October 2019

Dimensions of US Global Financial Power: Essays on Financial Sanctions, Global Imbalances, and Sovereign Default

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DIMENSIONS OF US GLOBAL FINANCIAL POWER: ESSAYS ON FINANCIAL SANCTIONS, GLOBAL IMBALANCES, AND SOVEREIGN DEFAULT

A Dissertation Presented

by

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Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2019

Department of Economics

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DEDICATION

For Jeff

ACKNOWLEDGEMENTS

This dissertation has benefited from much unwavering support. I am deeply grateful to the Chair of my Committee, Gerald Epstein, for his consistent and constructive feedback, patient mentoring, and enthusiastic interest in this dissertation project. The global financial arena is not easily corralled into understanding. But, through my many discussions with Jerry and study of his work, I was able to gain a steady glimpse into a dynamic that will undoubtedly hold my interest for some time. I am a better researcher for his ability to ask questions that gently reveal gaps in thinking, and my future work will surely be a reflection of his teaching.

I am also deeply indebted to my remaining Committee members. Since the coursework phase of my graduate studies, Michael Ash has not only consistently encouraged me to improve my theoretical arguments and empirical methods but also patiently weathered the storm that was (is) my incessant questioning. I am a better researcher for his ability to explain empirical methods intuitively, and I am a better teacher for realizing through his patience how improvement of the student relies upon their comfort in asking questions.

Douglas Cliggott has kindly acted as my tether from theory to reality. I am enormously grateful to him for our frequent conversations wherein his critique was always accompanied by practical advice and encouragement to keep moving forward. His experience in the financial sector, so generously shared, not only regularly captured my fascination but also cultivated my own understanding to the benefit of this project. This dissertation is also much improved owing to the generosity with which Bernard Morzuch gave of his time and expertise. Through

his careful critique and detailed instruction on how to improve, my methodology and writing gained in its precision. I am exceedingly grateful to him for sharpening the tools at my disposal as an economist.

Finally, it would be remiss of me if I did not thank, along with my Committee, my professor of economics during my undergraduate studies, G. Reza Ghorashi, who kindly introduced me to the topic of my third essay—financial sanctions on Iran—and provided helpful guidance in designing my methodology.

In addition to my Committee, I am enormously thankful to my colleagues in the Department of Economics at UMass-Amherst who selflessly gave not only of their friendship and humor but also of their expertise to make my experience in graduate school more pleasant. I am especially grateful to Amal Ahmad; Jackson Allison and his partner, Savannah; Khwlah Almutair and her daughter, Whateen; Ben Chalmers and his wife, Sally; Raphael Gouvea and his wife, Mariana; Osman Keshawarz; Sai Madhurika Mamunuru; Carly McCann; and Amanda Page-Hoongrajok and her partner, Kylie. It would be difficult for me to overstate the degree to which any success I enjoyed in graduate school is owing to their efforts.

I am also enormously grateful to my professors at what was formerly The Richard Stockton College of NJ, many of whom continued to guide me throughout my graduate studies. In particular, I thank Alan Arcuri, William Daly, Deborah Figart, Patrick Hossay, Ellen Mutari, Judith Vogel, and Linda Wharton. I also especially thank Anne F. Pomeroy to whom I owe an especially large intellectual debt.

I am grateful to my community in Southern New Jersey who effortlessly provided a laugh, shrug, and pat on the back when that sequence turned out to be the best answer. I am especially thankful to my neighbors, the McClay and Morris families.

I am indebted beyond measure to my family. My father was the first theorist of global politics with whom I had extended conversations, and the logic underpinning my thinking

is tighter owing to our discussions. My mother first demonstrated the joy in being curious and nurtured it in me. My excitement to learn is owing to her example. My four siblings—Mohammad, Ali, Ibrahim, and Jamie—trained me in resilience and continuously gave of their expertise to strengthen my weaknesses. My niece, Amelia, repeatedly narrowed my focus and renewed my determination. Her joyful curiosity is a consistent reminder and motivation.

Finally, this dissertation is dedicated to my husband, Jeff, who inspires with quiet kindness and humble strength. Without him, the pursuit manifested in the following pages simply would not exist.

ABSTRACT

DIMENSIONS OF US GLOBAL FINANCIAL POWER:
ESSAYS ON FINANCIAL SANCTIONS, GLOBAL IMBALANCES, AND SOVEREIGN DEFAULT

SEPTEMBER 2019

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This dissertation examines how U.S. capabilities in the global financial arena enable it to affect outcomes to its advantage. The first essay presents theoretical support for the hypothesis that holdings of U.S. sovereign debt collateralize public and private dollar borrowing in developing and emerging market economies, thus enabling the U.S. to receive continued easy financing despite declining economic fundamentals. The consensus view—what we refer to as the *Safe Assets theory*—contends that what motivates continued investment in US sovereign debt despite its drawbacks is its status as a *safe asset*: an asset that is strongly demanded during and following adverse macroeconomic shocks. Though a safe asset is primarily identified by virtue of its effect rather than by underlying determinants of safeness, the former is understood to be motivated by perceptions of the latter. Thus, the Safe Assets theory

argues that perceptions of a country's economic health buffer against consequences of its decline.

While we do not argue against the notion that perception can play an important role in sustaining demand for US sovereign debt, we draw on the well-developed sovereign debt literature and argue that perception is unlikely to act alone. Namely, for lending to a sovereign to occur, the structure of the relation between lender and sovereign borrower must be such that it facilitates endogenous enforcement of the lending contract. Indeed, the Safe Assets theory also concedes as much and assumes that if the US were to default on its sovereign debt obligations, it would suffer a large reputational cost levied by its lenders. We argue this assumption is unwarranted, however. To credibly threaten or levy such a cost necessarily requires that a lender possess greater capabilities than a borrower (i.e., the lender must be strong relative to the borrower.) It is therefore implausible to imagine that developing and emerging market economy lenders could credibly threaten or impose a cost onto the United States large enough to deter the latter from defaulting.

We argue that persistent demand for US Treasury securities from developing and emerging market economies is owing to its role as collateral for dollar credit. That is, public lending enables private and public borrowing. Specifically, we argue that the rapid growth in dollar credit to developing and emerging market economies leads to unfavorable investor perceptions of country volatility and increases the likelihood that inflows will reverse. Against this prospect, developing and emerging market economies are incentivized to offer their lenders collateral against the lending contract to secure continued access to dollar funds. US Treasury securities are an ideal form of collateral to dollar lenders for three main reasons: first, their scale of issuance enables lenders to require as collateral an asset large enough to disincentivize default; second, as a slightly less liquid form of a country's savings, US Treasury securities enable the lender to seize the means by which a defaulted borrower would secure

another lending contract; third, because custodianship of US Treasury securities largely lies with the US, the lender is capable of costlessly retaliating against a defaulting borrower.

The second essay empirically tests the theory presented in Chapter 1 that public lending enables public and private borrowing for developing and emerging market economies. Considering that most foreign holdings of US Treasury securities are in long-term securities held by foreign official institutions, we model the decision to hold long-term US Treasury securities as one to hold dollars in foreign exchange reserves, allowing us to draw from well-developed models of the latter decision-making process. We use a first-difference estimator to control for country-specific factors affecting both US Treasury security holdings and outstanding dollar credit in a panel of thirteen developing and emerging market economies. To incorporate a persistence effect of US Treasury security holdings, we introduce as a regressor the dependent variable lagged by one period and estimate the regression equation using an instrumental variable method.

We provide evidence that, indeed, a statistically significant relationship exists between a country's official holdings of US Treasury securities and its level of outstanding dollar credit. Our results demonstrate that even after controlling for a persistence effect (i.e., inertia) in US Treasury security holdings, increases in outstanding dollar credit lead to a statistically significant ($p < 0.01$) increase in holdings of US Treasury securities. Specifically, the estimated increase in US Treasury security holdings resulting from a \$1 billion increase in outstanding dollar credit is \$0.11 billion, all other factors held constant. Our result is robust to alternative definitions of our control variables and to the removal of outliers. Namely, our result is not driven by China's disproportionate holdings of both US Treasury securities and outstanding dollar credit. In fact, when China is removed from the sample and our empirical model estimated again, the effect of outstanding dollar credit on holdings of US Treasury securities *increases* in statistical significance ($p < 0.001$) and magnitude.

Specifically, when China is removed from the sample, a $1 billion increase in outstanding dollar credit is associated with a $0.18 billion increase in US Treasury securities, all other factors held constant.

Finally, the third essay of this dissertation examines the United States' unique and relatively recent ability to wield access to global financial networks as a distinctly effective sanctioning tool. Through a review of the literature on sanctions, we highlight the similarities between this latest form of financial sanction and its heavy-handed forerunner, comprehensive trade sanctions. We specifically trace the evolution of US command over the Society for Worldwide Interbank Financial Telecommunication (SWIFT) and its subsequent removal of the Islamic Republic of Iran from the platform in 2012 (hereafter referred to as the *SWIFT sanction*). To evaluate the impact of this new category of sanction, we utilize quarterly data on Iran's real GDP during the period 1988-2016 and employ a time-series forecasting technique to measure the cost of the SWIFT sanction to Iran's real GDP, where cost is measured by the difference between forecasted and actual real GDP.

Results generated from estimating a seasonal autoregressive integrated moving average (ARIMA) model indicate that the impact to Iran's real GDP of the SWIFT sanction is sizeable. Specifically, the average quarterly cost of the SWIFT sanction to Iran's real GDP is approximately $204.3 billion (PPP-adjusted, 2015 international dollars), or 14.7% and 13.8% of Iran's average quarterly actual and forecasted GDP, respectively.

