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Article

Sovereign Adaptive Risk Modeling and Implications for the Eurozone GREXIT Case

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Abstract: In the wake of the 2008 financial crisis, the Financial Stability Board (FSB) and the Basel Committee on Banking Supervision (BCBS) created a list of systemically important financial institutions (SIFIs) with the intention of determining which financial institutions were important enough to the global market that their failure would result in systemic collapse. In this work, we create a model that modifies the BCBS's five indicators of size, interconnectedness, cross-jurisdictional activities, complexity, and substitutability and apply these measures of systemic stress to governments. Although the cross-jurisdictional activities and size were almost identical to the SIFI calculations, the others had to be adapted to mirror the intent of the BCBS. Interconnectedness is calculated by simulation of what would happen to nearby countries if a country defaulted. Substitutability is estimated by the number of services that would no longer be provided if the government ceased to exist. Complexity is market-based and is derived from credit default swap (CDS) spreads. The original application of the model was to track the systemic interdependence of the Eurozone, with particular emphasis on the case of Greece. We anticipate that this model can be used in regional fiscal situations beyond the Eurozone.

Keywords: systemic risk; sovereign default; GREXIT

1. Introduction

The financial markets experienced some of the worst activity in recorded history during the global recession that began with the housing bubble crash in 2007. In the wake of that financial catastrophe, a new understanding of large corporations emerged, best summarized by the former Chairman of the Federal Reserve, Ben Bernanke. In an interview before the United States Congress's Financial Crisis Inquiry Commission, he stated, "Many of the vulnerabilities that amplified the crisis are linked with the problem of so-called too-big-to-fail firms. A too-big-to-fail firm is one whose size, complexity, interconnectedness, and critical functions are such that, should the firm go unexpectedly into liquidation, the rest of the financial system and the economy would face severe adverse consequences."

In the aftermath came the realization that governments relied on a foundation of certain financial institutions that had been acting with little accountability and that were prone to fail during the crisis. In order to combat this threat to global financial stability, the Financial Stability Board (FSB), along with the Basel Committee for Banking Supervision (BCBS), drafted a method to determine what constitutes globally systemically important banks (G-SIB), which changed in later reports to systemically important financial institutions (SIFI). They suggested more stringent requirements for these institutions so that any future financial crises would not cause them to fail. It is important to mention that their determination of what was systemically important was made on a loss-given-default (LGD) basis instead of on the more popular probability-of-default (PoD) basis. The LGD viewpoint measures how bad things can become when they become bad and not only the probability that things

will reach a certain such level. This methodology was chosen by the BCBS because the intent of systemic importance was an accounting of the systemic risk of the financial institution should a crisis already be underway and not only the probability of going into crisis ([Basel Committee on Banking Supervision 2013](#)). While both the FSB and BCBS are purely advisory bodies, many of the largest nations in the world have adopted their guidance into law.

The BCBS published reports on their methodology beginning in 2009, with further reports on a biannual basis. The BCBS separated their method of determination of SIFIs into five distinct indicators. These indicators were size, interconnectedness, cross-jurisdictional activities, complexity, and substitutability. They were chosen specifically to encompass different factors that demonstrate the systemic importance of any financial institution. The definitions of these indicators as defined by the BCBS can be found in their report ([Basel Committee on Banking Supervision 2013](#)).

Each of the five indicators were broken up into a series of sub-indicator categories. Equally weighted under cross-jurisdictional activity were cross-jurisdictional claims and liabilities. For size, the criteria was only the total exposure as defined by the Basel III ratio. Interconnectedness put equal weight on three categories: securities outstanding, intra-financial system assets, and intra-financial system liabilities. For substitutability assets under custody, payments activity and underwritten transactions in debt and equity markets were given equal treatment. As for complexity, the committee measured the notional number of over the counter derivatives, Level 3 assets, and trading and available for sale securities ([Basel Committee on Banking Supervision 2013](#)).

