrowly classified into safe assets as stores of value. The test finds that it is not the level of government debt but its change (a decrease in safe asset supply) that is associated with risky private credit booms that potentially give rise to banking crises. Using the SAS index yields the same result. The estimation outcomes of the probabilistic models for 17 advanced economies in 1960–2013 demonstrate that the high level of private credits at a time of increasing safe asset shortage is the most powerful indicator of a financial crisis.

As a second step, the study sets up a fixed-effect panel model, derived from the results of the previous exercise, and estimates the causality effects of a safe asset shortage on the growth of domestic bank credits to the private sector and the role of securitization in the presence of the shortage. The main mechanism is as follows. When the demand for safe assets intensifies at their limited supply, for instance a big wave (band) of retirement (to-be retirees) or a sudden drop in government bond issuance, it triggers an endogenous, bubbly credit supply by financial intermediaries as in Shin (2009).¹⁶ In the process, banks, using their balance sheets, exploit excessive demand for safe assets, either from households' portfolio channels or from outside the banking sector, such as institutional investors. Securitization enables banks to keep in leverage, inventing quasi-private-safe assets, constructed on loans on balance sheets, proceeds from whose sales are new funding sources to issue new credits.

The shortage pressure is eventually mitigated with excessive private credits, exposing the financial system's vulnerability to a negative shock like in the GFC. In an open economy, such domestic risks can be reduced via capital outflows, exporting the shortage. Through introducing a capital-flow term in the model, the paper also verifies whether cross-border investment flows economically increase or decrease domestic credit risks. The fixed effects estimation of the credit model for 18 advanced economies in 1980–2016 confirms a positive effect of a safe asset shortage on a domestic bank credit growth. The total effect of a safe asset shortage on domestic credit booms is affected positively by securitization growth and negatively by capital outflows. The latter effect is estimated as considerably stronger than the former.

This study is inspired by broad strands of literature on safe assets, the link between credit cycles and financial stability, and capital flows. It benefits greatly from the literature on safe assets discussions when developing ideas and assumptions. To my knowledge, however, empirical studies on the nexus of safe asset shortage-credit growth-financial instability in a unified framework are rarely found in the literature. To present a few, scattered but directly relevant to the paper, my work is indebted to JST (2016) and ST (2012) in terms of empirical strategy and data. JST (2016) investigate the role of private and public debts and their interactions in causing financial crisis episodes. In an analysis of data from 17 advanced countries in 1870–2012, the authors argue that it is mainly the private debt pile-up that induces financial crises, while public debt *ex ante* is scarcely relevant. Instead, the negative impact of public debt is evident in the aftermath of crises, as excessive public leverage tends to prolong the recession and is associated with weak growth after crises. By contrast, this paper supports the strong interaction between public and private debt as the main crisis predictor. This distinctive result comes from the use of government debt. JST (2016) employ the level of general government debt for the interaction term with private credits, while my paper uses the change in central government debt, that is, net safe asset supply. While the former studies focus only on domestic factors, Cesa-Bianchi, Eguren-Martin, and Thwaites (2017) help add a global

¹⁶ Shin (2009) points to the endogeneity of credit supply as the origin of the subprime crisis.

factor to the credit banking crisis discussion. They study the impact of credit growth abroad on the risk of a domestic banking crisis, using data from 38 advanced and emerging economies over 1970–2011. They empirically show a significant role of cross-border portfolio inflows as the main channel explaining the large positive effect of foreign credit booms on the probability of domestic banking crises. However, the study barely deals with structural factors behind the relationship. Perugini, Holscher, and Collie (2015) investigate the roots of financial instability, empirically estimating the relationship of inequality, credit growth and financial crisis for 18 Organisation for Economic Co-operation and Development (OECD) countries in the period 1970–2007. Authors find a positive, significant effect of income inequality on private debt growth but their empirical model seems to miss a clear link, for instance, an interaction term of credit growth and inequality in the crisis model, to explain why inequality-driven credit booms are directly relevant to increasing the probability of banking crises. In terms of an asset index, Chen and Imam (2014) construct an “asset” shortage index and show its positive effect on banking crisis occurrences for 41 emerging economies for 1995–2008. They argue that one origin of banking crises, asset bubbles and uphill capital flows in emerging markets lies in general asset shortages, not in safe asset shortages. Besides a different focus on the sample group, the indexing approach used in the paper, relying on flows of funds of assets, is distinct from my paper, which constructs a structural factor-based safe asset shortage index for advanced economies.

The paper is organized as follows. Section II estimates the public debt (safe assets) to financial instability nexus in probabilistic models, and discusses the results. Section III describes the safe asset shortage index and the stylized facts of the data related to empirical exercises, and explores the role of the index in the crisis classification model. Section IV presents the fixed-effects panel model for private credit growth and the estimation results. Section V concludes with policy implications.

2. CHANNEL OF FINANCIAL INSTABILITY: GOVERNMENT DEBT AND BANK CREDIT

I revisit the crisis classification model of JST (2016) to assess the relationship between a safe asset shortage and financial fragility via credit booms. The first empirical exercise replicates JST (2016) for the data selection check. Before creating the SAS index, it is necessary to examine the test results for a case using only the supply side of the SAS index, associated with government debt, and assess the suitability of the data set as a proxy for safe assets.

The empirical model is the following probability logit model, as in JST (2016) and ST (2012):

$$\text{logit}(p_{i,t}) = b_{0,i} + b_1(L)X_{i,t} + e_{i,t} \quad (1)$$

where the log-odds ratio ($\text{logit}(p_{i,t}) = \ln(p_{i,t}/(1-p_{i,t}))$) of a financial crisis episode in country (i) in year (t) is a linear function of lagged controls $X_{i,t}$ and country-fixed effects $b_{0,i}$. The lagged control variables include five-year moving averages of changes in the private credit-to-GDP and the public debt-to-GDP. They are further augmented by lagged levels of the private and public debt-to-GDP, as well as an interaction term of them.

The analysis adopts the data set from JST (2017),¹⁷ aside from public debt data. Given that the study limits safe assets to (central) government bonds as stores of value in its narrowest definition,¹⁸ it opts for the central government debt data from the International Monetary Fund (IMF) Global Debt Database (Mbaye, Badia, and Chae 2018),¹⁹ which represents an extensive public debt database over a long-time horizon back to the year 1950. The central government debt-to-GDP is employed as a proxy for safe assets²⁰ in the entire empirical models of the study. The sample include 17 advanced economies as in JST (2016) (see List A2), but the observation period covers only the range of 1960–2013, shortened from the period of 1870–2012 in JST (2016).

Table 1 documents the main results. Private credit growth is still a strong crisis predictor as in Column (1), while public debt growth alone does not offer any information (see Column (2)). This is a similar outcome as in JST (2016). A new observation is found in Column (5). When we add the lagged level of public debt-to-GDP and the interaction term between the lagged private credit and public debt-to-GDP level to the model, the estimation of the specification yields further information to predict a crisis.

Table 1: Financial Crisis Classification Ability: Central Government Debt (CGD)^(a)

| Classifier Logit Model | (1) | (2) | (3) | (4) | (5) |
|--|--------------------|-----------------|--------------------|-------------------|--------------------|
| Change in private credit/GDP (five-year moving average) | 34.59*** (3.81) | | 34.55*** (9.19) | 23.66* (12.31) | |
| Change in public debt/GDP (five-year moving average) | | -9.48 (8.82) | -0.20 (10.13) | | -22.73* (11.80) |
| Lagged level of private credit/GDP | | | | 1.47 (1.53) | |
| Lagged level of public debt/GDP | | | | | -4.50** (1.74) |
| Interaction term ^(b) | | | | 0.36 (1.03) | 6.18*** (1.85) |
| Observations | 1810 | 987 | 987 | 999 | 996 |
| AUROC | 0.65 (0.03) | 0.60 (0.06) | 0.74 (0.05) | 0.79 (0.04) | 0.76 (0.05) |

Note: (a) For the Netherlands, general government debts are used in all empirical exercises and indices as its central government debt data are not available in the IMF Global Debt Dataset.

(b) The interaction between the lagged level of private credit-to-GDP and of public debt-to-GDP.

(c) Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: Author's estimation. The government debt data from the IMF Global Debt Dataset and other data from JST (2017).

¹⁷ See the Appendix Table A1, or visit <http://www.macrohstory.net/data/#DownloadData> for more information.

¹⁸ Golec and Perotti (2017) provide a good overview of the types of safe assets, classified by safety and liquidity and issuers. See Figure 1 on page 7.

¹⁹ <https://www.imf.org/external/datamapper/datasets/GDD> for more information.

²⁰ As for data selection background, refer to the safe shortage index description in Section III.

The result is substantially different from JST (2016) that found little association between private credit and public debt to predict crises. Column (5) shows that central government debt both in change and in level play a role in restraining the occurrence of a financial crisis event, while a high level of public debt in the high level of private credit would raise the possibility of a future crisis. The coefficient of the interaction term in Column (5) is statistically significant. The AUROC²¹ shows a better performance for Specification (5) than for the same specification in JST (2016). The different outcomes of this study and JST (2016) may result from the distinct sample period and data selection for public debt. However, what deserves our attention is that when government debt is approached as (safe) assets in the use of central government debt in change, instead of as an indicator of general fiscal soundness in its level, the role of public debt and its interaction with private credits are positively verified as a useful information source in the model. The data selection of central government debt for safe assets, based on the hypothesis, is assessed as appropriate.