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WHAT EXPLAINS PERSISTENT FOREIGN DEMAND FOR US SOVEREIGN DEBT? A THEORETICAL ASSESSMENT

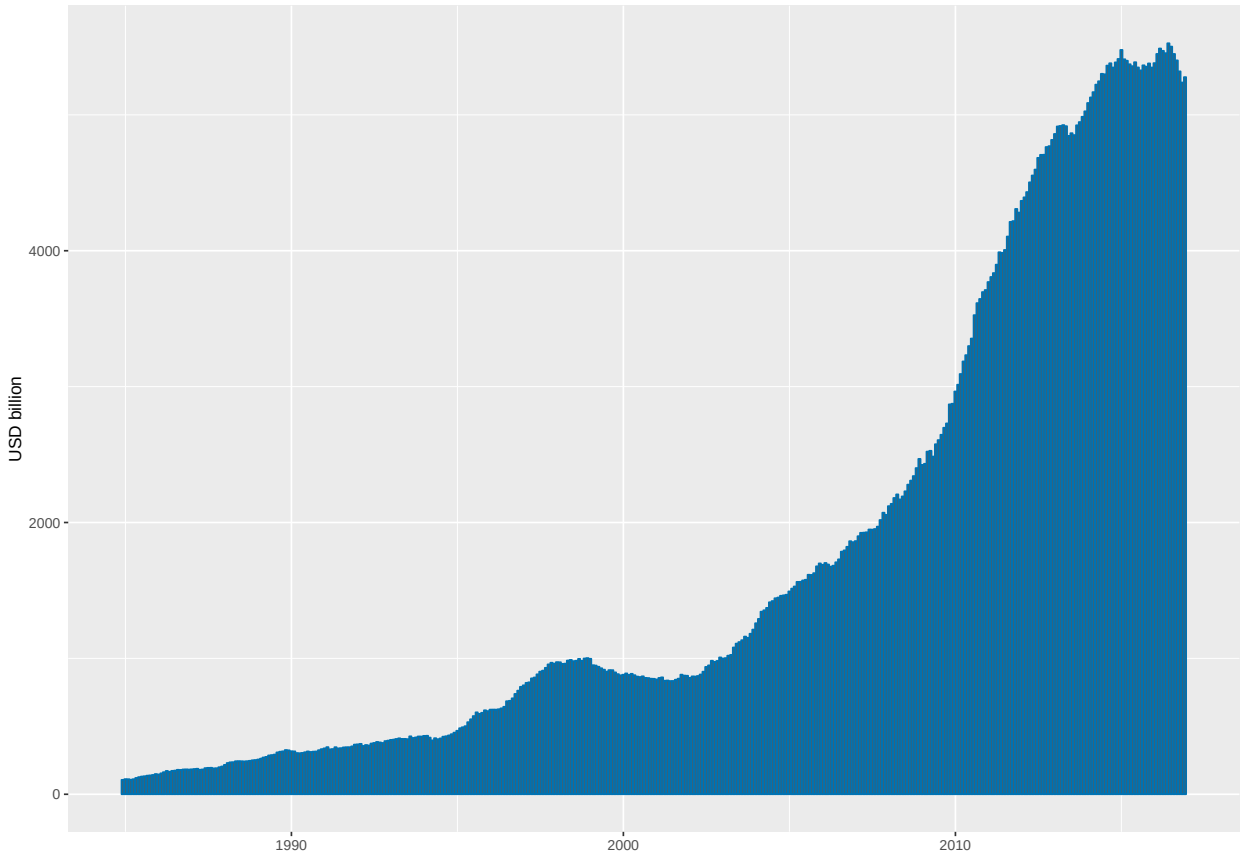
1.1 Introduction

The movements of global capital flows have been the subject of much debate in large part because of their selective and persistent flow toward long-term US sovereign debt. Figure 1 illustrates the growth of monthly foreign holdings of long-term US Treasury securities during the period 1984-2016. The figure demonstrates that foreign holdings of long-term US Treasury securities has grown rapidly since 2002 and at an increasing rate just prior to the 2008 global financial crisis.

Largely behind this inflow are foreign official institutions in emerging market and developing economies who, accordingly, constitute the largest proportion of investors in long-term US Treasury securities. Figure 2 shows foreign holdings of US Treasury securities by holder (private or foreign official) and type (long or short) during the period for which this data is available.

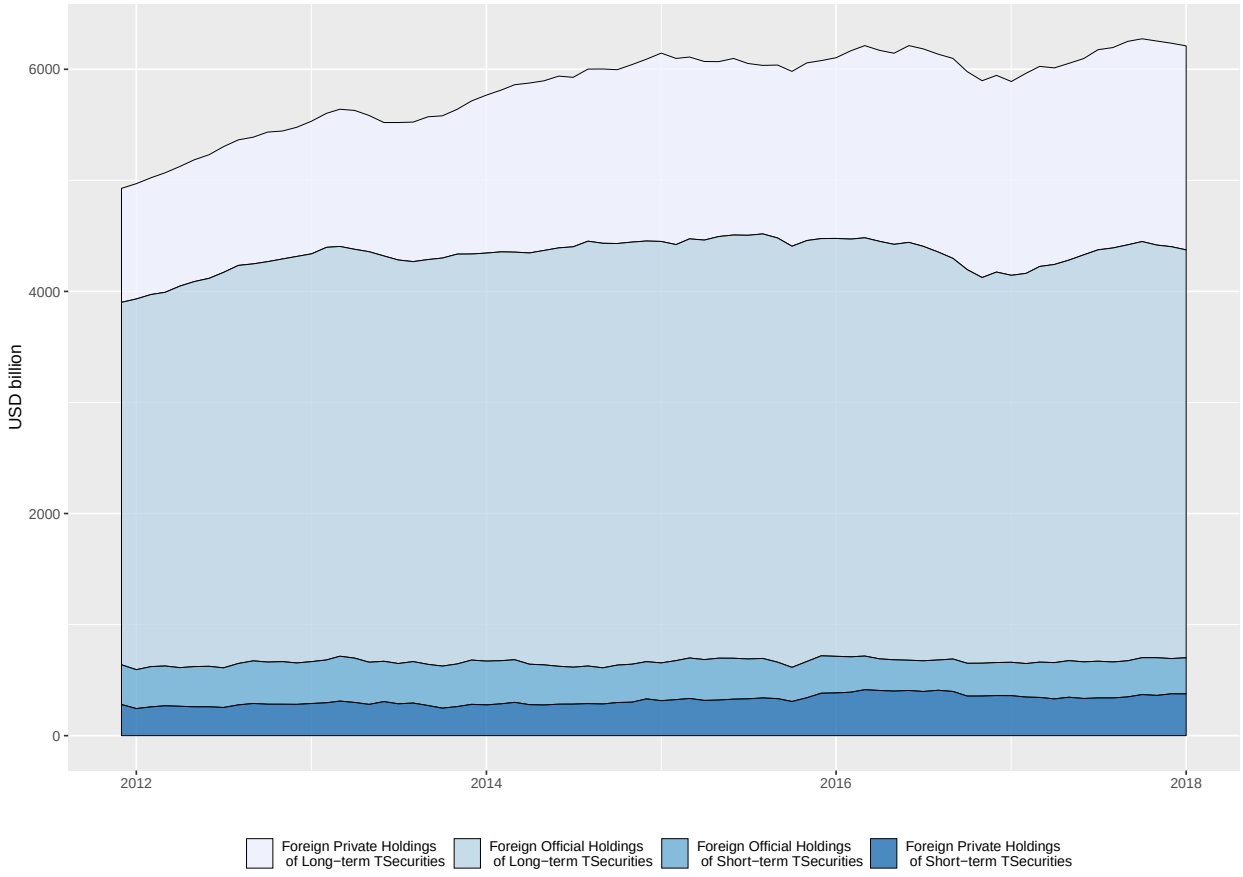
The figure demonstrates that foreign investors hold long-term Treasury securities in larger proportion than short-term Treasury securities; further, foreign official institutions hold the largest proportion of long-term Treasury securities held by foreigners, though foreign private

Figure 1: Foreign Holdings of US Long-term Treasury Securities 1984-2016



Notes: Data on holdings of long-term US Treasury securities is adjusted for valuation effects. Data is from Bertaut and Judson (2014).

Figure 2: Foreign Official Holdings of US Treasury Securities



Notes: Data is from the Treasury International Capital Reporting System.

holdings have grown since approximately 2013.

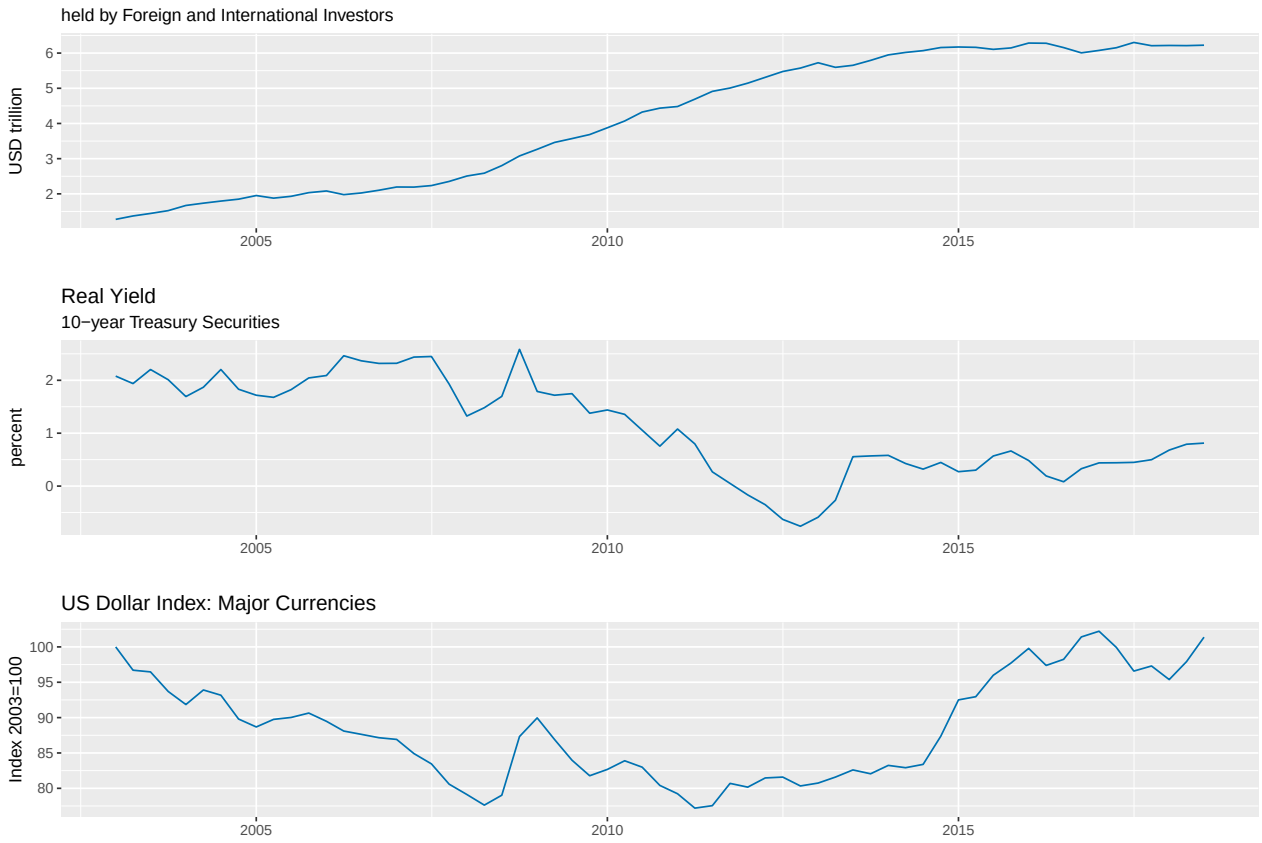
Interestingly, demand for US sovereign debt has persisted despite its naturally accompanying corollary: an increasing debt to gross domestic product (GDP) ratio. Indeed, by 2006, the US current account deficit had reached an unprecedented level of 6% of GDP (Gourinchas and Rey, 2014). Continued funding of the US to and past this point is puzzling since high debt to GDP ratios are conventionally understood to work against long-term prospects for economic growth and should therefore disincentivize investment in a country's public debt (Reinhart and Rogoff, 2010; Cecchetti, Mohanty, and Zampolli, 2011; Alfaro, Kalemli-Ozcan, & Volosovych, V., 2014; He, Krishnamurthy and Milbradt, 2016). More striking, demand for US debt has persisted despite two additional forces that typically operate to reduce it: declining yields and dollar depreciation.