The methodology for assigning a value for an indicated company was as follows:

“For each bank, the score for a particular indicator is calculated by dividing the individual bank amount (expressed in EUR) by the aggregate amount for the indicator summed across all banks in the sample. This amount is then multiplied by 10,000 to express the indicator score in terms of basis points. For example, if a bank’s size divided by the total size of all banks in the sample is 0.03 (i.e., the bank makes up 3% of the sample total) its score will be expressed as 300 basis points. Each category score for each bank is determined by taking a simple average of the indicator scores in that category. The overall score for each bank is then calculated by taking a simple average of its five category scores. The maximum total score, i.e., the score that a bank would have if it were the only bank in sample, is 10,000 basis points (i.e., 100%) . . .

. . . Banks that have a score produced by the indicator-based measurement approach that exceeds a cutoff level set by the Committee will be classified as G-SIBs. Supervisory judgment may also be used to add banks with scores below the cutoff to the list of G-SIBs . . .

. . . It should be noted that the number of G-SIBs, and their bucket allocations, will evolve over time as banks change their behavior in response to the incentives of the G-SIB framework as well as other aspects of Basel III and country-specific regulations.” ([Basel Committee on Banking Supervision 2014](#)).

Up to the time of writing, almost all the work done on sovereign default contagion was based solely upon CDS spreads and implied probabilities of default. [Alter and Beyer \(2014\)](#) use the CDS market to model the contagion effects in the case of default. However, this is a model that has a great deal of concern with commercial banks and not just with the issue of sovereigns. [Lucas et al. \(2014\)](#) assess joint and conditional sovereign default probabilities from CDS prices; thus we see some thought regarding contagion there. [Aizenman et al. \(2013\)](#) show that the pricing of Eurozone sovereign risk, as measured by CDS spreads, is not predicted well by looking at fiscal space and macroeconomic factors. This implies that the information found from, for instance, external debt figures tells more of the story than only CDS spreads alone. However, the work in the literature focuses almost entirely on CDS spreads. In no place do we find others trying to alter the SIFI criteria to apply them to sovereigns. Therefore, we believe this work to be an important next step as we consider sovereign default.

2. Methods

It is the purpose of this paper to modify the methodology used by the FSB and BCBS in order to apply it to sovereigns instead of financial institutions, with the intention of identifying countries that are systemically important. This systemic importance is relative to a specified financial system, whether solely their immediate neighbors or the global financial system. The work is done with the same mindset as for the original BCBS report. However, financial institutions and governments differ in significant ways. We alter the FSB/BCBS criteria while aiming to retain the perceived intent of their work.

This project was originally inspired by the situation in Greece during the summer of 2015 and by the possible effect that this could have had on the members of the Eurozone. Greece was faced with a debt crisis from which it seemingly could never escape, a large budget deficit, collapsing market assets, low bond confidence, high unemployment, massive proportional government spending, and few further means of foreign aid. The Greek public resigned itself to this fate, with bank runs taking place. Analysts saw the inevitability of a Greek financial collapse, and governments who loaned Greece money that hinged on recovery were facing the prospect of taking fractions of what they had lent or of receiving nothing at all. The most likely scenario of Greece's default seemed to be total Greek bankruptcy accompanied by its exit from the Eurozone fiscal union, popularly referred to as "GREXIT."

Much of the speculation surrounding the Greek financial crisis concerned what a Greek default would trigger in the Eurozone's financial system and beyond. Particularly concerning was the effect that a Greek default would have on other troubled economies in the Eurozone, such as Portugal, Spain, and Italy. While this model does not give an absolute determination of what the extent of a Greek default would entail, it will at the very least address the relative fiscal importance of Greece in the Eurozone.

The new model devised for the failure of countries, which we have named the Adaptive Country Exposure Model (ACEM), uses the same five indicators as the FSB/BCBS report. However, because of the differences between countries and companies, it is necessary to modify the methodology that determined each of the five indicators.

Before such a model can be properly devised, we must first believe that a country can default. Although sovereign default is an historical fact, many may object to default in today's world economy. When a sovereign is part of a fiscal union, it is particularly important that this assumption must hold for every country in the region of consideration. This may be a strong or weak assumption depending on the region and the viewpoint of the audience. It is important to note that countries have defaulted in the past few decades. Surprisingly, these countries have had less difficulty accessing financing than many would have expected. We note that we do not attempt to analyze the political ramifications of a country's default.