Next I generate an interaction term of lagged level of private credit-to-GDP ($c_{i,t-1}^{priv}$) and lagged yearly change in public debt-to-GDP ($\Delta d_{i,t-1}^{pub}$). Given that government debt is annually collected in terms of stock, its difference roughly approximates year-over-year net government bond issuance. This enables the interaction term to capture the effect of private credit expansion on financial risks at a time of a drop in safe asset supply.

Surprisingly, unlike the previous exercise, Columns (1) and (3) in Table 2 report that the level of private credit in response to the change in government debt (net government bond issuance) mainly accounts for future crises. The interaction term measuring the effect is the most powerful information source as a crisis predictor, followed by the private credit level. The coefficient estimates for the two terms are all statistically significant. The change in private credits or public debt loses its forecasting power when the former two control variables are added. Specifications (1) and (3) show better predictive ability compared to the result of Table 1. The AUROC of Specification (1) for the augmented model of private credit growth is 0.85 (standard error (SE.) of 0.04) and that of Specification (3) for the modified model of public debt growth is 0.88 (SE. 0.03).

Table 2: Financial Crisis Classification Ability in the Modified Model: CGD

| Classifier logit model | (1) | (2) | (3) | (4) |
|---|--------------------|------------------|---------------------|-------------------|
| Change in private credit/GDP (five-year moving average) | 10.28 (11.67) | 12.18 (12.18) | | |
| Change in public debt/GDP (five-year moving average) | | | 15.86 (10.68) | 5.94 (14.74) |
| Lagged level of private credit/GDP | 3.42** (1.54) | 2.57* (1.44) | 3.99*** (1.35) | 3.26*** (1.03) |
| Interaction term: $c_{i,t-1}^{priv} * \Delta d_{i,t-1}^{pub}$ | -31.95** (9.34) | | -41.38*** (8.38) | |
| Observations | 984 | 968 | 984 | 968 |
| AUROC | 0.85 (0.04) | 0.79 (0.05) | 0.88 (0.03) | 0.79 (0.05) |

Note: Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Source: Author's estimation.

²¹ AUROC is an abbreviation for Area Under the Receiver Operating Characteristic curve, a measure of the binary classification ability of the model. ST (2012) explain the method in detail.

It is the high private credit level at a time of diminishing public debt, that is, a drop in safe asset supply, which warns of a build-up of financial risks in advanced economies over the period 1960–2013. Given that this result empirically supports the hypothesis of the paper, the next section presents a safe asset shortage index combined with a demand component, and tests its validity in the same classification model.

3. SAFE ASSET SHORTAGE INDEX, DATA AND STYLIZED FACTS

3.1 Safe Asset Shortage Index (1970–2017²²)

The safe asset shortage index is constructed on the assumption of household life-cycle portfolio choice. Households' portfolio shares in risky (riskless) assets drop (increase) substantially with age of household heads.²³ According to Fagereng et al. (2017) analyzing Norwegian household data, the portfolio share in risky assets is high and constant up to mid-phases of the life cycle, remaining at around 50%. Subsequently, households start gradually decreasing their risky asset shares until investors' age reaches around 65.²⁴ When they retire, most people exit the stock market.

Based on such empirical evidence on household portfolio choice in the micro data analyses, the study assumes that investors have two choices of risk and riskless assets (such as safe government bonds), and their demand for safe assets grows as they age.²⁵ Thus, an aggregate demand for safe assets evolves contingent on a demographic transition in the economy. I simplify the relationship into a relative term, such that a relative demand for safe assets to risky shifts contingent on the ratio of old to young people. The study takes the retirement age of 65²⁶ as the threshold for exiting from a risky asset market or at least the lowest and constant level of risky asset share in terms of life cycle investment. The old-age dependency ratio is a useful tool here. It efficiently summarizes the relative demand for riskless assets on aggregate in an economy. The empirical strategy is that the relative demographic shift toward old against that of the base year proxies for the relative increase in the safe asset demand compared to the level in the base year.

It is formulated as in the first element on the right-hand side of Equation (2) for the SAS index. The index for demographics-based safe asset demand captures the relative increase of the old-age dependency ratio²⁷ against its level in 2000 of the base year

$$\left(\frac{old_d_{i,t}}{old_d_{i,2000}}\right).$$

²² I present the index series ranging from 1970–2017 in this section. They were originally constructed from the year 1950, based on an unbalanced data set.

²³ See again for empirical results, Cocco, Gomes, and Maenhout (2005) and Chang, Hong, and Karabarbounis (2018) for the US case and Brunetti and Torricelli (2010) for the Italian, especially Chang and colleagues in terms of participation rate.

²⁴ According to the study, participation in the stock market also follows a hump shape. It increases rapidly with investors' age up to a high level at age 45, and stays constant or slightly grows afterwards but investors leave the stock market at retirement.

²⁵ In the process, increasing precautionary savings on the balance sheet of banks and financial institutions also call for more safe assets. I abstract the financial sectors, linking their behavior to the motivation of household investors.

²⁶ The threshold age or range could be adjusted to construct a better index.

²⁷ The number of people older than 64 years per one hundred working age population aged 15-64.

$$sas_{i,t} = \frac{old_d_{i,t}}{old_d_{i,2000}} - \frac{cg_d_{i,t}}{cg_d_{i,2000}}, \quad (2)$$

$$\Delta sas_{i,t} = \frac{old_d_{i,t} - old_d_{i,t-1}}{old_d_{i,2000}} - \frac{cg_d_{i,t} - cg_d_{i,t-1}}{cg_d_{i,2000}} \quad (3)$$

The supply of safe assets is determined by government bond issuance. The index for safe asset supply measures the relative increase of government debt-to-GDP against its level in the base year 2000 ($\frac{cg_d_{i,t}}{cg_d_{i,2000}}$). I opt for the central government debt series, which is compiled mostly by core debt instruments such as debt securities. Given that it reports the gross outstanding stock of government liabilities, the annual change of the stock approximately quantifies the net amount of safe asset issuances. The central government debt-to-GDP is thus employed as a proxy for the safe asset supply as a portion of GDP.

A shortage of safe assets is assumed to occur when the government bond supply does not meet the age-dependent safe asset demand. The SAS index in Equation (2) measures the gap between two indices. There is no weight on each component. The relationship between two indices in the basic framework is simple and straightforward. Equation (3) presents the index in difference, which captures the annual gap between the yearly change in the size of new and old retirees relative to young, and the change in net government debt issuance to GDP.

Discussion. In terms of the baseline indices above, I assume that the ratio of the old generation's financial assets to the young's is constant over time. In addition, the supply side of the index does not include the asset purchase by major central banks during and after the GFC, despite its substantial shock to the amount of safe assets available to the public. However, such counterfactual elements are certainly worth testing. The extended indices to reflect them could be presented as follows.

$$e_sas_{i,t}^d = w_{i,t} * \frac{old_d_{i,t}}{old_d_{i,2000}}, e_sas_{i,t}^s = \frac{(cg_d_{i,t} - z_{i,t})}{cg_d_{i,2000}}, \quad (4)$$

$$\text{where } w_{i,t} = \frac{old_asset_r_{i,t}}{old_asset_r_{i,2000}}, z_{i,t} = \frac{cb_net_purchase_{i,t}}{gdp_{i,t}}$$

$$\ln(e_sas_{i,t}^d) = \ln(w_{i,t} * \frac{old_d_{i,t}}{old_d_{i,2000}}), \ln(e_sas_{i,t}^s) = \ln(\frac{cg_d_{i,t} - z_{i,t}}{cg_d_{i,2000}}) \quad (5)$$

$$e_sas_{i,t}^{shortage} = \ln\left(w_{i,t} * \frac{old_d_{i,t}}{old_d_{i,2000}}\right) - \ln\left(\frac{cg_d_{i,t} - z_{i,t}}{cg_d_{i,2000}}\right) \quad (6)$$

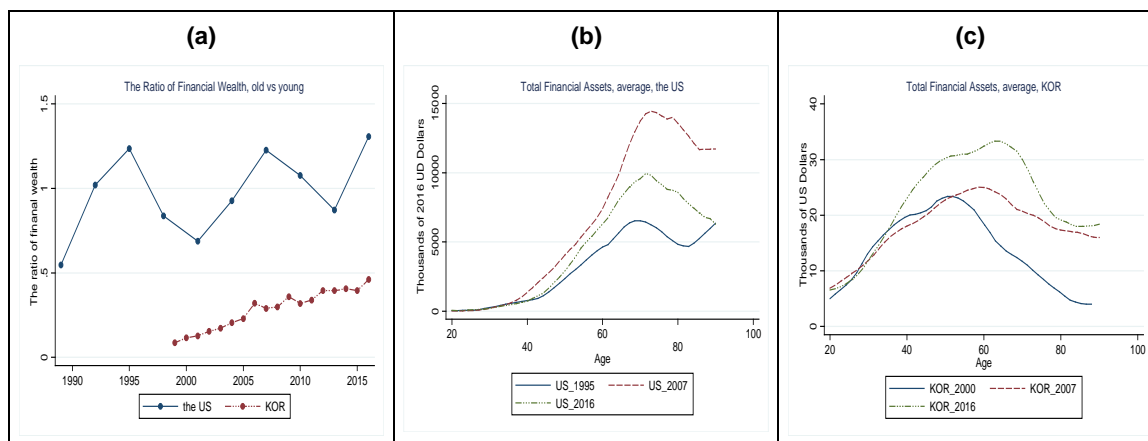
$$\Delta e_sas_{i,t}^{shortage} = \Delta \ln(old_d_{i,t}) + \Delta \ln(old_asset_r_{i,t}) - \Delta \ln(cg_d_{i,t} - z_{i,t}) \quad (7)$$