Figure 3 shows federal debt held by foreign and international investors, the real yield on 10-year Treasury securities, and the US dollar index during the period 2003-2018.

The figure shows that during the period 2008-2012 the real yield on 10-year Treasury securities dropped from a high of approximately 2.6% to a low of -0.76% while the level of federal debt held by foreign official and international investors steadily rose. This means that demand for US debt persisted even as investments yielded increasingly less of a real return and actually imposed a cost to investors. Additionally, during the period 2009-2011 the real value of the dollar was falling against other major advanced economy currencies, meaning holders could reasonably expect to be repaid in currency worth relatively less than it had been at the time the security was purchased.

According to conventional economic theory on capital flows and sovereign debt, none of what has been described thus far should be happening. First, that capital should flow from emerging market and developing economies to advanced ones contradicts the standard economic theory developed by Robert Solow and Trevor Swan in 1956 (hereafter referred to

Figure 3: Federal Debt, the Real Yield and the US Dollar Index



Notes: The US dollar index is a weighted average of the foreign exchange value of the US dollar against the following currencies: the Euro, Canadian Dollar, Japanese yen, British pound, Swiss franc, Australian dollar, and Swedish krona. Data on federal debt held by foreign and international investors is from the Federal Reserve Bank of St. Louis. Data on the real yield for 10-year Treasury securities is from the Treasury International Capital Reporting System. Data on the US Dollar Index is from the Federal Reserve Bank of St. Louis.

as the *Solow-Swan model*). The Solow-Swan model defines the rate of return on capital as being equal to its marginal product minus deprecation. Assuming that the marginal product of capital is decreasing in the level of capital stock, the model implies that the rate of return on capital is higher in countries possessing a lower capital-to- worker ratio. Further assuming that it is in "rich" countries where the capital-to-worker ratio is highest, then the Solow-Swan model's central prediction is that in an open and competitive environment, capital will flow "downhill" in search of higher rates of return until the latter are equalized; that is, capital will flow from rich to poor countries until international rates of return on capital are the same.

Standard economic theory is also challenged since increasing demand for US sovereign debt exists simultaneously with dollar depreciation and decreasing real yields. The literature on sovereign debt predicts that in response to dollar depreciation—considered to be synonymous with US default (albeit implicitly) on its sovereign debt obligation—demand and yields should decrease and increase, respectively.

The conventional approach to explaining sustained demand for US sovereign debt, even despite these declines in quality is what we will refer to as the *Safe Assets theory*, which argues that US Treasury securities are a *safe asset*: an asset that is flooded to during and following adverse macroeconomic shocks. Though a safe asset is primarily defined and identified by way of its effect rather than its characteristics, the attraction of US Treasury securities is argued to be ultimately owing to its safeness, the latter of which is itself reliant upon favorable investor perception of US financial development.

Thus, persistent demand for US Treasury securities in the Safe Assets theory is owing to the combination of risk-aversion among developing and emerging market economies and their perception that these securities constitute a safe asset. An important implication of the Safe Assets theory which follows from its reliance on perception is that the stability of the

US financial system—and the global financial system tethered to it—is tenuous as continued funding of the former only hinges on a change in perception.

Despite the popularity of the Safe Assets theory, it is subject to a logical flaw. Namely, the Safe Assets theory fails to offer a plausible explanation of what mechanism enables sovereign lending in the first instance. The literature has yielded strong conclusions that sovereign lending does not occur absent of a lender's ability to impose large punitive costs onto a defaulted borrower. That is, at least in the case of sovereign lending, the proverbial carrot is helpless to motivate when unaccompanied by the stick. The Safe Assets theory assumes US willingness to repay its sovereign debt obligation is motivated by a desire to avoid incurring a large reputational cost levied by its lenders; it does not consider, however, that the strength of lenders (here, developing and emerging market economies) relative to the borrower makes it highly unlikely that the former can impose a large punitive cost onto the latter.

In this paper, we fill the gap left by the Safe Assets theory and provide an explanation of what enables lending to the US in the first instance. Our theory is that developing and emerging market economies hold US Treasury securities to collateralize private dollar borrowing. That is, the persistent demand for US sovereign debt is at least partially motivated by the reality that public lending enables private and public dollar borrowing.

We argue that the persistent demand for US Treasury securities from developing and emerging market economies is a logical conclusion of the rapid growth in private dollar credit to the latter (McCauley, McGuire and Sushko, 2015). As is well-known, capital inflows have a perverse effect upon its recipients: inflows increase not only the recipient's reliance on still more inflows but also its debt to GDP ratio. This leads to unfavorable investor perceptions of country volatility and increases the likelihood that inflows will reverse, leaving crisis in their wake. Against these prospects, developing and emerging market economies are incentivized

to offer their lenders collateral against the lending contract to secure continued access to dollar funds.

US Treasury securities are an ideal form of collateral to dollar lenders for three main reasons: first, the scale of its issuance enables lenders to collateralize an asset large enough to make the consequences of default larger than its benefit; second, by seizing a country's savings, the lender prevents the borrower from defaulting one debt obligation to enter into another; finally, US Treasury securities are held in the lender's jurisdiction, making it relatively costless for the lender to retaliate against a defaulting borrower.

Because it identifies a motivation for investment in US Treasury securities less fleeting than perception, one important implication of our theory is that the US ability to receive continued and easy financing is more stable than the Safe Assets theory assumes. The theory is put to empirical test in Chapter 3.

The paper proceeds as follows. Section 1.2 reviews the literature on global imbalances to set the stage for the introduction of the Safe Assets theory. Section 1.3 presents an analysis and critique of the Safe Assets theory. Section 1.4 then presents an alternative theory to explain persistent demand for US Treasury securities among developing and emerging market economies. Section 1.5 concludes.

1.2 The Literature on Global Imbalances

In 1990, Robert E. Lucas, Jr. articulated what is popularly known as the *Lucas Paradox*: despite the predictions of the Solow-Swan model, capital does not flow from rich to poor countries to the degree expected (Lucas, 1990). Using the example of capital flows between India and the United States, Lucas argued that return to capital should be much higher in India than in the US, thus eliciting a flow of capital to the former of a magnitude not

observed in reality. Addressing two possible explanations commonly cited to reconcile the lack of downhill flows with higher returns to capital—differences in labor productivity and political risk—Lucas also challenges each in turn.

Differences in labor productivity can dampen the singular effect of higher worker to capital ratios if the latter are also accompanied by a high marginal product of capital. Controlling for possible differences in labor productivity, Lucas finds that though the profitability of investment projects in poor countries is revised downwards once controlling for these differences, capital investments in poor countries still generate a rate of return five times that of what would be yielded by capital investments in a rich country. That is, even controlling for the fact that levels of productivity may be higher in rich countries, economic theory still predicts that capital should still flow from rich to poor countries at a rate much higher than was observed.

Lucas further considers whether the puzzle can be solved if investments in human capital have an exponential effect on productivity through technological innovation (that is, where the investments in human capital are higher, the return to productivity is increasing and not diminishing). Lucas finds that this adjustment does seemingly reconcile the puzzle he presents, but only if unrealistic assumptions are adopted. Finally, Lucas addresses the possibility that capital fails to flow downhill to the extent predicted because political risk in poor countries compromises their ability to credibly commit to repayment. Rejecting the notion, he argues that if political risk was relevant to the flow of capital to poor countries, we might expect to have seen global capital flows equalized—at least between Europe and India—during the period when poor countries were subject to the ostensibly stabilizing force of colonial rule. Ultimately, Lucas leaves the puzzle he presents intact (Lucas, 1990).

Little more than two decades after the Lucas puzzle was articulated, the *allocation puzzle* again presented a challenge to standard economic theory. Because it is assumed that pro-

ductivity growth rises with technological progress, the neoclassical growth model predicts that in a search for higher returns, capital should flow into countries that have reached the same level of technological progress as the rest of the world (i.e., whose total factor productivity—or *Solow residual*—reaches the world frontier) and out of countries whose level of the same has receded. The allocation puzzle, however, presented the finding that capital flows to developing countries tend to be *negatively* correlated with their productivity growth. That is, whereas Lucas articulated a dynamic in which too little funds were being received by developing countries given their comparatively low capital-to-worker ratios, the allocation puzzle added the mystifying detail that those developing countries experiencing higher rates of productivity growth tend to receive less capital inflows.

More contemporary evidence suggests that the driving force behind this inverse relation between capital inflows and productivity growth is the public sector, as the sovereign governments of developing and emerging market economies have largely saved the income generated by comparatively high rates of economic growth (Gourinchas and Jeanne, 2013). Again, standard economic theory is challenged by this phenomenon: higher volatility of income and lower relative levels of development among developing and emerging market economies yields the expectation that they will possess *higher* rates of borrowing and investment to smooth consumption intertemporally and promote development (Obstfeld and Rogoff, 1995).

A number of theories have been posited to explain why levels of national savings have increased in developing and emerging market economies. Highlighting the importance of an export-led growth strategy for emerging markets, the *Bretton Woods II hypothesis* initially focused on the dynamic between the United States and China to argue that emerging market economies accumulate advanced economy debt (namely, US debt) to undervalue their own currencies, thereby allowing their exports to remain competitive in advanced economy

markets (Dooley, Folkerts-Landau and Garber, 2003). Because the demand for advanced economy debt reflects a kind of dependency of emerging market economies on advanced economies, the earliest version of the Bretton Woods II hypothesis implies that global imbalances are fairly sustainable. That is, so long as advanced economy funding is used to support an export-led growth strategy in emerging market and developing economies, global imbalances will persist uninterrupted (Dooley, Folkerts-Landau and Garber, 2003, 2004).

Research efforts have been focused not only on discovering why developing and emerging market economies have largely become net savers but also on why their savings are stored in advanced economy assets. The latter reality is naturally an exacerbation of the Lucas puzzle as it implies that capital not only fails to flow downhill in sufficient quantity (as Lucas noticed), but that it also flows in the reverse direction. That is, capital flows *uphill* from poor to rich countries.

One explanation is that the advanced economy with the highest rate of productivity growth relative to other advanced economies will receive a disproportionate amount of capital inflows (Engel and Rogers, 2006). This justification does not, however, explain why global capital flows are found distributed among advanced economies in the first place. In addition, investment in advanced economies is mainly in fixed-income instruments and in equity; if productivity growth was a factor attracting investment to advanced economies, then we might reasonably expect those investments to be in assets that earn a rate of return proportional to the rate of productivity growth (i.e., investors would want a portion of the return generated from the increasing rate of productivity growth.) What is seen instead, however, is that investments in advanced economies are in assets that offer a fixed rate of return (Balakrishnan, Tulin and Bayoumi, 2007).