The BCBS methodology was frustrating in its simplistic approach to the mathematical bases for each of the indicators and in the fact that equal weights were, seemingly arbitrarily, assigned to each of the five indicators. Preliminary findings suggested that a higher importance placed on the indicators of size, interconnectedness, and complexity would be best, at the expense of the other two indicators. The highest importance would be assigned to interconnectedness because of the systemic impact of a highly interconnected country defaulting. The indicated country, and the system itself, may be defined at the discretion of whomever is utilizing the model.

We compute two different scores for each of the countries. The first is a SIFI-based score for which we weight all five categories equally, following the methods of the BCBS and FSB. We then compute a modified score, for which we have different weights for each of the five categories on the basis of the relative importance of the scores for countries. In this situation, we place a weight of 35% on interconnectedness, 25% on size, 15% apiece on cross-jurisdictional activities and substitutability, and 10% on complexity. For the stability of a system, interconnectedness is clearly the most important, with size ranking second. It is also notable that interconnectedness focuses on a LGD basis, while the

others deal with only PoD calculations. Because we had the most difficulty emulating the complexity calculation from the SIFI documentation, we felt this should hold the smallest weight.

Thus, the new model can be defined. Important definitions are as follows:

1. Cross-jurisdictional activities:

An analysis of a country's foreign liabilities to gain an understanding of the extent to which the country in question exists as a regional or global presence instead of a domestic presence is calculated as follows:

- Proportion of debt money lent by surrounding countries divided by the total number of loans to the indicated country presently outstanding.
- This indicator is partially applicable to the substitutability indicator and as such should be completed first.

This follows the committees' work almost completely.

2. Size:

This is the gross earnings of the country in proportion to its total debts, as well as its market share in the financial system. In addition, there is an added penalty to the size calculation should a country fail the Basel III leverage ratio.

- Combination of several metrics:
 - Proportion of equity assets in relation to the GDP of the indicated country.
 - Market share of the indicated country in the system.
 - $size = \frac{Revenue\ Entity}{Revenue\ System} * (Members\ System) * \frac{Exposure\ Liability}{GDP}$
 - If the indicated country falls underneath the standards set by the Basel III structure, then the value will be multiplied by a factor. We have chosen 2 as this factor, but future data may imply that a different choice is better.

Again, this was very straightforward to adapt from the SIFI calculations.

3. Interconnectedness:

This is the effect that the default of a country would have on surrounding countries and the possible problems that would emerge from such an event. This would be an accounting of the debt structure of the indicated country within the system as well as any regulatory actions that would have to be taken as a result of the indicated country's default.

- Simulation of the default exposure on neighboring governments and financial institutions as a direct result of the failure of the indicated country's government.
- This would be surmised by a series of weighted directed graphs, a simplified version of the counterparty interactions of national banks.
- In pseudocode, a single iteration for one node is as follows:

For $i = 1$ to N do

If CAI (capital assets of institution) – DE (default exposure) ≥ 0 but Basel III structure fails, then "1"

If $CAI - DE \geq 0$ and Basel III structure passes afterward, then "2"

If $CAI - DE < 0$, then "3"

Sum "3" cases $3_1, 3_2, \dots, 3_k$, and rank them by quantity $(CAI - DAE)$

For highest rank, apply regulatory funds V_n to each case “3” until they qualify as “1”

If no more “3” cases remain, apply V_n to “1” cases

If V_n is limited, add international claims of second country to DE

End

- We note that “3” cases are the most unstable and face impending bankruptcy, while the “1” cases are considered not financially viable by an objective deterministic source but are not as troubling.
- Regulatory funds are those in place by bodies of leading countries or those partially outside of the system.
- Only $\frac{3}{4}$ of these funds are available (arbitrarily chosen) so as to leave some in reserve for any future defaults in the system.
- Critical value at the end of the summation will be a 15% loss of the initial total systemic assets.
- N would represent as many central banks or governments as are in the area under consideration.
- This process would have to be run many times through to generate a steady-state value for the process.
- This indicator is unique from the other indicators for two important reasons. Firstly, it is not understood as a correlated value of systemic importance but rather as a direct calculation of the LGD of the indicated country. Secondly, it is also possible that this indicator affects other indicators recursively in the case of a complete default of the system.