The extended index for safe asset demand is weighted by $w_{i,t}$, the level of over 64 old agents' financial wealth relative to the young, compared to the base year. Taking a log on each safe asset demand and supply index in Equation (4) gives more direct intuition when we solve the shortage in level ($e_sas_{i,t}^{shortage}$) in Equation (6) and in yearly changes ($\Delta e_sas_{i,t}^{shortage}$) in Equation (7). Then, the extended safe asset shortage index in difference is affected by a change in the relative share of old agents' financial wealth and

by the central banks' asset purchase shock to the amount of safe assets available to the public.²⁸

The variation in age-contingent financial wealth distribution over time is substantial. A comparison of the figures in the Republic of Korea and the US explains why the ratio of financial wealth could be important in safe asset debates. Financial wealth by age does not increase evenly. Figure 2 (a) depicts that the amount of financial wealth held by people aged over 63 grows faster than that of younger agents. Moreover, the growth rate of this ratio in the US is much steeper than in the Republic of Korea. The financial wealth share of agents over 63 accounts for 69% of the younger generation's in 2001 in the US. However, the figure records 131% in 2016, rising by 62 percentage points (%p). In the Republic of Korea, the level of financial wealth of senior agents reaches only 13% of younger generations' in 2001, steadily increasing to 46% in 2016. During the same period, it only grows by 33%p, approximately half of the US figure. This simple micro data analysis reveals that the demand for safe assets in the US may have been stronger than in the Republic of Korea, given that the relative asset share of senior agents in the US dominates that in the latter in scale and growth. In Figure 2 (c), younger household heads held more financial assets in per-head average term in the Republic of Korea in 2000. By contrast, Figure 2 (b) shows that already in 1995, the age profile of average total financial assets in the US saw a peak in agents over 60.

Figure 2: Total Financial Wealth Distribution: Republic of Korea vs. the US



Note: (a) summarizes the ratio of aggregate financial wealth between the group of household heads aged over 63 and the young aged below 64. The data for the Republic of Korea come from the Korean Labor & Income Panel Study of the Korea Labor Institute, adjusted to the 2015 price level, while the data for the US come from the Survey of Consumer Finances (SCF) of the Federal Reserve Board. (b) and (c) are the age profile of the households' average amounts of total financial assets for the US and the Republic of Korea in the US dollars. Also refer to Figure A2.

Source: Author's calculation.

3.2 Demographics

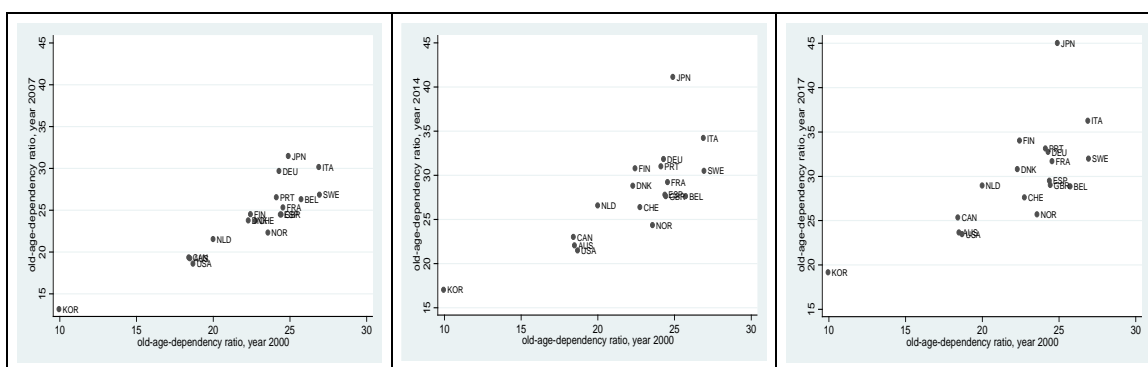
The present and the following part describe the data from the sample of eighteen countries used for the empirical analysis of Section IV²⁹ and stylized facts. The level of population aging is heterogeneous over countries, but the trend of aging over time is a

²⁸ It could be further extended and modified, as other determinants of the supply and demand of safe assets such as a series of uncertainty and regulations also need to be considered.

²⁹ See Appendix List A3 and Table A1.

significant global phenomenon, with a secular fall in fertility and a surge in longevity.³⁰ It may imply a gradual increase in safe asset demand globally, or at least in advanced economies³¹ from the view of an investor’s portfolio choice over the life cycle. According to data from the UN World Population Prospects, most sample countries belonged to the group of aging society³² in 1950, except for the Republic of Korea (2000³³), the Netherlands (2004) and Norway (1977). In the year 2015, most economies were classified into the aged society, while Germany (21.1%³⁴), Italy (22.3%), and Japan (26%) entered the hyper-aged society. Besides the Republic of Korea (elderly population share, 13%), the US (14.6%) is the youngest country in the sample, followed by Australia (15%), Canada (16.1%), and Norway (16.3). From 2000 to 2015, the aging occurred fastest in Japan (average annual growth of 0.6%p in elderly population share), with the Republic of Korea (0.4%p), Finland (0.4%p), and Germany (0.3%p) behind.

Figure 3: Demographics: Old-Age Dependency Ratio



Source: UN World Population Prospects. Author’s calculation.

Figure 3 depicts the time interval progress of old-age dependency ratio. The five-year interval data also come from the UN World Population Prospects. For here and the following empirical study, I interpolate the data set to the annual data. The figure is little different from the evolution of the elderly share in the total population, owing to a stagnant birth rate and increasing longevity across countries. In 2017, Japan showed the highest record of 45, followed by Italy (36.3), Finland (34), and Germany (33). Relative to the level in the base year of 2000, the safe asset preference share of population (the old-age dependency ratio) grew most quickly in Japan (annually by 1.18%p). Next was Finland (0.68%p), followed by Italy (0.55%p), the Republic of Korea (0.54%p), Portugal (0.54%p), and the Netherlands (0.53%p), while Norway (0.12%p) and Belgium (0.19%p) showed rather slow progress in aging over 2000–2017.

³⁰ Refer to Amaglobeli et al. (2019) and Barany, Coeurdacier, and Guibaud (2019) for a broad description of the global and regional aging trend, including fertility and life expectancy rates.

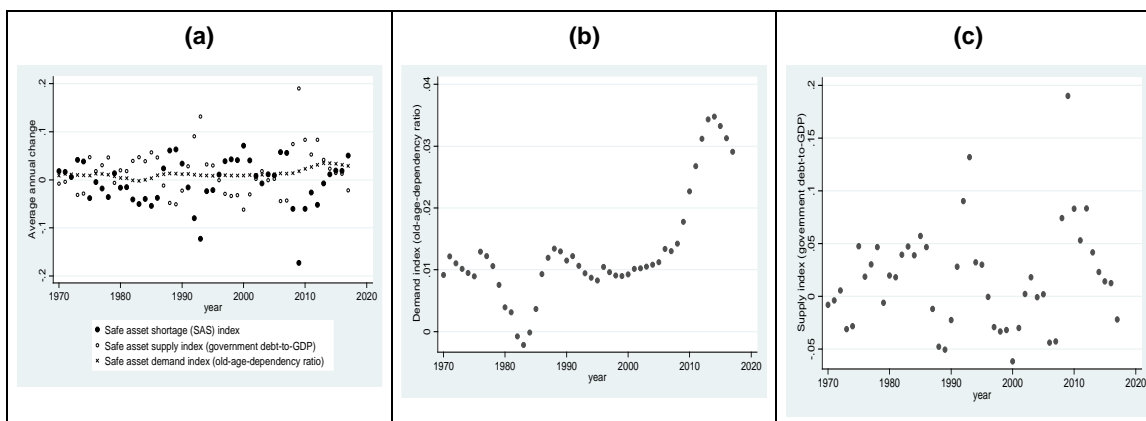
³¹ With substantially high financial assets held in the private sector.

³² According to the UN definition, when the elderly population (+65) in a country exceeds 7% of its total population, it is classified as an aging society. When it accounts for 14% (21%) or more, it is defined as an aged society (a hyper-aged or super-aged society).

³³ The figure in parentheses refers to the year in which the countries became part of the aging society.

³⁴ This refers to the % share of elderly population (+65) in the total population.

Figure 4: Safe Asset Shortage Index in Difference (Average across Countries)



Note: The graphs (a)-(c) plot the sample average annual difference in (a) the SAS index across countries in 1970–2017, (b) demand index of old-age dependency and (c) supply index of central government debt.

Source: Author’s calculation.

In Figure 4(b), the sample average of annual changes in the old-age dependency ratio revealed a striking feature. Though it seemed stable in early 2000s, it was not constant at all in the long-run time series; rather, it exhibited big swings. The recent hike is dramatic, driving the SAS index after the GFC. The average change in the ratio elevates in year 1986, 1991, 1996, 2006, 2010, and 2012. Some of the upturns came roughly before banking crises.