Another explanation highlights the function advanced economy debt serves as a *reserve asset*: an asset that acts as a highly-liquid, international store of value. This view sees the

increased savings rates among developing and emerging market economies as a reflection of lessons learned from the series of domestic financial crises occurring in the mid-late nineties, allegedly catalyzed by poorly allocated capital inflows. Thus, while the earliest version of the Bretton Woods II hypothesis suggests the contemporary saving behavior of developing and emerging market economies is opportunistic, this view understands it as precautionary: saving reflects a precautionary motive according to which developing and emerging market economies save to fortify their stock of foreign reserves in case severe macroeconomic shocks are experienced again (Bernanke, 2005; Caballero, 2006; Bussiére, Cheng, Chinn, and Lisack, 2015). The notion that developing and emerging market economies possess a precautionary motive to save may imply a somewhat more forgiving view of saving behavior than the Bretton Woods II hypothesis. Importantly, however, blame for precaution is squarely placed upon developing and emerging market economies since it is theorized to be the inefficiencies in the latter that ostensibly catalyzed the financial crises now acting as a motivating force (Bernanke, 2005).

Why, then, investment in advanced economy debt? The conventional view argues that uphill capital flows are the result of heterogeneity in securitization capacity; that is, uphill capital flows are the result of the ability of countries to produce financial assets that are both innovative and capable of acting as a store of value for a large amount of savings (i.e, financial depth and breadth) (Balakrishman, Tulin, and Bayoumi, 2007; Caballero, Farhi and Gourinchas, 2008; Caballero and Krishnamurthy, 2009; Vermeulen and de Haan, 2014). The ability of a country to generate financial assets is understood to depend on a host of institutional, political, and economic factors that allow future output to be credibly pledged to financiers; these factors include strong property rights that minimize the probability of expropriation, strong economic fundamentals, institutions that are capable of enforcing contracts, economic policies amenable to market liberalization, high levels of macroeconomic stability,

and low levels of political corruption and cronyism (Caballero, 2006; Alfaro, Kalemli-Ozcan and Volosovych, 2014; Caballero, Farhi and Gourinchas, 2008).

When these securitization-enabling factors are absent in a country that also possesses a high growth rate and high desired rate of precautionary savings, the conventional view argues that the result will be a flow of funds from asset-poor to asset-rich countries (i.e., from countries where financial assets are scarce to countries where financial assets are plentiful).[1]

The empirical evidence on the link between financial depth and uphill flows has been mixed. If a factor drawing global financial flows toward advanced economies is financial depth and breadth, then we might expect those countries with less of a capacity to generate deep and innovative financial assets to be more likely to invest in advanced economy financial assets. Yet, some evidence demonstrates the opposite is true: levels of financial deepening (measured by the ratio of near-money [M2] to GDP) is positively correlated with current account balances; that is, among developing and emerging market economies, more financial development is associated with a *greater* level of national saving (Chinn and Prasad, 2003; Chinn and Ito, 2007; Gruber and Kamin, 2009). In addition, developing and emerging market economy savings overwhelmingly flows to perhaps the least innovative, advanced-economy financial asset: sovereign debt. This offers a reason to question the appeal of financial breadth in drawing global capital flows toward advanced economies.

The asset-rich country receiving a disproportionate inflow of developing and emerging

[1]The formal treatment of this explanation relies on a model of global intertemporal equilibrium. Given two, one-good, pure endowment economies and two time periods (1 and 2), the autarky rate of interest for either country will be driven upwards when the savings rate in a country is lower and impatience (the degree to which agents prefer to consume in period 1 and therefore prefer to borrow against future income) is higher; accordingly, the autarky rate of interest will be driven downwards when the savings rate is higher and impatience lower. If the model is populated by two countries, A and B, that differ in their preferred rate of savings and level of impatience—where country A possesses more impatience and a low savings rate (characteristic of advanced economies) and country B possesses less impatience and a high savings rate (characteristic of developing and emerging economies)—then country A will have a higher autarky rate of interest than country B; accordingly, in period 1, we would expect that country A will borrow from country B. That is, we would expect that capital would flow uphill (Obstfeld and Rogoff, 1995).

market economy savings for at least the past two decades is the United States. Indeed, this reality prompted many to identify a *global savings glut* as the culprit of the 2008 global financial crisis and the subsequent ineffectiveness of US monetary policy to respond. That a country's financial sector would act as such an influential determinant of uphill capital flows is challenged by this persistent demand for US sovereign debt, especially prior to the 2008 financial crisis. Figure 1 illustrates that in 2008, foreign holdings of long-term US Treasury securities grew at an increasing rate even as New York-based Bear Stearns and Lehman Brothers collapsed.

Thus, demand for US sovereign debt—ostensibly motivated by the financial depth and breadth of the US—was most strong when by all reasonable measure, the US was on the verge of financial collapse. What is more, at this same time, the real yield on 10-year Treasury securities precipitously fell and the dollar depreciated against other advanced economy currencies (see Figure 3). Relatedly, empirical evidence suggests that large trade balance adjustments in the US have little effect on the demand for US sovereign debt (Kamin, Reeve and Sheets, 2007).

In response to these uniquely puzzling aspects of developing and emerging economy demand for US sovereign debt, the predominant *Safe Assets theory* argues that US Treasury securities are a *safe asset*. We now turn to that theory in more detail.

1.3 The Safe Assets Theory

The Safe Assets theory argues that uphill capital flows and the persistence of demand for US Treasury securities can be explained by the latter's status as a safe asset, particularly in the foreign exchange reserves of developing and emerging market economies. What exactly determines a safe asset is somewhat difficult to discern, however, as is readily acknowledged

by the literature itself (Caballero and Farhi, 2014). In its most concrete form, a safe asset is defined as one that is flocked to during periods of crisis, thus allowing it to retain its value even (and especially) under such circumstances (Maggiori, 2013; Caballero and Farhi, 2014). Thus, the Safe Assets theory is in many ways a restatement of an earlier explanation of uphill capital flows whereby investments in advanced economy debt act as a reserve asset (Bernanke, 2005; Caballero, 2006; Bussiére et al., 2015). What is different about the Safe Assets theory, however, it that it now adds as a quality of reserve assets a strong appeal during periods of severe macroeconomic instability.

Thus, a safe asset is primarily detected by virtue of its effect rather than by underlying determinants of safeness. That is, a safe asset is safe because it behaves *as if* it is safe, though determinants of safeness are not subject to rigorous analysis. Curiously, however, to the degree that safeness is reflective of belief in the solvency of a sovereign borrower, the perception of safeness can make the quality manifest since continued financing allows a borrower to meet past debt obligations. This dynamic is referred to in the literature as strategic complementarity whereby investor behaviors are complements since more safe asset purchases generates even more safe asset purchases. The conclusion yielded from a stylized model developed to explain the safe asset status of US Treasury securities is illustrative: "The safety of a safe asset depends on investor beliefs. Safety is endogenous, and when investors believe an asset will be safe, their actions can make that asset safe" (He, Krishnamurthy, and Milbradt, 2016, p. 523).

Though the Safe Assets theory is borne from dynamics that challenge whether a country's financial asset-generating capacity is a determinant of capital inflows, it is still tethered to this view in the following ways. First, the theory argues that what determines the choice *between* safe assets is understood to be relative debt capacity. That is, if the existence of safe assets is given (i.e., we begin from a state of the world where safe assets exist though for

reasons unknown), then what determines investor selection between safe assets—i.e., whether a foreign official or private investor chooses to hold the safe assets of country A or B, for instance—is how much debt a country can issue.

Debt capacity plays a large role in safe asset selection according to the Safe Assets theory because of investor preferences and expectations: investors prefer to sustain the largest quantity of safe assets possible and expect other investors to prefer the same; as a result, investors expect investment flows into countries with the largest capacity to issue debt and will therefore also invest in the same. This behavior constitutes an endogenous process whereby the debt of countries with the largest debt capacity actually *becomes* safe. The theory argues that this herding behavior towards the safe assets of the sovereign nation with the largest debt capacity illustrates a "nowhere else to go" principal: investors seeking safe assets have "nowhere else to go" but the debt of the sovereign nation with the largest debt capacity (He, Krishnamurthy, and Milbradt, 2016, p.519).

Second, though not readily apparent, a detailed analysis of the safe asset theory reveals that debt capacity is understood to stand as a proxy for the financial depth of a country which is, in turn, generated by the strength of its economic fundamentals. Given that the goal of the safe asset theory is to explain the resiliency of US sovereign debt *in the absence of* strong economic fundamentals, this last point could reasonably be a source of confusion. The argument can be made clearer, however, once thresholds are considered. The Safe Assets theory effectively holds that absolute economic fundamentals may sustain a level of debt issuance so large that it surpasses a certain threshold beyond which the debt enters a class of its own: it is *perceived* to be safe simply by virtue of its size (i.e., the debt is safe because it was able to reach such a large level.)

Once beyond this threshold, it becomes assumed that debt capacity stands as a proxy for financial depth generated from strong economic fundamentals, where the strategic comple-

mentarity of investor behavior serves to reinforce the perception. The assumption becomes so embedded and the reinforcing effect of investor behavior so strong that the primary determinant of safe asset selection becomes debt capacity, even to the extent that it overrides the implications of its required result: poor economic fundamentals of a safe-asset issuing country (He, Krishnamurthy and Milbradt, 2016). In this way, the debt capacity of a safe-asset issuing country is both dependent on and a departure from the literature attempting to explain the phenomenon of uphill capital flows by way of the financial depth and breadth of advanced economies (Balakrishnan, Tulin, and Bayoumi, 2007; Caballero, Farhi and Gourinchas, 2008; Antras and Caballero, 2009; Caballero and Krishnamurthy, 2009).

One important implication of the Safe Assets theory is that because the safeness of safe assets is ultimately perceived, its loss as an attribute is simply dependent on the loss of this perception. Applied to the case of the United States, which is understood to have possessed the world's largest store of safe assets for at least the past fifty years, the reliance on investor perceptions of safeness implies that the solvency of the United States is necessarily tenuous as it only requires a change in investor confidence to threaten it (Caballero and Farhi, 2014; He, Krishnamurthy and Milbradt, 2016; Caballero, Farhi and Gourinchas 2016, 2017; Farhi and Maggiori, 2017). That is, the stability of the US financial system (and by extension, the global financial system) stands on a knife-edge where the central factor determining continued balance is investor perception of the US ability to repay its sovereign debt. Further, because investor confidence may be strengthened to an extent that sustains declining economic fundamentals of the safe-asset issuing country, it becomes unclear at what point a safe asset-issuing country will have gone too far in stretching its debt capacity. The system is, therefore, fragile (Farhi and Maggiori, 2017).