Here we aim to address the calculations that the committees wanted to perform. The committees sought to capture the linkages to other entities, both direct and indirect, in order to understand how a financial stress of one company would affect others in their industry. We sought to do something similar on the sovereign level.

We calculate interconnectedness by looking at the amount of debt that a country holds for other countries versus the amount of debt that it has outstanding. Because our goal is to see what would happen should a country default, it is important to look beyond the first-order effects. Should Country A default, it may leave Country B short to return what it owes to Country C. This type of domino effect must be investigated to determine just how interconnected a country is on a relative basis. This is why we have to reach a steady state before being willing to report the answer as the true value of a country's interconnectedness.

4. Substitutability:

The amount of domestic expenditure is calculated as a percentage of the country's tax base, as well as on a per capita basis comparable to neighboring countries.

- Several metrics are possible to use in the hope of understanding true domestic tax expenditure. Alternates and corollaries could be the following: domestic liability dollarization, which takes into account the debts that a citizen holds internally (per <http://chartsbin.com/view/34074>); and unemployment, a measure of the work force collecting from taxes instead of paying into them (per <http://databank.worldbank.org/>).
- The most comprehensive metric of the list is final consumption expenditure, both as a proportion of the specified countries' GDP and on a per capita basis.

The committees hoped to ascertain the extent to which other institutions could materially provide the same services at a similar price over a similar length of time to the institution under consideration. We sought to find the notional amount that countries provide that would not be easily replicated by the private sector as a complement to what the committee wished to calculate.

Here we view substitutability in the sense of the services that the country provides to its citizens. Does the country take a larger role than its neighbors? Does it do substantially more than the private sector? If the government were no longer able to function because of fiscal problems, how difficult would it be to make substitutes?

5. Complexity:

This is the relative stability of the country as defined by the consumer market. This is calculated by compiling the valuation of the indicated country relative to the systemic average scaled appropriately. For this, any market action is also taken into account.

In the SIFI criteria, this measure attempts to determine just how complex the financial instruments that a financial institution holds are. Although the committees look only at derivatives that are centrally cleared, they also look at illiquid or difficult-to-value assets (Basel Level III assets). We have to develop something that approximates this type of riskiness for a sovereign. One reasonable proxy for the riskiness is the market's opinion of a country's riskiness, spreads on credit default swaps. We use these data to find implied annual probabilities of default.

3. Results

3.1. Greece

As stated above, the situation that was afflicting Greece, GREXIT, was the inspiration for the model and, as such, was its first test case. For most of the statistics, the annual reports of the appropriate central banks [Oesterreichische Nationalbank-Eurosystem](#) (2015), [Banco D'España-Eurostema](#) (2015), [Banco De Portugal](#) (2015), [Bank of Finland](#) (2015), [Bank of Greece-Eurosystem](#) (2015), [Bank of Italy](#) (2015), [Banque de France](#) (2014), [Banque de Luxembourg-Eurosystem](#) (2015), [Central Bank of Cyprus-Eurosystem](#) (2015), [Central Bank of Ireland-Eurosystem](#) (2015), [Central Bank of Lithuania-Eurosystem](#) (2015), [Central Bank of Malta-Eurosystem](#) (2015), [De Nederlandsche Bank](#) (2014), [Deutsche Bundesbank-Eurosystem](#) (2015), [Eesti Pank-Eurosystem](#) (2015), [Latvijas Banka](#) (2015), [Narodna Banka Slovenska](#) (2015), [National Bank of Belgium](#) (2015), [World Bank](#) (2015), [European Financial Stability Facility](#) (2015) and [Central Intelligence Agency World Factbook](#) (2015), were used to generate the necessary metrics.

Cross-jurisdictional activities: For this section, statistics for external debt and public debt were found using the CIA Factbook and were applied for each of the member states of the Eurozone.

Size: The relevant revenue stream for each of the Eurozone members was found to be the tax base, as this mirrors the logic posed in the definition of the SIFI size indicator. The tax base and GDP numbers for the member states were found in the World Databank, and the total debt and capital reserve numbers were found in the CIA Factbook.