3.3 Government Debt

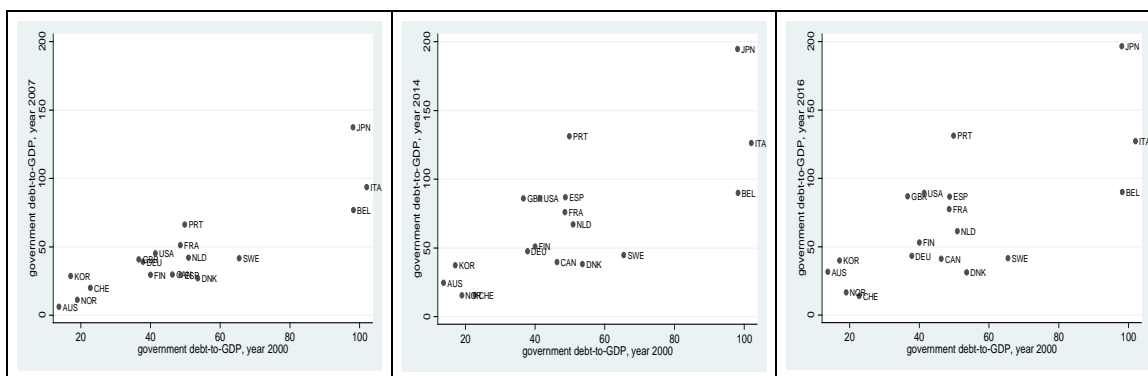
The central government debt-to-GDP is adopted as a proxy for annual safe asset supply in the study, and the data set comes from the Global Debt Database (2018) released by the IMF. The Global Debt Database provides the widest coverage in terms of time series of debt starting in the year 1950 and of sample countries (190 countries). It enables the study to overcome problems arising from data coverage and access to government debt issuance. The data set is unbalanced over the period 1950–2017. Among the eighteen sample countries, the time series of debt for Canada (1990),³⁵ Germany (1961), the United Kingdom (UK) (1974) and the Republic of Korea (1960) are relatively short.

Figure 5 summarizes the evolution of the central government debt across countries over time interval. The countries that maintained the lower level of sovereign debt in 2017, compared to the level in 2000, were Belgium (98.2 (2000³⁶)→77.0 (2007)→88.1 (2017)), Canada (46.3→29.7→39.1), Switzerland (22.7→20.0→14.5), Denmark (53.6→27.1→30.0), Norway (19.0→11.3→15.8), and Sweden (65.5→39.6 (2008)→39.7). The group of countries that saw a big jump in debt by more than 50 percentage points after the crisis were Portugal (66.2 (2007) →131.3 (2016)), Japan (137.3 (2007)→196.7 (2016)), and Spain (29.5 (2007)→87.1 (2015)). By contrast, Switzerland shrunk liabilities by about 5%p over the same period. The Republic of Korea expanded its debt-to-GDP from 17.1% in 2000 to 29.3% in 2006, reducing it slightly in 2007–2008 to 28.2%. After the GFC, the level rose to 39.5% in 2017.

³⁵ This denotes the year that the data run back to.

³⁶ This indicates the year of the record.

Figure 5: Government Debt: Central Government Debt-to-GDP Ratio



Source: The Global Debt Database, IMF. Author's calculation.

One stylized fact indicates that the government debt-to-GDP generally dropped in the year before the GFC and dramatically inflated after the crisis, although the latter saw some variation by countries. In the case of the 2007–2008 GFC, all thirteen countries out of 18 dropped the debt ratio, that is, net government bond issuance relative to GDP, at the lowest point in 2007 or 2008 since year 2000.³⁷ Interestingly, a year before some banking crises, the sample average of annual changes in government debts declined, while the old-age dependency ratio jumped. In Figure 4 (c), this decreased in 1987 (1986),³⁸ 1996 (1996), 2006 (2006), 2010 (2010) and 2013 (2012), except for a lift in the demand index (old-age dependency ratio) in 1991.

3.4 Index-Based Safe Asset Shortage across Countries, 1970–2017

Figure 6 provides an overview of the index-based safe asset shortage trend across countries over 1970–2017. Certain features emerge. First, out of all the sample countries except for the UK, the SAS index moved up consecutively for a couple of years just ahead of the 2007–2008 GFC. The relatively sharp bounce during this period could be observed in the Scandinavian countries. The SAS index in Norway picked up by 28%p in 2005–2007, Denmark by 26%p and Finland by 18%p. The Netherlands, Switzerland, and Canada experienced a rise in the index by 16%p, 10%p, and 12%p, respectively. The shortage grew modestly in the US by 4%p. By contrast, the UK did not show such a trend. Rather, the index steadily fell over 2004–2015, rebounding only recently.

The second feature is the resurgence of the shortage after the culmination of the deep repercussion of the crisis. A strong upturn in the shortage could be observed in Switzerland, Denmark, Sweden, and the Netherlands. The SAS index of Switzerland revealed a dramatic surge from 2003, reaching the point of 0.58 in 2016, the deepest shortage since 1980. Denmark also recorded the greatest shortage of 0.83 in 2017 since 1980, rebounding from the level of 0.41 in 2011. Sweden and the Netherlands also experienced the most severe safe asset shortages in 2017 over the entire observation period of 1970–2017, with indexes of 0.58 and 0.25, respectively.

Another distinct case is Japan. During the observation period, Japan showed a relatively decreasing trend in the SAS after 1991. The anticipated strong demand pressure for safe

³⁷ The US, Germany, France, and Japan reduced the level but not much by the scale compared to other countries. The UK did not curtail the level.

³⁸ The year of local peak in the sample average change in the old-age dependency ratio.

assets, coming from steep aging in Japan, looks alleviated by the corresponding huge government debts. The index for the Republic of Korea headed downward from 1996.

A new, interesting finding is that the sample average of annual difference in the SAS index moved cyclically. The safety pressure tends to hike just before crises and dampened after them. I decompose the contribution of demand (aging) and supply (public debt) factors to the sample average change in the safe asset shortage. Figure A1 displays the dominant role played by government debt supply over the entire period, specifically up to year 2009, but a closer look also reveals that at a time of a rise in safe asset shortage ahead before crises, the portion of demand side contribution increased. Further, the post-GFC role of aging has been escalating. This necessitates greater attention to demand-side factors in the shortage.

Using the data set from Jordà et al. (2019), I check the correlation among sample average changes in the SAS index and the sample average returns on risky (equities), safe (government bonds) and quasi-private-safe assets (housing). While Jordà et al. (2019) combined housing and equities in a risky asset basket, I split them, defining housing as quasi-private safe assets in terms of stores of values, and whose securities are alternative long-term assets for financial institutions. If safe asset shortage is driven by aging-contingent demand, the returns on both government bonds and equities would decrease, as the shift in asset demands toward safe assets affects negatively (spurs) the prices of equities (bonds). The housing returns increase in the process of interaction between financial institutions and real sectors to narrow the shortage. In the case of a supply shock to the shortage, the association between government bonds and equities returns is not clear-cut. However, the returns on alternative safe assets of housing would still appreciate in the shortage.

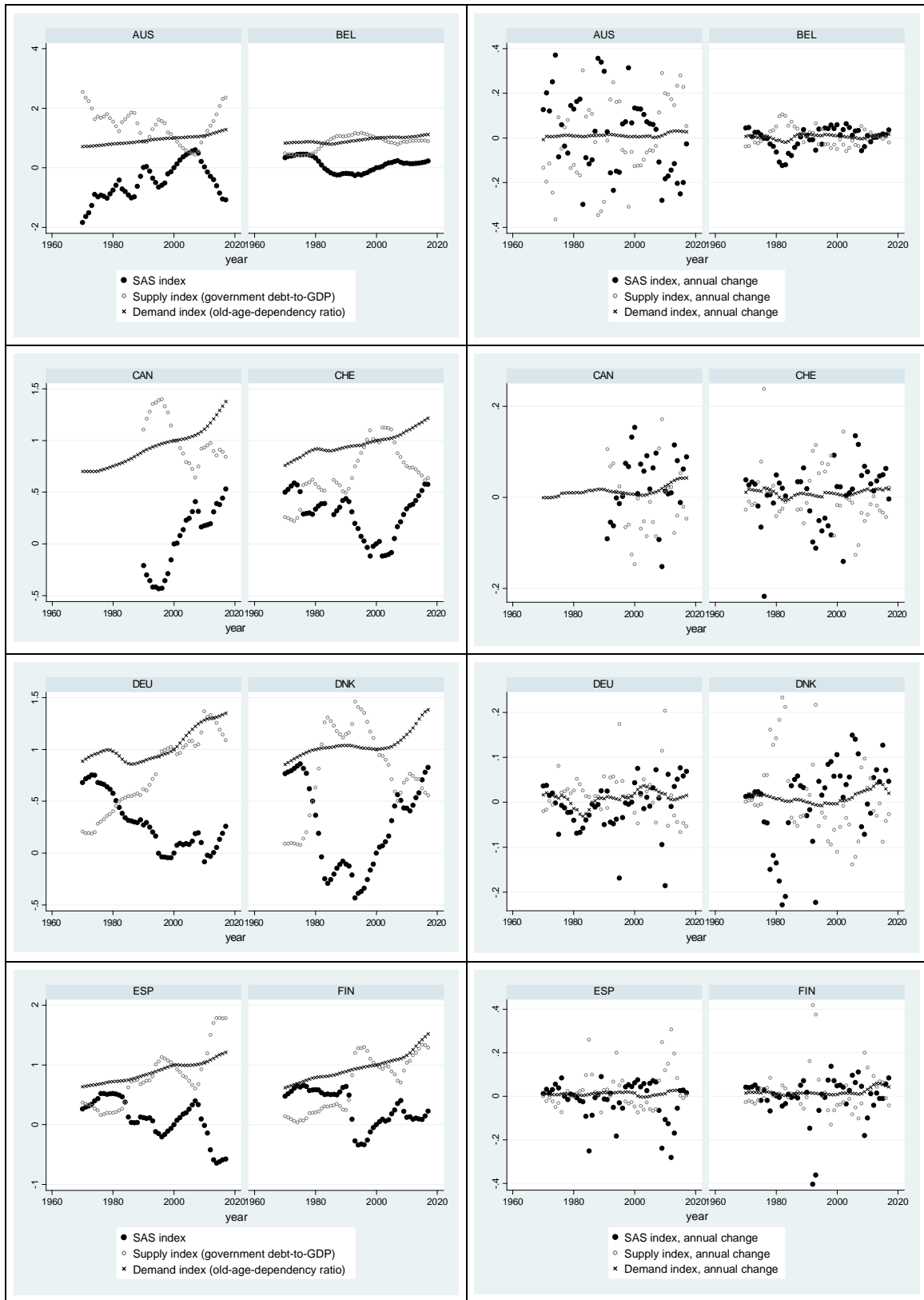
Table A2 documents the results for 16 countries³⁹ in 1970–2015. The sample average returns on bonds correlate positively with the equity returns, but negatively with the housing returns. As expected, the association of annual changes in the SAS index with the returns on bonds and equities is negative, while the shortage changes are positively related to housing returns. This implies that, the risk premiums, the spreads between the returns on equities and government bonds would not get wider in a rise in the safe asset shortage since both returns tend to move in same direction to the shortage shock, but the spreads between the returns on housing and government bonds would increase in the shortage. The last three rows of Table A2 support this interpretation. The spreads between the returns on equities and bonds co-move negatively with the index in difference, although it is not statistically significant, while the changes in the index are positively and significantly related to risk premiums on housing.