1.3.1 A Critique of the Safe Assets Theory

In this section, we will critique the logical foundation of the Safe Assets theory, thereby challenging the notion that perception can provide a comprehensive explanation to the puzzle that is persistent demand for US sovereign debt. To set the stage for our critique, we begin this section with a brief overview of the sovereign debt literature. Our main point will be that this literature yields the strong conclusion that lending to a sovereign fails to occur in the absence of a mechanism enforcing the debt contract. We argue that the Safe Assets theory does not provide such a mechanism to a plausible degree, thus rendering it insufficient as a complete explanation of persistent foreign demand for US sovereign debt.

A central focus of the sovereign debt literature is the risk of lending to a sovereign in the presence of *sovereign immunity*—a legal doctrine protecting the independence of sovereign governments by ensuring their immunity to criminal or civil prosecution. The doctrine necessarily restrains lenders from enforcing debt contracts with sovereign borrowers since there does not exist any supra-national legal system that can facilitate enforcement. As a result, sovereign lending belongs to a distinct group of economic exchanges where an agency problem exists because the difficulty inherent in monitoring the good or service to be exchanged makes a contract unable to be third-party (exogenously) enforceable at the same time that one of the parties (namely, the borrower) has the ability to benefit or harm another by repaying the loan or defaulting on it, respectively. [2]

Nevertheless, lending to sovereigns does indeed occur and the current consensus view

[2]In this context of a sovereign borrower who enters into a non-contingent debt contract—a contract that specifies a set of dates and payments that must be made to the lender irrespective of (i.e., not contingent upon) the state of the sovereign—default is a failure of a sovereign borrower to honor its debt contract, either by a refusal to pay or by necessitating a renegotiation of the debt contract in terms less favorable to the lender (Aguiar and Amador, 2014). If the debt is to be repaid in the borrower's currency, then the latter form of default—repayment in terms less favorable to the lender—can occur implicitly through inflation or depreciation of the borrower's currency. Through implicit default, the lender may receive repayment that fulfills the debt contract in nominal terms but is worth less in real terms.

argues this is because there *is* enforcement power governing debt contracts with sovereign borrowers; it simply is not exercised by a third-party. Rather, enforcement power is understood to arise *endogenously* from the relation between the parties to the contract. That is, by virtue of the relationship between lender and sovereign borrower, a structure either exists or is created that makes default costlier to the sovereign borrower than repayment. The methods by which repayment is endogenously secured are called *endogenous enforcement mechanisms* (Bowles and Gintis, 1990, as cited in Prem, 1994).

Endogenous enforcement mechanisms generally fall within three categories: contingent renewal, collateralization, and retaliation (Bowles and Gintis, 1990, as cited in Prem, 1994). Contingent renewal utilizes the desire of the borrower to borrow again (i.e., to renew the debt contract) and accordingly requires future borrowing to be contingent upon present payment. As applied to the case of international credit markets and sovereign borrowing, contingent renewal implies that lending to sovereign borrowers occurs because lenders are confident that the threat of exclusion from international credit markets in the case of default operates to endogenously enforce repayment; in such a circumstance, sovereign borrowers are said to be incentivized to protect their *reputation* (where exclusion from international credit markets is said to constitute a *reputational cost*.)

Collateralization as an endogenous enforcement mechanism refers to the loss of a defaulting borrower's asset posted as collateral; importantly, for the loss to disincentivize default, the asset must be large enough so that the borrower's cost of default is greater than the cost of compliance. Collateralization is also linked to the endogenous enforcement mechanism of *retaliation* since it is when the lender retaliates against a defaulting borrower by seizing collateral that collateralization is employed as an enforcement mechanism. But, retaliation also encompasses a wider set of methods, especially in the context of international credit markets and sovereign borrowers. These methods include seizing the borrower's assets over-

seas (financial or otherwise), impeding its trade, and/or intervening militarily. Again, these methods only operate to endogenously enforce repayment if the cost levied onto the sovereign borrower outweighs the benefit from default.

Importantly, for endogenous enforcement mechanisms to enable lending to sovereign borrowers, it must necessarily be the case that lenders are strong, or better situated, than borrowers. This is so because excluding defaulting borrowers from international credit markets requires coordination among lenders and other market participants to make the cost of the latter's potential engagement with defaulting borrowers larger than its benefit. But, encouraging coordination requires capital and influence since cooperation must extend widely in international capital markets and imposing costs is not costless (Eaton and Fernandez, 1995; Epstein and Gintis, 1995). Similarly, military intervention or seizure of the borrower's assets requires that the lender possess a powerful military and be powerfully situated in trade and financial networks, respectively (Epstein and Gintis, 1995). If the borrower possesses greater capabilities than the lender, then the outcome is straightforward: the borrower will be capable of circumventing the lender's attempts of endogenously enforcing the debt contract, thus rendering endogenous enforcement mechanisms ineffective.

The literature on sanctions is also helpful in demonstrating the requisite relative capabilities between borrower and lender. For sanctions levied onto a sovereign nation to be successful, researchers find that the recipient, or *target*, must bear more costs than the sender (Eaton and Engers, 1992, 1999; Davis and Engerman, 2003; Drezner, 1999; Hufbauer, Schott and Elliott, 1990). For instance, Eaton and Engers (1992) describe the impacts of what they call *toughness*—a measure of a country's willingness to incur costs and ability to withstand them—on sanction outcome. They find that the likelihood of sanction success is greatest when the sender is *tough* relative to the target (i.e., when the sender's ability and willingness to withstand costs is high relative to a target). Indeed, reality is a testament to this

requisite dynamic: sanctions generally tend to be levied by stronger countries onto weaker ones (Hanlon, 1986; Drury, 1998; Levy, 1999). As reported in Davis and Engerman (2003), "In the 115 cases of economic sanctions deployed since 1914...the GNP of the sender (or principal initiator) of sanctions was nearly always over ten times that of the target and in the majority of cases more than 50 times greater" (p. 191).

Having briefly reviewed some of the basic findings of the literature on sovereign lending, we can now return to the Safe Assets theory. The Safe Assets theory assumes that the endogenous enforcement mechanisms enabling lending to the US are *contingent renewal* and *retaliation*; specifically, it assumes that if the US defaults on its debt obligation, it will incur a reputational or direct cost. As has been shown, such an assumption relies on conceptualizing the lending dynamic as one between a strong lender and a weak borrower (Farhi and Maggiori, 2017).

But, can the United States reasonably be considered weak relative to its developing and emerging market economy counterparts? That is, is it reasonable to assume that standard endogeneous enforcement mechanisms are operative because developing and emerging market economies can coordinate to exclude the US from international capital markets or credibly threaten to seize assets large enough to make the cost of default higher than its benefit?

The evidence suggests that this is not a reasonable assumption. Research findings strongly suggest that the United States maintains a central position in the structure of what can be thought of as a global financial network.[3] The research in international political economy, particularly from the vantage point of political science, is instructive in describing

[3]It is worth noting that we are aware of the declinist narrative predicting the demise of US hegemony (see, for example, Wallerstein, 2006). While a description or analysis of this literature is beyond the scope of this paper, it is useful to point out that the declinist narrative argues that, currently, US hegemony has declined in a relative sense and not in an absolute sense. That is, while the absolute structural position of the United States in the global arena is subject to debate, its current hegemony relative to other countries is not. Thus, even if the declinist narrative is adopted, the point highlighted in this paper—that relative to the United States, emerging and developing countries possess a less central position in the global arena—should not constitute a challenge to our conclusion.

the central position and consequent capabilities of the United States in the international financial arena. For instance, using network analysis to analyze data on cross-national banking ties from the Bank of International Settlements, Winecoff (2015) concludes that the United States possesses the most cross-national banking ties of any other leading economy such that the US can properly be described as the "world's banker" (p. 507).[4] Winecoff argues that this position not only failed to be diminished by the 2008 global financial crisis but was actually *enhanced* as US competitors were weakened.[5]

Additional research demonstrates that the Federal Reserve's access to liquidity enables it to take on the global financial role of international lender of last resort during crises and especially to countries where instability would threaten US interests (McDowell, 2017).[6] Further demonstrative of US capabilities in global financial networks is its ability, post 9-11, to monitor global financial institutions and transactions. In 2001, Title III of the USA Patriot Act gave the US Treasury Secretary broad discretion to subject banking and financial institutions (domestic and global) to increased scrutiny. Further, in 2006, the CIA, overseen by the Treasury department, subpoenaed and won access to the financial records database of the Society for Worldwide Interbank Financial Telecommunications (SWIFT): a privately-run, Brussels-based global financial messaging company currently possessing the world's only centralized infrastructure through which international financial institutions interact.

Considering the centrality of the US in the global arena, the notion that lenders and market participants from developing and emerging market economies could credibly threaten or impose a reputational cost onto the United States that would disincentivize default is

[4]Per Winecoff (2015), a tie is formed when banks in one country hold assets in another.

[5]See also Oatley, Winecoff, Pennock and Bauerle Danzman (2013).

[6]The term "international lender of last resort" originates with Kindleberger (1986). An international lender of last resort is defined as: "An actor that is prepared to respond to international financial crises by providing credit to illiquid institutions in foreign jurisdictions when no other actor is willing or able" (McDowell, 2017, p. 4).

implausible. Realistically these lenders and market participants possess neither the access nor the reach to obstruct US circumvention of their efforts.[7] Further, by virtue of the US role as "world's banker," it is necessarily the case that it holds the largest variety and amount of foreign financial assets, reasonably warranting consideration of how, in the case of default, developing and emerging market economy lenders might seize the requisite amount of financial assets that would make retaliation effective. Finally, though it is generally accepted that military intervention is no longer employed as a response to sovereign default, it is worth noting that this antiquated strategy is unlikely to reemerge as a tactic given US military capabilities.