Interconnectedness: In order to best approximate the strain that would be placed upon the Eurozone members as a direct result of Greece's default, proportional quotas were found within the three major lending bodies in the situation: the [IMF](#) (2015), the [European Central Bank-Eurosystem](#) (2015a), and the Eurozone states. Less-than-obvious counterparty interactions between central banks, such as the TARGET2 payment system, were also taken into account and were added to the default exposure of Greece.

Substitutability: Final consumption expenditure data, both per capita and as a percentage of the Eurozone members' GDP, was found in the World Databank.

Complexity: CDS spreads came from S&P Capital IQ.

Results of the Greece test case as of July 30, 2015:

The cross-jurisdictional activities index (Table 1) indicates that Greece operates at slightly less than the systemic average on foreign soil, holding its debt more in domestic markets. While the definition of the indicator would identify this as systemically less important, the unique case of the Eurozone's financial systems, where much of the foreign debt is hidden and where public debt can be transferred to foreign entities, dampens the small influence that this category would have on sovereigns.

Table 1. Greece's cross-jurisdictional activities (C-J Act.).

| Mean | Standard Deviation (Std. Dev.) | Standard Score | Systemic Importance |
|---------|--------------------------------|----------------|---------------------|
| 0.54741 | 0.2996 | −0.3072 | 44.88 |

The size indicator (Table 2) implies that Greece as a country is proportionally a smaller financial presence, relative to the systemic average, which is logically coherent. Even with the penalty as a result of failing the Basel III leverage ratio, its miniscule size determined the point value. It is important to understand that the standard deviation (Std. Dev.) of this indicator is massive relative to the mean. This is indicative of the great financial disparity within the Eurozone.

Table 2. Greece's size.

| Mean | Std. Dev. | Standard Score | Systemic Importance |
|---------|-----------|----------------|---------------------|
| 3.30966 | 4.0575 | −0.36653 | 43.89 |

The results of the interconnectedness simulations (Table 3) indicate that Greece's default leveraged in the worst possible way would result in the potential default of eight members of the Eurozone.

Table 3. Greece's interconnectedness (interconn.).

| Number of Simulations | Mean Default | Max Default | Mean Assets Lost (bn) | Systemic Importance |
|-----------------------|--------------|-------------|-----------------------|---------------------|
| 250 | 0.26 | 8 | 1060 | 23.46 |

In the most recent estimation of the umbrella debt funds, the relevant regulatory bodies have sufficient funds to save the eight system members without drawing on their external claims within the rest of the system; thus this determines that Greece is not systemically important by the standard set in the ACEM. However, it is important to note that approximately 560 billion euro of the 750 billion euro available would have to be used to stop the bleeding that a Greek default and/or GREXIT would cause. Umbrella funds for the entire Eurozone would be used to stabilize the region in the event of GREXIT, thus making the rest of the member states extremely vulnerable to further financial distress.

Table 4 indicates that Greece spends more domestically than the systemic average, implying that it is systemically important by this metric. Logically, high domestic expenditure makes it more costly for any future governmental authority to step in to the financial situation of the populace. This would most likely result in payment loss domestically, which would then trigger further financial issues, such as continued bank fragility, public unrest, and a decline in the available domestic industry.

Table 4. Greece's substitutability (subst.).

| Mean | Std. Dev. | z-Score | Systemic Importance |
|--------|-----------|---------|---------------------|
| 76.142 | 9.076 | 0.617 | 60.29 |

The summarized data for the complexity indicator (Table 5) is as follows:

Table 5. Greece's complexity (complex.).

| CDS Spread | Annual Prob. of Default | Score |
|------------|-------------------------|-------|
| 5003.09 | 0.45 | 100 |

It was commonly known that Greece was in trouble, and the expectation was for Greece to default on its debts. This meant that many financial entities wanted to take credit default swaps, paying a premium

to have a payday when (or if) Greece defaulted. Few individuals wanted to take the other side of this bet, and thus prices rose astronomically. This led to the highest possible score for this indicator.

Combining the results of the five indicators into a total systemic importance, it was determined that Greece, while an inconvenience to the rest of the Eurozone, is not systemically important. A lack of systemic importance in the relative size of Greece as well as the default scenario simulations of the interconnectedness portion were particularly crucial to the determination. Complexity was the indicator with the largest value. The substitutability indicator result was largely in favor of systemic importance, implying that the Greek people would be extremely negatively affected in the result of a GREXIT.