Jordà et al. (2019) doubt the safe asset shortage argument based on recent risk premiums at the historical average. The risky assets in this seminal paper include equity and housing whose returns tend to move in opposite directions in the safe asset shortage in my exercise, canceling out the risk premiums⁴⁰ in 1970–2015. The definition of risky assets and hypothesis on safe asset shortages would affect the debate on risk premiums and safe asset shortages.

³⁹ The sample countries are the same in the List A3, excluding Canada and the Republic of Korea.

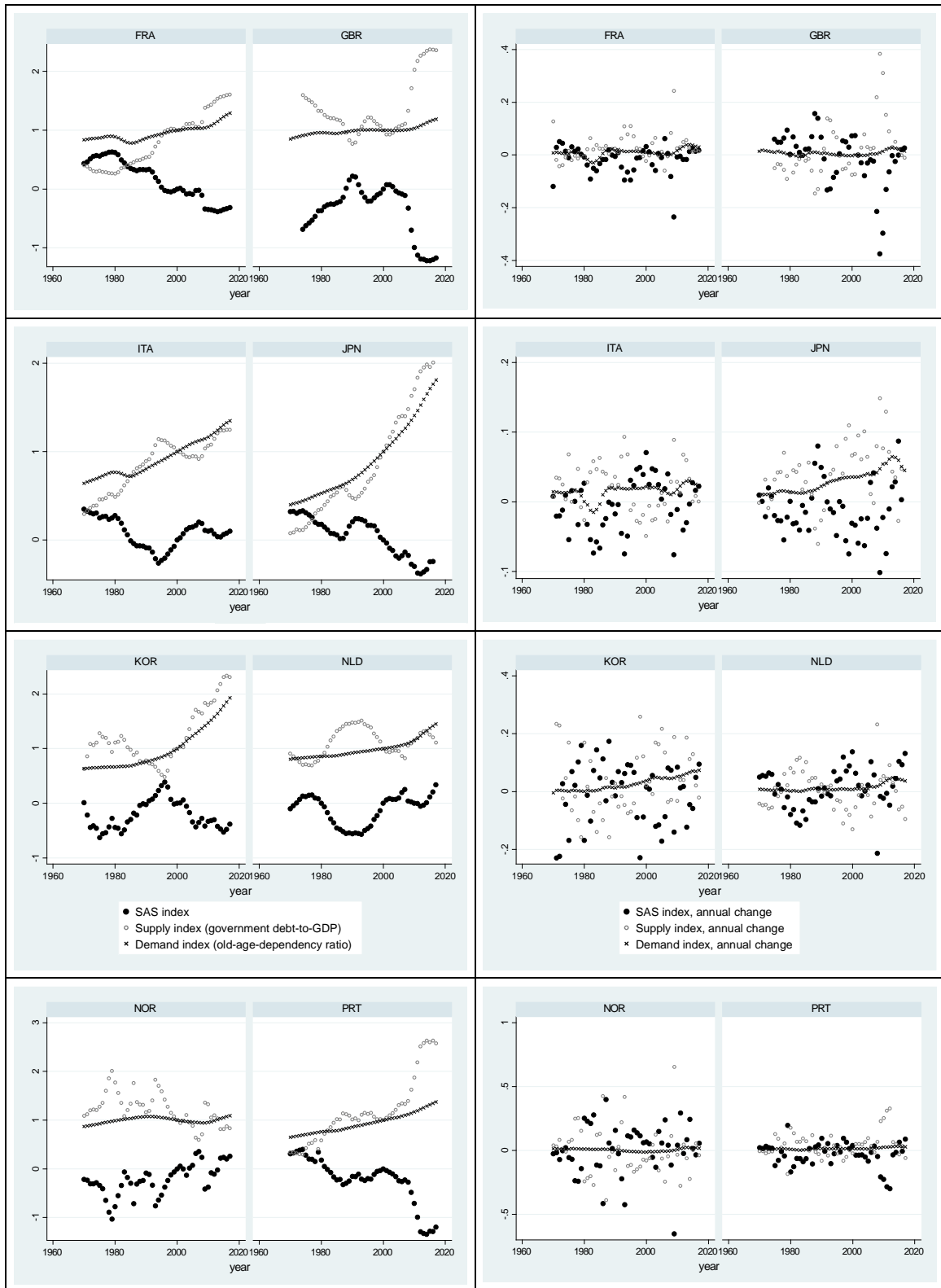
⁴⁰ In Table A2, the shortage change is positively correlated with the returns and the premiums on the risky assets which are composed of both equity and housing as in Jordà et al. (2019). However, the equity returns alone are negatively associated with the shortage change.

Figure 6: Safe Asset Shortage Index, Individual



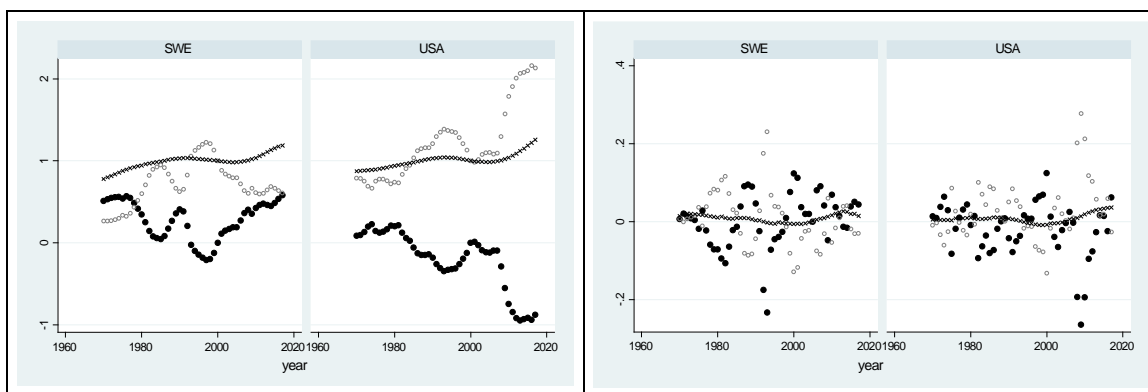
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Figure 6 continued



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Figure 6 continued



Note: The panel on the left-hand side of the Figure plots the evolution of indices in level (year 2000=1 for supply and demand indices, year 2000=0 for SAS index) while the panel on the right-hand side plots it in terms of yearly difference. Source: Author’s calculation.

3.5 Financial Crisis Classification Ability: Safe Asset Shortage Index (1960–2013)⁴¹

In this section, I assess the power of the SAS index as a crisis predictor in the same empirical model as in the previous Section II. Table 3 presents similar results as in Table 2 in Section II. The change in private credit-to-GDP still has a significant impact on the possibility of crises as in Columns (2) and (3), while there is no role of change in the safe asset shortage used alone (see Column (1)). Nevertheless, the private credit growth loses power when the model facilitates an interaction between private debt and safe asset shortage.

Table 3: Financial Crisis Classification Ability: Safe Asset Shortage (SA) Index

| Classifier Logit Model | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|----------------|--------------------|--------------------|------------------|--------------------|--------------------|--------------------|
| Change in private credit/GDP (five-year moving average) | | 34.26*** (9.20) | 34.03*** (9.26) | 17.18 (13.72) | | | 9.70 (11.36) |
| Change in SAS index (five-year moving average) | 4.96 (3.99) | 1.42 (4.12) | | | -6.83 (4.76) | -3.64 (5.40) | |
| Lagged level of private credit/GDP | | | | 2.11* (1.28) | | 4.21*** (1.46) | 3.63** (1.62) |
| Lagged level of SAS Index | | | 0.32 (0.77) | | 0.94 (0.94) | | |
| Interaction term: $c_{i,t-1}^{priv} * sas_{i,t-1}$ | | | | 0.36 (1.03) | | | |
| Interaction term: $c_{i,t-1}^{priv} * \Delta sas_{i,t-1}$ | | | | | 22.56*** (3.86) | 18.06*** (3.46) | 16.21*** (3.75) |
| Observations | 938 | 938 | 950 | 950 | 935 | 935 | 935 |
| AUROC | 0.60 (0.06) | 0.74 (0.05) | 0.75 (0.05) | 0.79 (0.05) | 0.85 (0.03) | 0.89 (0.03) | 0.88 (0.03) |

Note: Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Source: Author’s estimation.