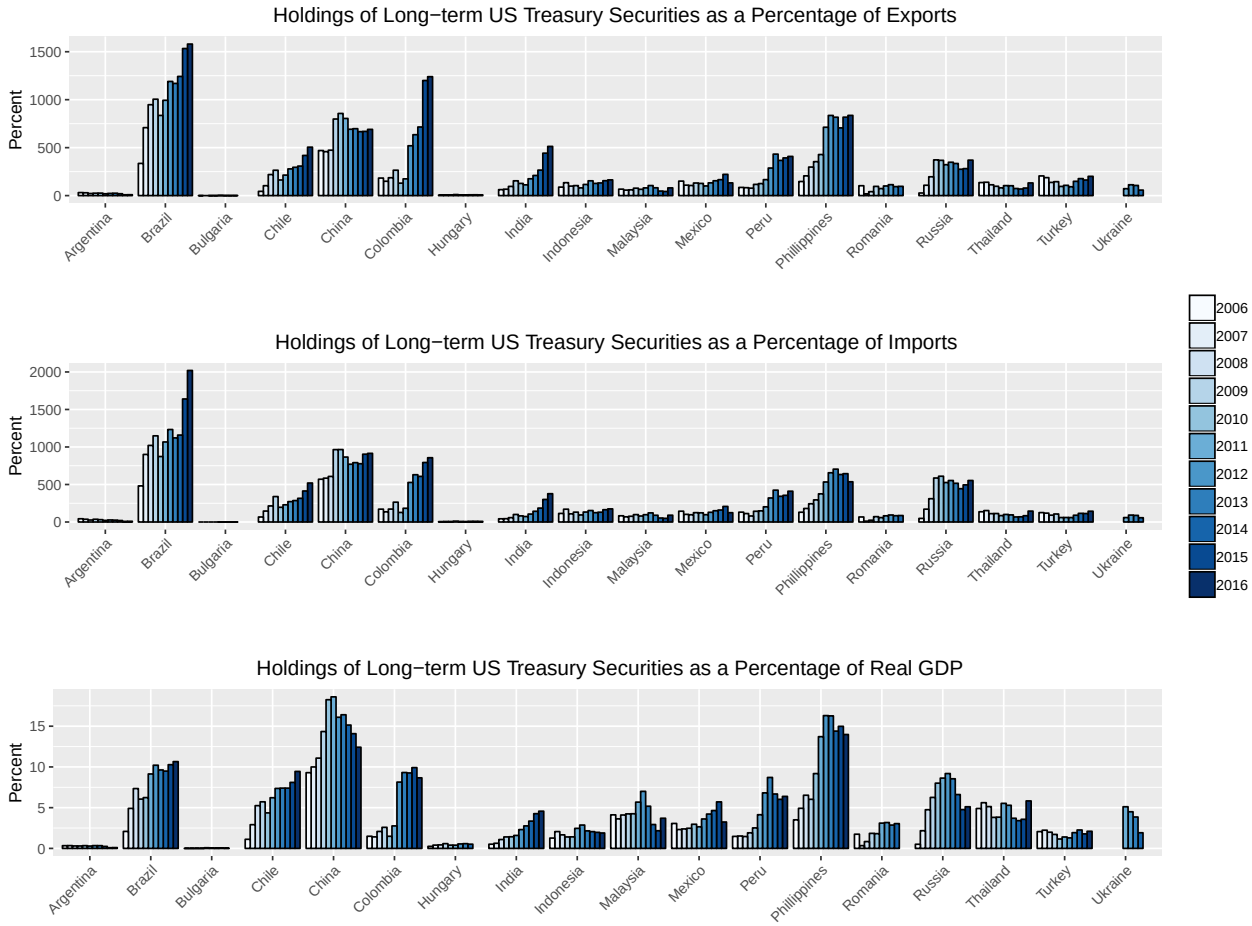
The loss of standard endogenous enforcement mechanisms leaves only perceptions of safeness to account for the phenomenon of sovereign lending in the Safe Assets theory. While perception likely plays some role in sovereign debt dynamics, it is implausible that it can be the only factor enabling sovereign lending. That something more substantive than perception motivates persistent demand for US Treasury securities is also suggested by the variation of holdings across emerging market economy foreign official institutions. To illustrate, Figure 4 plots data on long-term Treasury security holdings for a select group of emerging economies as a percentage of their gross domestic product (GDP), imports and exports during the period 2006-2016.[8]

Given its reliance on investor perception, the Safe Assets theory concludes that investors have "nowhere else to go" but the advanced economy with the largest debt capacity. The empirical reality, however, belies such a strict constraint. Given a set of countries motivated

[7]It is useful to point out that even China, perhaps the most capable of emerging economy holders of US sovereign debt, is not understood to exert substantial influence in financial markets (Aizenman & Ito, 2016). For this reason, critics of the declinist narrative argue that the latter puts too much emphasis on factors such as GDP to argue that the US is in decline. Rather, they argue that a more comprehensive set of indicators should be analyzed to determine prominence in the global arena (Beckley, 2012; Norloff, 2014).

[8]Long-term Treasury security holdings are expressed as the percentage of the country's GDP to control for country size across selected emerging-market countries.

Figure 4: Holdings of Long-term US Treasury Securities by Indicator and Country



Notes: Data on long-term holdings of US Treasury securities is adjusted for valuation effects. Data on long-term US Treasury security holdings is from Bertaut and Judson (2014). Export and import data specifically refers to merchandise exports and imports, respectively, and is from the World Trade Organization. Data on real GDP is from the World Bank.

to invest a disproportionately high level of national savings (i.e, emerging market economies), however, we would expect to see a somewhat more even distribution of US government debt holdings if investors have "nowhere else to go." That is, a singular determinant should produce a more uniform outcome across similarly-situated countries.[9] What is seen from Figure 4, however, is that holdings of US government debt among emerging market countries displays quite a bit of variation across country and through time.

In the next section, we introduce a more plausible alternative to the Safe Assets theory that is consistent with standard sovereign lending dynamics and implications arising from the relative strength of borrowers in this circumstance.

1.4 US Treasury Securities as Collateral for Private Dollar Borrowing

Occurring simultaneously with the persistent demand for US Treasury securities, yet unconnected to it in the literature thus far, is dollar credit to developing and emerging market economies. McCauley, McGuire and Sushko (2015) report that dollar credit to non-US residents reached approximately $7 trillion or 13% of non-US GDP by 2014. Indeed, dollar credit to non-US residents picked up faster than to US residents after the global financial crisis and at rates between 10-20%. China accordingly saw non-financial businesses and households more than double its holdings of foreign currency credit immediately after the crisis (Borio, McCauley and McGuire, 2011).

In one respect, capital inflows fulfill its conventional purpose of allowing developing and emerging market economies to smooth consumption. At the same time, however, developing

[9]Naturally, we do not argue that all emerging-market economies are similarly situated; rather, we argue that they are conceived to be similarly situated in their demand for US sovereign debt.

and emerging market economies face significant obstacles in constraining the capital inflows on which they are reliant. For instance, non-financial residents and businesses have historically reacted to higher domestic interest rates by borrowing from non-domestic sources. Further, the standard prescription for damming capital inflows—allowing the exchange rate to appreciate (i.e., enabling it to float)—can actually exacerbate international credit inflows since appreciation relieves the debt-to-cash-flow ratio, thereby creating room for a greater debt burden (Borio, McCauley, and McGuire, 2011).

Supply of capital inflows is similarly unwieldy since the forces dictating the flow of international credit are beyond the purview of recipient countries. For instance, McCauley, McGuire and Sushko (2015) find that during tranquil times (i.e., non-crisis periods when advanced economies' financial institutions are healthy) easy US monetary policy drives a surge of private dollar credit into developing and emerging economies. Similarly, Rey (2015) famously argues that US monetary policy travels via a "global financial cycle," the movements of which are dictated by perceptions of risk and volatility manifested in the Chicago Board Options Exchange Volatility Index (VIX).[10]

A principal risk of unwieldly capital inflows is derived from the fact that leverage ratios are directly factored into calculations of country volatility by investors (McCauley et al., 2015; Avdjiev, Kuti and Takats, 2012). Thus, higher leverage is accompanied by the risk that capital inflows will be reduced—often spontaneously and rapidly—below desired levels, inciting crisis upon departure. Indeed, a higher growth rate of international credit relative to overall total credit has generally become cause for concern given that the trend tends to precede crisis, with the Asian Financial Crisis serving as one particularly severe example (Borio, McCauley and McGuire, 2011).

[10]The Bank for International Settlements loosely defines a financial cycle as "self-reinforcing interactions between perceptions of value and risk, risk-taking and financing constraints which translate into financial booms and busts." (Borio, McCauley and McGuire, 2011, p.2)

Given the unwieldiness of capital inflows, developing and emerging market economies necessarily lack control over the degree to which their financial systems are leveraged. They can, however, control the degree to which they are vulnerable to endogenous enforcement mechanisms. That is, developing and emerging market economy borrowers can calm investor fears and secure access to credit by increasing the degree to which they suffer a penalty in the case of default.

Specifically, the sovereign debt literature yields the conclusion that borrowers can increase their vulnerability to lenders by offering the latter collateral against the debt contract. Indeed, from the lender's vantage point, collateralization is the most preferred endogenous enforcement mechanism because it allows the lender to avoid most of the difficulties inherent in other endogenous enforcement mechanisms. To illustrate, recall that seizing the borrower's assets in the case of default requires that a lender be sufficiently strong to withstand the costs incurred (e.g., fending off an aggrieved borrower and its allies). It also requires the borrower's assets be in the jurisdiction of a legal system amenable to the lender's demands. Indeed, the difficulty in gaining the cooperation of foreign jurisdictions where a borrower's assets are held is one that the literature highlights as a main factor preventing the effectiveness of retaliation (Eaton and Gersovitz, 1981; Bulow and Rogoff, 1989; Eaton and Fernandez, 1995; Pitchford and Wright, 2013).

The seizure of collateral, however, obviates these difficulties as the asset to be seized is presumably already in the possession of the lender and within the jurisdiction of a legal system amenable to the latter's interests. Additionally, because it was offered prior to the debt contract taking effect, the lender is assured upon entering the agreement that collateral is large enough to make the consequence of default larger than its benefit.

Accordingly, we theorize that faced with an inability to control the degree to which their financial systems are leveraged but wanting to maintain access to much needed dollar credit,

developing and emerging market economies collateralize inflows of dollar credit with US Treasury securities. Indeed, given those qualities of collateral that make collateralization a particularly preferred endogenous enforcement mechanism among lenders, US Treasury securities are uniquely suited to act as collateral for dollar credit.

Because the US is unique in the scale of its debt issuance, dollar lenders are presumably able to require borrowers to hold US Treasury securities in sufficient quantity to make the cost of default greater than its benefit. Additionally, because foreign official holdings of US Treasury securities are held with the Federal Reserve Bank of New York, lenders are assured that assets to be seized reside with a custodian amenable to lender interests, making retaliation virtually costless.[11] Finally, US Treasury securities are ideally suited to collateralize sovereign borrowing because being the form in which country savings are held, Treasury securities are also the means by which a defaulting sovereign would service another loan. Thus, in the case of default, dollar lenders are able to costlessly exclude the borrower from international capital markets by disrupting the latter's future payments.

1.5 Concluding Remarks

The persistent flow of investment toward long-term US sovereign debt by foreign official investors in developing and emerging market economies is puzzling for two reasons. First, that capital should flow "uphill" from developing and emerging market economies to advanced ones contradicts standard economic theory assuming higher marginal rates of return in relatively poorer economies; that is, standard economic theory predicts capital will flow

[11] If retaliation is costly to the lender (perhaps because impeding the borrower's trade also significantly affects the lender's current account), the borrower has less reason to believe the lender will in fact retaliate (i.e., the threat of retaliation will not disincentivize default because it will not be viewed as credible) (Eaton and Fernandez, 1995).

downhill until marginal rates of return on capital are equalized. Second, holdings of US Treasury securities among developing and emerging market economies persist even despite dollar depreciation, decreasing real yields, and declining US economic fundamentals.