The Greek test case listed above contained just a single data point for the systemic importance of the country. We wished to create a time series of systemic importance data, but we were unable to obtain reliable detailed TARGET2 data, despite the request to several sources. Even the European Central Bank was unwilling to provide us with such data.

3.2. Eurozone

Although it is interesting to score Greece, the more compelling question regards which of the nations are most important to the fiscal stability of the Eurozone. Once again, the only data point we have is from July 30, 2015, as this was the only date for which detailed TARGET2 data were available [European Central Bank-Eurosystem \(2015b\)](#). With the appropriate TARGET2 data, we would be able to compute a time series of these systemic importance scores. It would be incredibly interesting to see whether the relative systemic importance is static, or whether countries change rankings over time. With the information we have, we can tell what the Eurozone systemic importance levels were on 30 July 2015.

From Table 6, we can see that Germany and France were by far the most important countries for the systemic health of the Eurozone. The Netherlands was a clear third. Using the somewhat arbitrary mark of 50 to determine the systemic importance, we found that Luxembourg was the only other country to clear this level in our scoring system. It is interesting that just below the score of 50 were two countries with fears about their continuing stability: Italy and Greece, although Belgium was nearly equal in the modified (unequal-weight) score for 30 July 2015. It is also interesting that an equally weighted version of the score had Greece and Luxembourg trading places, with Greece above the mark of 50 and Luxembourg dropping below.

Table 6. Eurozone Adaptive Country Exposure Model (ACEM) scores.

| Country | Size | C-J Act. | Subst. | Complex. | Interconn. | SIFI Score | Modified Score |
|-------------|-------|----------|--------|----------|------------|------------|----------------|
| Austria | 47.45 | 18.87 | 60.78 | 0.24 | 26.46 | 30.76 | 33.10 |
| Belgium | 52.88 | 81.08 | 63.50 | 0.22 | 25.57 | 44.65 | 43.88 |
| Cyprus | 22.36 | 81.35 | 51.36 | 7.59 | 5.01 | 33.53 | 28.01 |
| Estonia | 21.00 | 97.48 | 15.91 | 0.64 | 3.42 | 27.69 | 23.52 |
| Finland | 30.04 | 21.51 | 75.76 | 0.26 | 20.32 | 29.58 | 29.24 |
| France | 98.04 | 21.87 | 67.44 | 0.19 | 150.42 | 67.59 | 90.57 |
| Germany | 99.34 | 39.54 | 58.02 | 0.08 | 198.57 | 79.11 | 108.98 |
| Greece | 35.70 | 49.21 | 65.43 | 100 | 23.46 | 54.76 | 44.33 |
| Ireland | 64.68 | 15.96 | 28.92 | 1.76 | 39.78 | 30.22 | 37.00 |
| Italy | 31.68 | 28.85 | 59.97 | 1.64 | 77.95 | 40.02 | 48.69 |
| Latvia | 21.27 | 86.11 | 30.18 | 0.51 | 1.97 | 28.01 | 23.50 |
| Lithuania | 22.68 | 55.25 | 33.23 | 1.00 | 11.75 | 24.78 | 23.15 |
| Luxembourg | 85.52 | 29.36 | 39.21 | 0.22 | 52.70 | 41.40 | 50.13 |
| Malta | 23.19 | 29.36 | 49.78 | 1.10 | 7.01 | 22.09 | 20.23 |
| Netherlands | 93.32 | 89.35 | 53.14 | 0.13 | 45.20 | 56.23 | 60.54 |
| Portugal | 38.45 | 17.26 | 52.16 | 2.14 | 18.30 | 25.66 | 26.64 |
| Slovakia | 22.10 | 14.25 | 26.39 | 0.58 | 7.53 | 14.17 | 14.31 |
| Slovenia | 21.20 | 29.49 | 25.83 | 1.13 | 5.67 | 16.66 | 15.70 |
| Spain | 34.07 | 18.80 | 45.35 | 1.31 | 42.50 | 28.41 | 33.15 |

By looking at the chart, we can notice some trends among the scores. The four most systemically important countries were the four that had the largest size. Germany and France also had the highest interconnectivity. The Netherlands's score was bolstered by having the second-largest cross-jurisdictional activity. As we have seen in the test case above, Greece's complexity was the largest.