⁴¹ I used the same time range of the SAS index from 1960-2013 despite some missing data points in government debt, for instance, for Canada, for a better comparison with the former exercises in Table 1 and 2.

The AUROC in Specifications (2) and (3) are clearly lower than in Columns (6) and (7) where the lagged private credit-to-GDP level and the interaction term of the lagged level of private credit as well as the lagged change in the SAS index are added. Specifications (6) and (7) show that in the presence of the two former terms, neither private credit growth nor the change in the SAS index provides any information on future financial turbulence. Instead, the (high) level of private credit associated with a (positive) change in the SAS index demonstrates significant power to detect a financial vulnerability. The coefficient estimates for the interaction term of lagged difference of the SAS index and the lagged level of private credit-to-GDP are statistically significant (see Columns (6) and (7)). The AUROC value for each specification is 0.89 (SE. 0.03) and 0.88 (SE. 0.03), respectively, exhibiting the strong crisis forecasting power of the models. Both are significantly different from the AUROC=0.54 (SE. 0.03) for the null reference model with only a country-fixed effect as a control variable.

The key finding to be underlined in this exercise is two-fold. First, the test result offers empirical support for the interaction between the safe asset shortage and private credits as a useful financial risk predictor. Second, it is not the level of the shortage but its change that destabilizes the financial system via private credit channels.

4. EMPIRICAL MODEL AND ANALYSIS

4.1 Empirical Model

This part studies the causality effect of safe asset shortages on private credit expansion as part of an extended econometric model. In doing so, it focuses on the contribution of safe asset shortages to boosting the risky upturn of private credits. For this purpose, the paper sets up the fixed-effects panel models of Equations (8) and (9) with unobserved country-specific (α_i) and time-fixed effects (τ_t). The securitization term ($secu_{i,t}$) explains the role of banks in producing quasi-private safe assets that foster private credit growth. The interaction term of lagged securitization growth and lagged yearly change in the SAS index measures the causality effect of an increase in securitization in the presence of a safe asset shortage, that is, the potential role of banks in filling the gap between supply and demand for safe assets.

Equation (8) is for the closed version of the economy that does not consider cross-country capital flows. All variables are in real terms, where subscripts (i) and (t) denote countries and years, respectively.

$$\Delta credit_{i,t} = \alpha_i + \tau_t + \beta_1 \Delta sas_{i,t-1} + \beta_2 \Delta secu_{i,t-1} + \beta_3 iy_{i,t-1} + \beta_4 \Delta gdp3_{i,t} + \beta_5 stir_{i,t-1} + \delta_1 \Delta secu_{i,t-1} \times \Delta sas_{i,t-1} + \beta_6 lgdppc_{i,t-1} + \varepsilon_{i,t} \quad (8)$$

$$\Delta credit_{i,t} = \alpha_i + \tau_t + \beta_1 \Delta sas_{i,t-1} + \beta_2 \Delta secu_{i,t-1} + \beta_3 iy_{i,t-1} + \beta_4 \Delta gdp3_{i,t} + \beta_5 stir_{i,t-1} + \delta_1 \Delta secu_{i,t-1} \times \Delta sas_{i,t-1} + \beta_6 lgdppc_{i,t-1} + \beta_7 \Delta niip_{i,t-1}^* + \delta_2 \Delta niip_{i,t-1}^* \times \Delta sas_{i,t-1} + \varepsilon_{i,t} \quad (9)$$

The dependent variable $\Delta credit_{i,t}$ is the annual growth rate of bank credit to private non-financial sectors, for which data come from the BIS database. The SAS index in difference, the main explanatory variable in interest, is introduced as a one-year lagged term to measure the causality effect of the shortage on credit growth. In the same account, a variable for securitization growth is also employed in a lagged form. Adding an interaction term of the lagged change in the SAS index and securitization growth, the model examines if the safe asset shortage affects private credit growth via securitization.

Other control variables include the lagged investment-to-GDP ($iy_{i,t-1}$) ratio, the three-year moving average of GDP growth ($\Delta gdp3_{i,t}$), lagged short-term interest rates and lagged GDP per capita level in local currency, as generally employed in studies on credit growth.

Augmented by the term of net international investment position (niip) from the IMF database, Equation (9) measures the effect of a safe asset shortage on credit growth in the presence of cross-border investment. For this purpose, the lagged yearly difference in the net international investment position-to-GDP ratio ($\Delta niip_{i,t-1}^*$) is introduced. The positive net investment position in difference indicates a rise in net capital outflows, which I assume would subdue the risk of excessive credit boom in a domestic economy. Employing the interaction term of the lagged change in the niip-to-GDP ratio and the lagged change in the SAS index ($\Delta niip_{i,t-1}^* \times \Delta sas_{i,t-1}$), the model evaluates the extent to which this effect determines the total effect of a safe asset shortage on domestic credit growth.

4.2 Estimation Results (1980–2016)

The data cover eighteen advanced economies⁴² (see List A3) in annual observations from 1980 to 2016. Table 4 summarizes the main empirical outcomes. First, the safe asset shortage substantially drives the growth of bank credits. Across all variations of the model, the contribution of a safe asset shortage is robust and statistically significant.

Table 4: Main Results

| Bank credit growth ($\Delta credit_{i,t}$) | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| <i>L(1) diff. safe asset shortage index ($\Delta sas_{i,t-1}$)</i> | 0.173*** (0.031) | 0.108*** (0.030) | 0.134*** (0.043) | 0.152*** (0.043) | 0.158*** (0.044) | 0.160*** (0.044) |
| <i>L(1) securitization growth ($\Delta secu_{i,t-1}$)</i> | | | 0.000 (0.005) | 0.004 (0.005) | 0.005 (0.005) | 0.005 (0.005) |
| <i>Interaction term: $\Delta secu_{i,t-1} \times \Delta sas_{i,t-1}$</i> | | | | 0.090* (0.010) | 0.087* (0.010) | 0.122** (0.052) |
| <i>L(1) investment/gdp ($iy_{i,t-1}$)</i> | | 0.308** (0.134) | 0.906*** (0.047) | 0.914*** (0.211) | 0.872*** (0.217) | 0.863*** (0.215) |
| <i>gdp growth ($\Delta gdp3_{i,t}$)</i> | | 0.791*** (0.210) | 0.573* (0.310) | 0.620** (0.313) | 0.646** (0.318) | 0.590* (0.317) |
| <i>L(1) short-term interest rates ($stir_{i,t-1}$)</i> | | -0.003 (0.003) | -0.006 (0.005) | -0.006 (0.005) | -0.006 (0.005) | -0.006 (0.005) |
| <i>L(1)gdp per capita (log) ($gdppc_{i,t-1}$)</i> | | 0.099 (0.061) | 0.008 (0.072) | 0.009 (0.070) | 0.016 (0.071) | 0.020 (0.070) |
| <i>L(1)change in net int'l investment position/gdp ($\Delta niip_{i,t-1}^*$)</i> | | | | | -0.016 (0.045) | -0.068 (0.053) |
| <i>Interaction term: ($\Delta niip_{i,t-1}^* \times \Delta sas_{i,t-1}$)</i> | | | | | | -0.568* (0.320) |
| <i>Nr.countries/observations</i> | 18/306 | 18/288 | 14/177 | 14/177 | 14/172 | 14/172 |
| <i>R-squared</i> | 0.369 | 0.390 | 0.486 | 0.496 | 0.511 | 0.524 |

Note: Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01. The dependent variable is the annual growth of bank credits to the private non-banking sector.

⁴² The Republic of Korea is added to the sample countries of 17 used for the previous estimations.

Specification (4) in a closed economy framework indicates that a 1%p lift in safe asset shortage growth stimulates a growth of bank credits by 0.15%p in the following year. The securitization variable alone does not account for credit growth, but its role turns out to be substantial and statistically significant in an interaction with the lagged change in the SAS index. Once the safe asset shortage has intensified, the securitization expands credit volumes. A 1%p increase in securitization growth, associated with an increasing asset shortage, raises credit growth by 0.09%p. One caveat of this exercise is that the securitization issuance data set from the Association for Financial Markets in Europe (AFME) database is short, available from 1999 and unbalanced across sample countries. This is why the number of countries and observations shrink in Columns (3) to (6).

As expected, physical investment and economic growth are strong predictors of credit expansion, with a 1%p increase in each variable inflating the credit growth by 0.91%p and 0.62%p, respectively. A rise in short-term interest rates tends to subdue the credit volume but the coefficient is not statistically significant. The per capita GDP, a proxy for the level of economic advancement, is statistically irrelevant in the sample analysis.

The estimation outcome of Equation (9) with cross-border capital flows shows that the coefficient of the variable for the change in net capital outflows displays a negative sign. While the estimate would partially signal that increasing capital outflows reduces the domestic credit boom, it does not have a statistically significant meaning in Column (5). The interaction term, however, makes a surprising difference. Specification (6) reports that an increase in net capital outflows (1%p) at an increasing safe asset shortage significantly restrains domestic credit expansion (by 0.57%p), which is comparable to the magnitude of the GDP growth. Investment and GDP growth are still key drivers of credit growth in the open economy. A 1%p rise in the growth of the shortage inflates domestic credit growth by 0.16%p. The role of securitization has strengthened. A 1%p rise in securitization growth in response to a rise in the shortage boosts credit growth by 0.12%p.

The total effect of a safe asset shortage on private credit expansion depends on the interaction with securitization growth and capital outflows. The latter effect is considerably dominant. Net capital (in)outflows could significantly (intensify) mitigate the potential financial risk coming from the shortage-induced domestic credit expansion.