The conventional view, which we refer to as the *Safe Assets theory*, explains the persistence of demand for US Treasury securities among developing and emerging market economies by way of the asset's safeness, which is a function of the issuer's financial breadth and depth. The Safe Assets theory is logically flawed, however, in that its assumptions run counter to sovereign lending dynamics. Specifically, the Safe Assets theory assumes endogenous enforcement mechanisms enabling sovereign lending are satisfied when the relative strength between borrowers and lenders in this circumstance renders such mechanisms ineffective. In the absence of an endogenous enforcement mechanism, perceptions of safeness alone cannot enable sovereign lending and this suggests that another factor besides perception motivates demand for US Treasury securities.

We present an alternative theory to explain what motivates the persistent demand for US Treasury securities among developing and emerging market economies. We contend that US Treasury securities act as collateral for private dollar borrowing. In the next chapter, we put this theory to empirical test.

CHAPTER 2

LENDING TO BORROW: US SOVEREIGN DEBT AS COLLATERAL FOR DOLLAR CREDIT

2.1 Introduction

Over the past two decades, foreign investment in US sovereign debt (i.e., Treasury securities) has grown at an increasing rate, more than quintupling to approximately $5.3 trillion dollars by 2016. Persistent foreign demand for US Treasury securities presents a number of challenges to conventional economic theory. Because high debt to GDP ratios are conventionally understood to counteract a country's long-run economic growth prospects, the former should disincentivize investment in a country's sovereign debt (Reinhart and Rogoff, 2010; Cecchetti, Mohanty and Zampolli, 2011; Alfaro, Kalemli-Ozcan and Volosovych, 2014; He, Krishnamurthy and Milbradt, 2016). Yet, foreign demand for US Treasury securities remains strong despite an unprecedented US current account deficit of 6% of GDP (Gourinchas and Rey, 2014). What is more, since roughly 2000, the real yield on 10-year Treasury securities and the foreign exchange value of the dollar against leading currencies has fallen. That is, the US continues to receive financing even as it offers less of a return to investors and implicitly defaults on its current debt obligations.[1]

[1]Aguiar and Amador (2014) define default as a failure of a sovereign borrower to honor its debt contract, either explicitly by an outright refusal to pay (which is how borrower default is conventionally understood) or

Largely behind this increasing level of financing are foreign official investors in developing and emerging market economies who hold US Treasury securities in foreign exchange reserves. This rapid accumulation gained new attention as a culprit not only of the 2008 global financial crisis but also of the ineffectiveness of monetary policy to respond.[2] While subsequent research has revealed new insights on the causes of the crisis and its aftermath, the persistent demand for US Treasury securities from developing and emerging economies continues to fuel debate.[3]

What explains these puzzling features of demand for US sovereign debt and can we expect them to continue? One prominent theory argues that US Treasury securities are perceived to be a "safe" asset. Specifically, debt capacity beyond a certain threshold is assumed to be generated from strong economic fundamentals, leading to the perception that those countries with the highest debt capacity must necessarily be the safest sources of investment. Thus, while standard determinants of asset selection are thought to inform investment decisions between safe assets, the perception that an asset is safe increases the degree of deterioration in terms lenders will tolerate.

Owing to the ubiquity of this perception, the latter is self-reinforcing since during periods of crisis investors will flood the asset they perceive to be safe. This herd behavior drives a secular decline in real interest rates, thus rendering monetary policy ineffective once nominal interest rates hit the zero lower bound. According to this view, which we will call the *Safe Assets theory*, the continued financing of the US deficit is highly tenuous since its reliance on perception makes it highly vulnerable to a self-fulfilling debt crisis (Maggiori, 2013; Caballero

implicitly by repaying in terms less favorable to the lender. When the loan is to be repaid in the borrower's currency, then one form of implicit default occurs through depreciation of the borrower's currency since repayment only fulfills the debt contract in nominal terms.

[2]See Ben Bernanke's well-known Sandridge Lecture on the "Global Savings Glut" (Bernanke, 2005)

[3]For instance, Shin (2011) argues that European global banks played a key role in generating easy credit conditions in the US prior to the 2008 Global Financial Crisis.

and Farhi, 2014; He, Krishnamurthy and Milbradt, 2016).

Despite its popularity, the Safe Assets theory is flawed. If perceptions based on debt capacity played such a large role in determining the degree of investment in US Treasury securities among developing and emerging market economies, then holdings among the latter should be somewhat uniformly distributed. Yet, developing and emerging market economy holdings of US Treasury securities are heterogeneous, indicating that country-specific factors may influence levels of holdings.[4] Additionally, it is unlikely that a loan to the US would serve as an investment in the traditional sense since there exists no plausible enforcement mechanism to secure it. The literature on sovereign debt has long established that sovereign immunity makes it highly unlikely that sovereign lending will occur in the absence of a lender's ability to reasonably secure repayment (Eaton and Gersowitz, 1981; Bulow and Rogoff, 1989; Epstein and Gintis, 1995).[5] This ability is exercised through an enforcement mechanism that imposes a cost to the borrower larger than the benefit from default. (Bulow and Rogoff, 1989).

But, naturally, imposing a cost and especially a large one, is itself costly; thus, we can reasonably expect that when loans are made, lenders will be strong and borrowers weak (Epstein and Gintis, 1995). Otherwise, lenders expecting a sovereign borrower to circumvent any attempt to enforce the lending contract, would not lend in the first instance. Given the relative strength between lenders (developing and emerging market economies) and borrowers (the US) in this circumstance, it is implausible that lenders would be capable of threatening the borrower with a cost of default high enough to outweigh its benefits. Thus, while perception can certainly play a role in the appeal of US Treasury securities, it

[4]See Figure 4 in Chapter 1 of this dissertation for an illustration of heterogeneity in US Treasury security holdings across a subset of developing and emerging market economies.

[5]Though a review of the sovereign debt literature is beyond the scope of this essay, a review can be found in the Chapter 2 of this dissertation.

is unlikely that this perception alone can offer a comprehensive explanation of the puzzle.

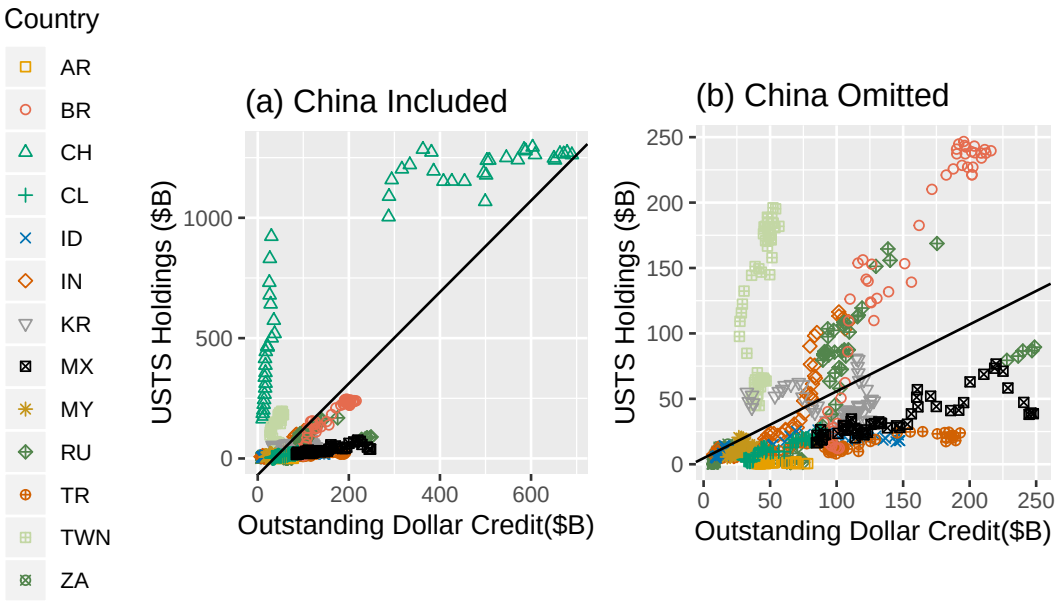
In this paper, we present and provide empirical evidence supporting the hypothesis that US Treasury securities play the role of collateral for private and public dollar credit. That is, public lending to the US enables private and public borrowing for developing and emerging market economies. Our argument highlights a significant development in the global financial arena that, despite occurring simultaneously with the buildup of US Treasury security holdings, has yet to be connected to the latter: the growth of dollar credit in developing and emerging market economies. Indeed, dollar credit to borrowers outside of the US reached approximately $7 trillion, or 13% of non-US GDP (McCauley, McGuire and Sushko, 2015).

But, credit is not secured on hope. As mentioned, lenders must be reasonably sure the loan will be repaid and employ enforcement mechanisms to maximize the likelihood of this outcome. While these mechanisms are easily availed to lenders in the domestic context owing to the presence of courts and an abiding legal system, lenders to sovereign borrowers must rely on endogenous enforcement mechanisms, or disciplining devices arising from the structure of the lending relationship itself. One of the more effective mechanisms can be provided by the borrower who offers the lender collateral to be seized in the event of a default.

The role collateral plays in facilitating the smooth transaction of funds has gone relatively unnoticed in the more recent literature, but it is crucial nevertheless.[6] US Treasury securities are an ideal form of collateral to dollar loans not only because the borrower's financial assets are denominated in the lender's currency but also because custodianship enables the lender to costlessly seize these assets in the case of default. Importantly, because retaliation is virtually costless (i.e., all the lender must do is seize a financial asset already in its possession), the

[6]For a full treatment of the role collateral plays in facilitating the smooth transition of funds, see Singh (2016).

Figure 5: US Treasury Security Holdings and Outstanding Dollar Credit 2003-2016



Notes: See Table 12 in Appendix A for data sources and definitions. See Table 13 in Appendix A for country codes. The regression illustrated by the fitted line in the left panel (China included) results in a coefficient of 1.90 (standard error = 0.058), N=689, and Adjusted R-squared=0.612. The regression illustrated by the fitted line in the right panel (China Omitted) results in a coefficient of 0.51 (standard error = 0.037), N=636, and Adjusted R-squared=0.231

threat of retaliation is credible, making default less likely in the first instance. Finally, while collateralization is naturally the lender's most preferred enforcement mechanism because it is virtually costless to employ, it has typically been limited in use because of the difficulty in finding an asset large enough to outweigh the benefit of default to the borrower. With US Treasury securities, however, the lender can directly supply collateral in proportion to the loan.

Panel (a) in Figure 5 plots US Treasury security holdings against outstanding dollar credit for the countries included in our sample and illustrates a pronounced, positive relationship between US Treasury security holdings and outstanding dollar credit. It is clear, however,

that China is not only an outlier but also seems to be driving the slope of the fitted line. Panel (b) demonstrates that even when China is omitted from our sample of countries, however, US Treasury securities and outstanding dollar credit continue to be positively related.