4. Discussion

Because of the political situation for a government in default, there may be ramifications that are unnoticed by the purely fiscal ACEM. While these influences are not seen the model in any way, they open up avenues for future study on how countries act when there is some fiscal danger in the Eurozone.

Governments might be swayed by public opinion more than financial institutions, and thus the effects that a catastrophe would have on the public and the public's response to those effects should possibly be considered when determining the systemic importance of a country. Explaining this mathematically would be incredibly difficult. The devaluation of citizens' assets by a possible shift back to a domestic currency could conceivably be calculated from historical cases of governmental default in the modern age. For the case of Greece, up to a 40% loss in the value of assets for individual citizens from a shift back to the drachma has been proposed. It is clear that this would lead to significant civil unrest.

It is conceivable that the decisions made by leading politicians during financial crises will cause some volatility, most apparently in the country that would default, but also possibly in neighboring countries. Particularly interesting is the effort needed from the leading bodies in the system to restore consumer faith, even in their own countries. Extraordinary measures, such as quantitative easing and similar fiscal policies, would likely be necessary. These policies would then result in the devaluation of one currency compared to all others.

With the issues in Venezuela, we believe a study of South America could be particularly insightful. The situation of North Korea could be an interesting case with which to analyze the Asian region. The pull of the Organization of Petroleum Exporting Countries on the Middle East could lead to some provocative results. Zimbabwe is one of several African countries that would be compelling to investigate. Again, the major problem in any of these calculations is likely to be obtaining reliable data.

In general, this model is as imprecise as its predecessor. During the construction of the model, we were particularly dissatisfied with the complexity and interconnectedness indicators. It is the hope of the authors that in later iterations of the model all of the indicators will become more comprehensive. The more involved indicators, such as interconnectedness and complexity, should specifically be developed in more depth. However, it is with the original intention of the BCBS and FSB model that the value of the ACEM model is found. As advisory bodies, it is the responsibility of the FSB and BCBS to prepare regulators to contain the damage that would be caused by the default of a SIFI. The ACEM model, while imperfect, aims for the same goal for regulatory governmental bodies, and at the time of writing, there was no superior model that served the same purpose. As with all things, the ACEM model can be improved over time, and to this end, we would be more than willing to receive any ideas from others.

With the centralization of debt around national, public institutions it may become possible that sovereign default will become a real concern, not just strategically but also fiscally. This work is intended as the beginning of a framework describing which nations are systemically important so that the risk to the global financial system can be estimated and hopefully mitigated.

5. Conclusions

In this work, we produced a SIFI-based model for sovereigns in order to determine whether Greece was systemically important to the European Monetary Union on a purely economic basis. We first scored Greece using equally weighted measures, as the SIFI model does. We then modified weights in such a way that placed more stress on those areas that seemed more important for contagion issues. In both cases, Greece was found to be systemically unimportant.

From here, we investigated which countries would be scored as systemically important under our model. Our own biases told us that Germany and France should be the most important countries to the systemic health of the Eurozone. When these two countries ranked the highest in our rating system, we felt more comfortable with our methodology. We were not surprised to see the Netherlands come third. The countries at the bottom of the list further confirmed that our system was producing reasonable results.

Although Greece was found to be systemically unimportant, it is vital to note that simulation implies a GREXIT would lead to an average of one other country defaulting for every four Greek defaults. We also calculate a mean loss of 1.06 trillion euro spread throughout Europe, which is certainly not an insignificant sum. Further, we saw as many as eight countries defaulting in the wake of a GREXIT, and thus it is imperative that we realize that a lack of systemic importance should not be construed as a country being irrelevant for the fiscal health of its neighbors. The holes that a Greek default would rip into other countries would need significant bailout funds to be repaired.

Finally, our methods only account for economic and fiscal issues and not political issues. Many posit that one country leaving the European Monetary Union may lead to others following suit. This is something that we explicitly do not consider, and our present methods are wholly incapable of doing so.

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