5. CONCLUSION AND POLICY IMPLICATIONS

A safe asset shortage contributes to a build-up of financial risks by driving private credit growth. Through employing the newly constructed SAS index, I have demonstrated that shortage-induced private credit expansion is the key crisis predictor. Neither the SAS index nor the private credit growth provides better information when used alone in the crisis classification model. But, the study has found that when the two variables are combined in an interaction term, private credit booms in response to a surge in safe asset shortage reveal strong power to warn of financial crises in advanced economies in the period 1960–2013. The paper has also confirmed economically a significant, positive causal effect of a safe asset shortage on a domestic credit boom. The total effect of the shortage is positively associated with securitization growth and negatively with net capital outflows. An increase in net outflows at a time of rising shortage reduces domestic credit growth to the extent that it could make the total effect of the shortage on credit growth negative. From this result, we can infer that capital flows may have played a significant role in determining the (de)leverage position of the domestic financial system. However,

this study has not examined the externality of net capital flows in the presence of the shortage at home and abroad. This remains an issue for further research.

The findings of the paper have a couple of important policy implications. The timing of counter-cyclical fiscal policy and its magnitude matter for financial stability, specifically when policy causes a sudden drop in the net government bond issuance facing a high retirement wave. Such a deep shock to the shortage could evoke bubbly credit booms. From the view of safe asset shortage-financial instability, fiscal and macroprudential policies need to be coordinated, minimizing a fiscal shock to the financial market, and carefully monitoring the scale of new retirees or soon-to-be retirees, associated with its shock to a portfolio rebalance of an economy.

Second, a proper response to capital flows is crucial. A real challenge comes when the safe asset shortage is a global or a regional phenomenon. A couple of Asian economies have recently become exposed to an unprecedented deep aging shock (see Figure A3). As fiscal and monetary policies have got more synchronized across countries, most economies could face a negative mega-global or regional shock to safe asset supply at a time of a major influx of new retirees. In such cases, the solid macroprudential measures of one country might exacerbate a financial risk in others via capital flows. Under this condition, where should the shortage-induced capital flows go? International cooperation for financial stability may need to pay due attention to a new way of managing a safe asset supply and the externality of macroprudential policy, tracking the evolution of an individual safe asset shortage in either the global or the regional context. Central banks would find their role in more active, proper asset management via their balance sheets.

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APPENDIX

List A: 1 List of Economies

Argentina (ARG); Australia (AUS); Austria (AUT); Belgium (BEL); Brazil (BRA); Canada (CAN); Czech Republic (CZE); Denmark (DNK); Finland (FIN); France (FRA); Germany (DEU); Greece (GRC); Hong Kong, China (HKG); Hungary (HUN); India (IND); Indonesia (IDN); Ireland (IRL); Italy (ITA); Japan (JPN); Luxembourg (LUX); Malaysia (MYS); Mexico (MEX); Netherlands (NLD); Norway (NOR); People's Republic of China (CHN); Poland (POL); Portugal (PRT); Republic of Korea (KOR); Russian Federation (RUS); Singapore (SGP); South Africa (ZAF); Spain (ESP); Sweden (SWE); Switzerland (CHE); Thailand (THA); Turkey (TUR); United Kingdom (GBR); and United States (USA)

List A: 2 Country List (17) and Systemic Banking Crises, 1960–2013

AUS: 1989; BEL: 2008; CAN; CHE: 1991, 2008; DEU: 2008; DNK: 1987, 2008; ESP: 1977, 2008; FIN: 1991; FRA: 2008; GBR: 1974, 1991, 2007; ITA: 1990, 2008; JPN: 1997; NLD: 2008; NOR: 1988; PRT: 2008; SWE: 1991, 2008; USA: 1984, 2007

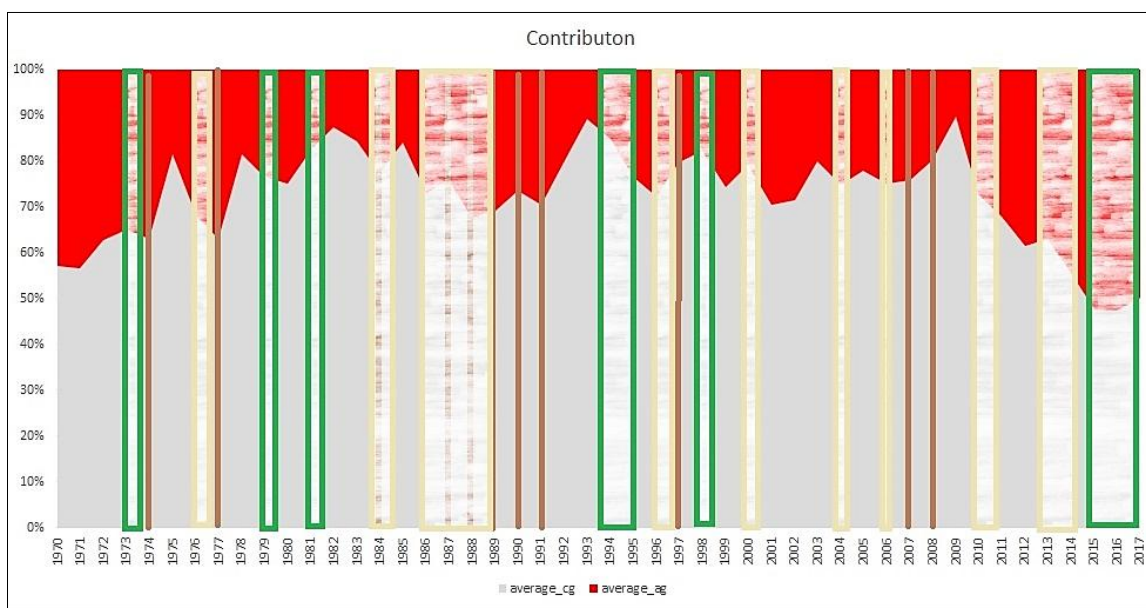
Note: Systemic Banking Crises Classification and Records from <http://www.macrohistory.net/data/>.

List A: 3 Country List (18)

AUS, BEL, CAN, CHE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, KOR*, NLD, NOR, PRT, SWE, USA

Note: *The fixed-effects panel analysis includes the Republic of Korea.

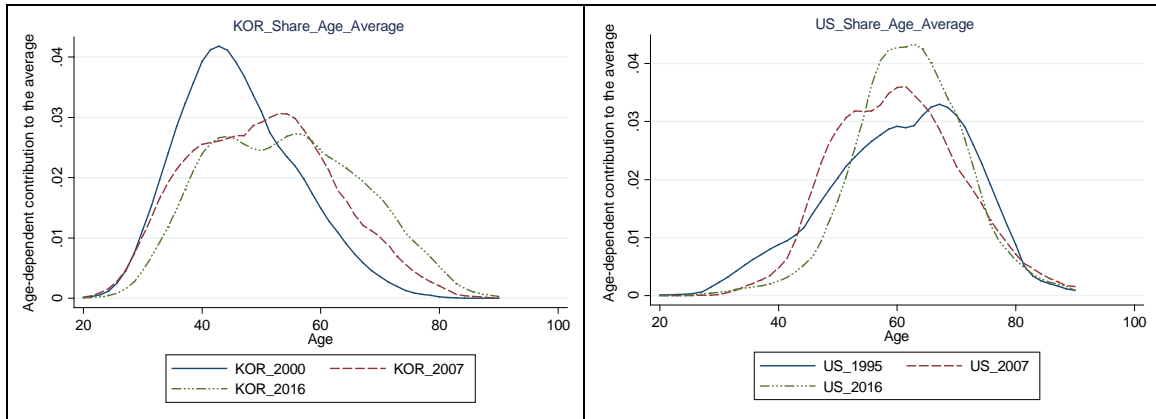
Figure A1: Contribution of Demand and Supply Factors to Annual Change in the SAS



Note: Red (gray) area represents the contribution of sample average change in demand (supply) side to the sample average change in the SAS index. Brown lines denote the year of banking crises of 18 countries. The boxes show the years in which safe asset shortages deepened. Among them, green boxes indicate the year for a dual drop in demand and supply sides, where a drop in government debt dominated. Orange boxes mark the year the safe asset shortages deepened, but in such cases the demand side of the sample average ratio of the retiree population increased while the supply of the net government securities declined.

Source: Author's calculation.

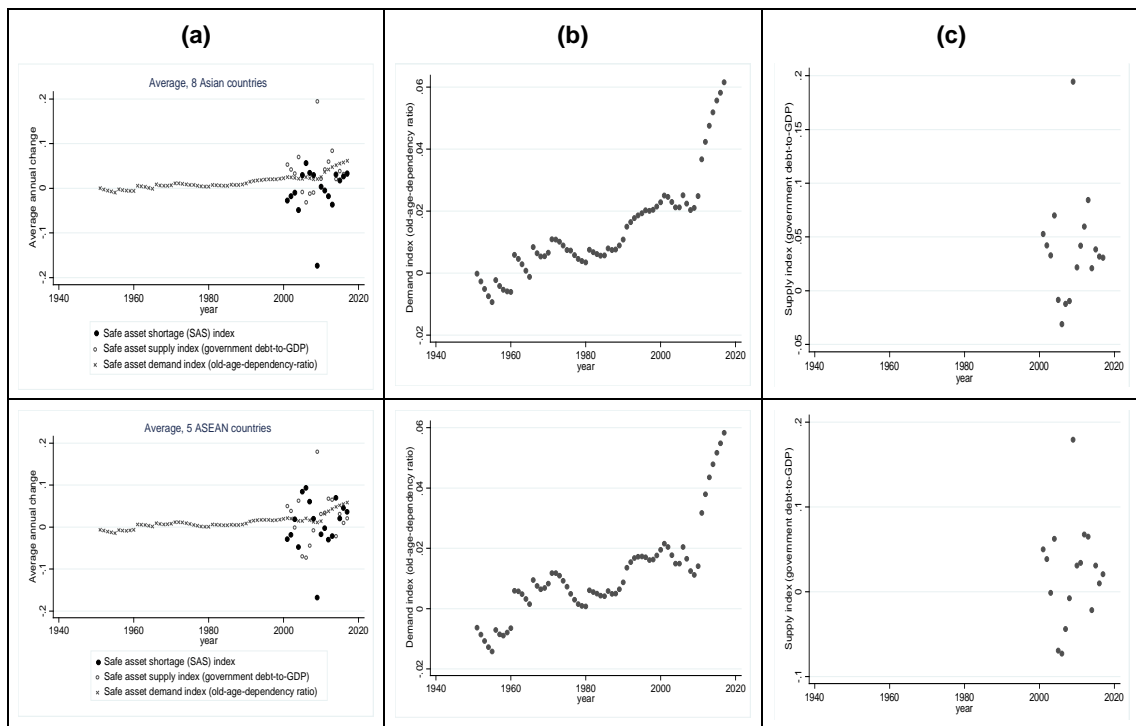
Figure A2: Age-Dependent Contribution to the Weighted Average of Total Financial Wealth



Note: The distribution is normalized by the weighted average of total financial wealth.

Source: Author's calculation.

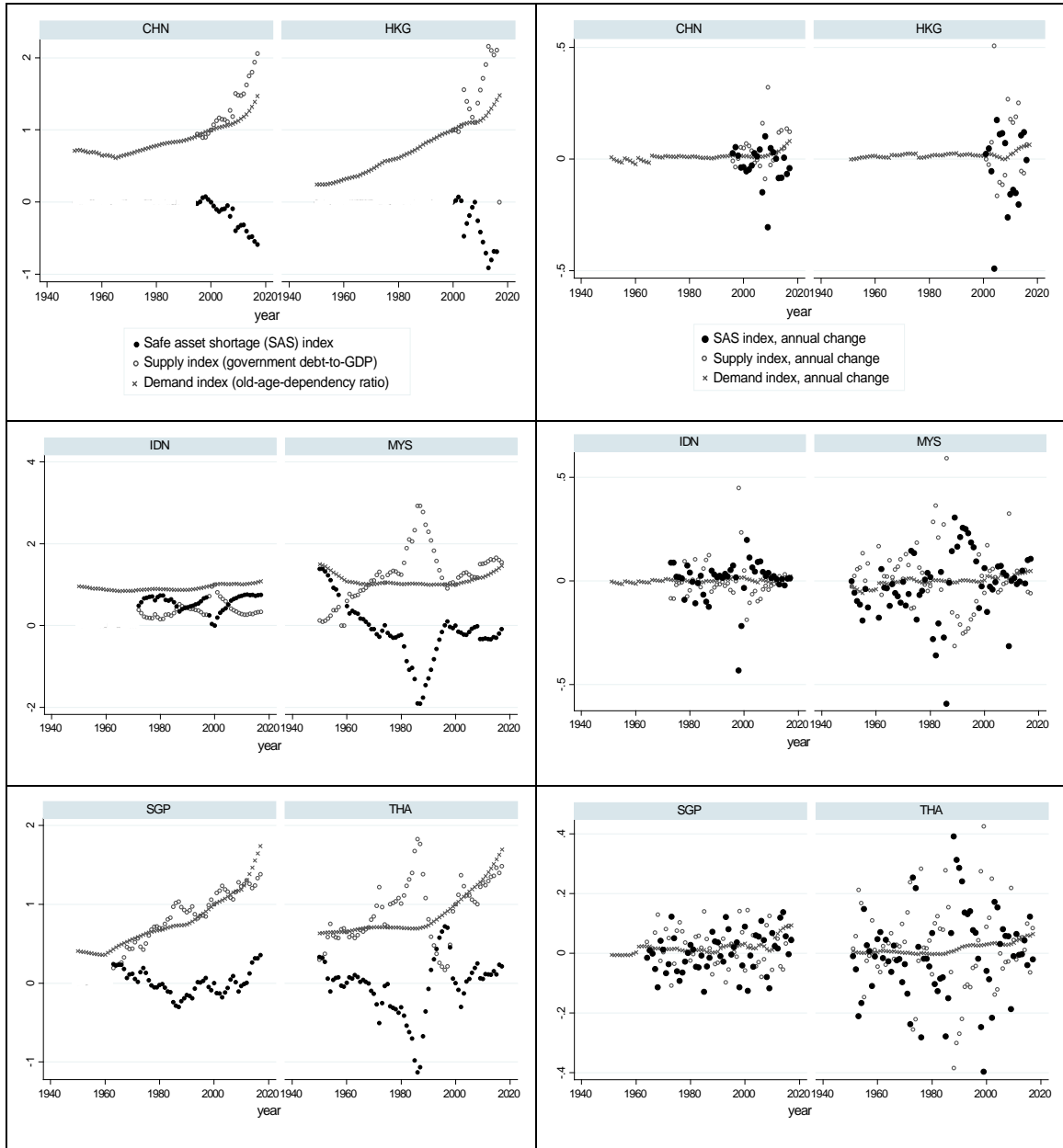
Figure A3: Safe Asset Shortage Index in Difference (Average across Countries)



Note: The graphs in the first row summarize the analysis of eight Asian countries (CHN, HKG, IDN, JPN, KOR, MYS, SGP, and THA) while the graphs in the second row present that of the sub-group of five Association of Southeast Asian Nations (ASEAN) countries (excluding CHN, JPN and KOR). Panel a is the sample average annual difference of the SAS index in 2000–2017. Panel b is the sample average annual change of the old-age dependency index in 1950–2017, while Panel c that of central government debt index in 2000–2017. General government debt data are used for the PRC.

Source: Author's calculation.

Figure A4: Safe Asset Shortage Index, Individual (Asian Countries)



Note: The panel on the left-hand side plots the evolution of indices in level, while the panel on the right-hand side plots it in terms of yearly difference. As for the range of time series of each index, refer to the note in Figure A3.

Source: Author's calculation.

Table A1: Data Source

| Variable | Source | |
|---|--|--|
| (Crisis Probabilistic Model) | Data for Table 1, 2 and 3 (1960–2013) | |
| Central government debt | Global Debt Database | IMF |
| Old-age dependency ratio | UN World Population Prospects | UN World Population Prospects |
| Other variables | Jordà, Schularick, and Taylor (2017) | www.marohistory.net /data#DownloadDate |
| (Fixed-Effects Panel Model) | Data for Table 4 (1980–2016) | |
| Dependent Variable | | |
| Private credit growth: ($\Delta credit_{i,t}$) annual growth of bank credit to private non-financial sector | Bank credit to private non-financial sector, local currency | BIS |
| Explanatory Variables | | |
| Change in SAS index: ($\Delta sas_{i,t}$) | | Author's calculation |
| Securitization growth: ($\Delta secu_{i,t}$) | Unbalanced. Converted into local currency, using year-end average US exchange rates from the BIS. | Association for Financial Markets in Europe (AFME) |
| NIIP-to-GDP change: ($\Delta niip_{i,t}^*$) | Unbalanced. Net International Investment Position, converted into local currency, using year-end average US-exchange rates from the BIS. GDP in local currency. | International Financial Statistics (IFS), IMF |
| Other Control Variables | | |
| GDP growth (previous three-year moving average), Investment-to-GDP ratio, Short-term interest rates, Per capita GDP (in log), CPI | For sample countries (excl. Republic of Korea): Jordà, Schularick, and Taylor (2017) | www.marohistory.net /data#DownloadDate |
| | For the Republic of Korea, all corresponding data compiled. | IMF |

Table A2: Sample Average Return Correlation (16 Countries, 1970–2015)

| | Bond | Equity | Housing | Risky Asset | Safe Asset | SAS Index |
|---|---------------------|---------------------|---------------------|--------------------|---------------------|--------------------|
| Bond | 1 | | | | | |
| Equity | 0.230* (0.0000) | 1 | | | | |
| Housing | -0.154* (0.0000) | 0.174* (0.000) | 1 | | | |
| Risky Asset | 0.004 (0.9076) | 0.812* (0.0000) | 0.622* (0.0000) | 1 | | |
| Safe Asset | 0.967* (0.0000) | 0.270* (0.0001) | -0.078* (0.0296) | 0.063 (0.078) | 1 | |
| SAS index | -0.286* (0.0000) | -0.141* (0.0001) | 0.698* (0.0000) | 0.289* (0.0000) | -0.253* (0.0000) | 1 |
| R.P. Equity (the spreads between returns on equity and bond) | | | | | | -0.024 (0.5174) |
| R.P. Housing (the spreads between returns on housing and bond) | | | | | | 0.521* (0.0000) |
| R.P. Risky (the spreads between returns on risky assets and safe assets, defined in Jordà et al. (2019)) | | | | | | 0.397* (0.0000) |

Note: * Indicates significance at 5% level. Data, except for SAS index, from JSTdatasetR4 (Release May 4, 2019) and Jordà et al. (2019). All variables are real terms. R.P. denotes risk premium, and bonds in the analysis are government bonds. The SAS index is used in annual difference. The sample countries are the same as in List A3, excluding Canada and the Republic of Korea.

Source: Author's calculation.