To empirically investigate whether US Treasury securities serve as collateral to dollar borrowing, we focus on the stylized fact that most foreign holdings of US Treasury securities are in long-term securities held by official institutions (i.e., central banks) as foreign exchange reserves (Gourinchas and Rey, 2014; Sunner, 2017).[7] We use this fact to model the decision to hold long-term US Treasury securities as one to hold dollars as opposed to other feasible currencies (the Euro, Pound Sterling, and Japanese Yen) in foreign exchange reserves, which allows us to draw from well-developed models of the latter dynamic.[8] We then use a first-difference estimator to control for country-specific factors affecting US Treasury security holdings in a panel of developing and emerging-market economies. To incorporate a persistence effect of US Treasury security holdings, we introduce as a regressor the dependent variable lagged by one period and estimate the regression equation using an instrumental variable (IV) method.

Our results demonstrate that even after controlling for a persistence effect (i.e., inertia) in US Treasury security holdings, increases in outstanding dollar credit are related to a statistically significant ($p < 0.01$) increase in holdings of US Treasury securities. Specifically, the estimated increase in US Treasury security holdings related to a $1 billion increase in outstanding dollar credit is $0.11 billion, all other factors held constant. Our result is robust to outliers. Namely, our results are not driven by China's disproportionate holdings of US

[7] See Figure 2 in Chapter 1 of this dissertation for an illustration of this stylized fact.

[8] Our approach follows that taken by Ito, Jongwanich, and Terada-Hagiwara (2009) and Terada-Hagiwara (2011). Our selection of feasible alternatives to the US dollar in foreign exchange reserves is informed by the currencies included in the International Monetary Fund's Special Drawing Rights which is composed of the most widely used currencies in global trading and financial systems. We do not include the Chinese Yuan as an alternative to the dollar because our data set spans 2003Q1-2016Q4 and the Yuan was only added to Special Drawing Rights' basket of currencies in the last quarter of 2016.

Treasury securities and outstanding dollar credit. In fact, when China is removed from the sample and our empirical model estimated again, the relationship between outstanding dollar credit on holdings of US Treasury securities *increases* in statistical significance ($p < 0.001$) and magnitude. Specifically, when China is removed from the sample, a \$1 billion increase in outstanding dollar credit is associated with a \$0.18 billion increase in US Treasury securities, all other factors held constant.

Our results are non-trivial, especially given the magnitude of US Treasury security and outstanding dollar credit holdings, as reported in Table 1. Generally speaking, a \$1 billion increase in outstanding dollar credit is minimal given that the mean level of outstanding dollar credit and US Treasury security holdings in our sample of developing and emerging economy countries is approximately \$91.5 billion and \$105.2 billion, respectively. In more recent years (2010-2016), the average yearly increase in outstanding dollar credit among countries in our sample is \$14.5 billion when China is included and \$9.2 billion when it is not. Perhaps more tellingly, outstanding dollar credit in each sample country has grown during the period 2003Q1-2016Q4 by approximately \$115 billion on average.[9]

We also find that with the exception of outstanding dollar credit and the relative yield on long-term US Treasury securities, none of our explanatory variables are . statistically significant when China is included in our sample. Because our analysis compares the US to other nations or regions which might reasonably also issue safe assets (the Euro Area, United Kingdom, and Japan), this result challenges the notion presented in the Safe Assets theory that standard determinants of asset selection, including debt capacity, are operative in the selection *between* safe assets.

Finally, while our motivating question is specific to developing and emerging market

[9]If China is omitted from our sample, then the level of outstanding dollar credit in 2016Q4 is approximately \$84.8 billion higher on average than it was in 2003Q1.

economy holdings of US Treasury securities, the role of these securities in foreign exchange reserves also allows our results to provide insight on the global role of the dollar generally. Indeed, our assumption that holdings of long-term US Treasury securities effectively represent the dollar composition of foreign exchange reserves allows us to work around the highly confidential nature of this data.[10] Though a detailed review of the literature on the currency composition of foreign exchange reserves is beyond the scope of this paper, a central concept emerging from it is that the global role of a currency is strongly dictated by its use as a reserve currency.[11] Thus, the research on determinants of reserve currency choice is typically part of a larger effort to develop insights on the continued dominance of a particular currency, usually the dollar.[12]

Contrary to the Safe Assets theory that envisions continued financing of the US deficit as teetering on a knife-edge and related research in the currency composition of foreign reserves that warns of a spontaneous demise in the international role of the dollar, our results suggest that these fears may be less than warranted. Specifically, if holdings of US Treasury securities and the global role of the dollar are driven at least in part by outstanding dollar credit, then naturally the former are at least partially dependent on demand for dollar credit and the ability of the US to provide it.

The paper proceeds as follows. Section 2.2 reviews the determinants of demand for US Treasury securities. Section 2.3 presents our variables and describes the data. Section 2.4 presents our econometric model and describes our estimation strategy. In Section 2.5, we

[10]A number of researchers have commented on the unavailability of country-level data on the currency composition of foreign exchange reserves (Truman and Wong, 2006; Galati and Woolridge, 2006; Eichengreen, Chitu and Mehl, 2016; Sunner, 2017). The closest alternative is the IMF's Currency Composition of Official Foreign Exchange Reserve (COFER) data—discontinued in 2015—which disaggregates by country groupings (advanced and developing/emerging) annually for the period 1995-1998 and quarterly for the period 1999Q1-2015Q2.

[11]An older but excellent treatment can be found in Prem (1994).

[12]See, for instance, Krugman (1984), Prem (1994), Chinn and Frankel (2005), Eichengreen, Chitu and Mehl (2016), Eichengreen, Mehl and Chitu (2017).

present our results using a first-difference and IV strategy for samples including and omitting China (an outlier). Section 2.6 presents the results from a series of robustness checks. Section 2.7 concludes.

2.2 Determinants of Demand for US Treasury Securities

Owing to the role of US Treasury securities in the foreign exchange reserves of developing and emerging market economies, demand for these financial assets are typically modeled as a preference to hold dollars in foreign exchange reserves. Likewise, determinants of US Treasury security demand can properly be considered synonymous with determinants of the currency composition of foreign exchange reserves. We exploit this fact to model the demand for US Treasury securities as demand for dollars in foreign exchange reserves.

Empirical efforts to determine whether a variable acts as a determinant of the currency composition of foreign exchange reserves typically introduces it as a regressor among a set of *standard determinants* (Prem, 1994; Eichengreen, Mehl and Chitu, 2017). These standard determinants, or factors conventionally believed to affect the currency composition of foreign exchange reserves, are theorized to operationalize more general motivations among foreign official institutions of reducing transaction costs and preserving a store of value. That is, those currencies that are disproportionately held in foreign exchange reserves are generally theorized to be those that are most stable and least costly, and the standard determinants are those which signal these qualities in a currency. These standard determinants typically account for the following characteristics of issuing countries: financial depth, exchange rate, trade relations, and inertia.

Deeper financial markets are understood to be more resilient and better able to lower transaction costs of a currency. More specifically, deep financial markets are theorized to

facilitate better absorption of adverse shocks through diversification of risk, thus enhancing stability (Prem, 1994; Sahay et al., 2015). One particularly popular proxy for financial depth is the ratio of broad money to GDP (Eichengreen, Chitu and Mehl, 2016).[13] Though its attractiveness as a measure is likely owing at least in part to data availability, the ratio of broad money to GDP is also lacking as a proxy for financial depth. Specifically, the ratio of broad money to GDP more appropriately acts as a proxy for the depth of financial *institutions* in a given country but ignores the depth of financial markets in the same. A more robust measure of financial depth should also account for the depth of financial markets in a given country by incorporating the level of a country's domestic private credit, stock market capitalization and bond market capitalization relative to a country's GDP (King and Levine, 1993; Chinn and Frankel, 2005; Cihak, Demirguc-Kunt, Feyen and Levine, 2012).

A currency's exchange rate reflects the degree to which a currency is a stable source of value.[14] The intuition is straightforward: if a financial asset is held in a currency that depreciates, then its holders will be repaid in currency worth relatively less than it had been at the time the asset was initially invested in; as a consequence, the financial asset will yield less of a return than was originally anticipated by the investor.

The most efficient way of measuring the stability of a currency is to measure its exchange rate against the Special Drawing Rights (SDR), an international reserve asset created by the IMF (Chinn and Frankel, 2005; Eichengreen, Chitu and Mehl, 2016). The value of the SDR is determined by a weighted average of the currencies where the assigned weights correspond to a currency's importance in global finance and trade. The exchange rate of a currency to the SDR is calculated on the basis of its dollar exchange rate; that is, a given currency is

[13]Typically, M3 is preferred as a measure of broad money but where data on M3 is not available, M2 has been utilized instead (King and Levine, 1993).

[14]Thus, later in section 2.3, we view our variable capturing the exchange rate of the dollar as operationalizing the latter's stability.

first converted to dollars and then to SDRs using the latter's value against the dollar. As a result, this method has the advantage of comparing the value of the dollar not only relative to any currency of notable importance in global finance and trade but also in proportion to this importance. For instance, if the dollar depreciates against any of the currencies included in the currency basket comprising the SDR, the dollar will depreciate against the SDR and in proportion to the importance of the currency it has depreciated against, offering a more robust measure of currency stability.

Though goods trade is typically associated with the private sector, the currency composition of a country's foreign exchange reserves is understood to reflect international trade relations. This reflection is mostly owing to efforts by central banks in developing and emerging market economies to manage the domestic exchange rate. Thus, central banks in developing and emerging market economies are prompted to hold in its foreign exchange reserves that currency which is commonly used in international trade transactions.

Recently, research on the determinants of an international currency has attributed a greater weight to an issuing country's overall size in international trade networks than individual trade ties. That is, countries are increasingly less likely to hold the currencies of their trade partners simply on account of the partnership and more likely to hold the currency of a country dominant in international trade networks. Empirical evidence of this reality and especially in favor of the dollar is relatively easy to see: for instance, Goldberg and Tille (2008) show that while dollar-use varies across countries, its prevalence is high even in non-US transactions, so that the role of the dollar is larger than can be explained by the number of US trade partners.

The use of the US dollar in non-US transactions can be explained by way of a *network effect* whereby transaction costs are lowered by using the US dollar as a *vehicle currency*, or as a medium of exchange between currencies (Krugman, 1979; Portes, Rey and Oh, 2001;

Devereux and Shi, 2013). The network effect of currencies is essentially an economies of scale argument: as the number and scale of a country A's international trade ties grows, so do the cost advantages to its trade partners of transacting in country A's currency. That is, if countries B and C are weaker trade partners of each other than either are of country A, then transacting in country A's currency allows countries B and C to avoid costs associated with exchanging their own respective currencies for country A's currency.[15]

Additionally, using the currency of the largest issuer is convenient in the sense that it obviates the need, which is sometimes costly, of acquiring information about multiple currencies. Thus, assuming that countries prefer to use a currency that minimizes transaction costs and that the latter is inversely proportional to the volume of transactions, then countries will opt to use the currency of leading trade nations and this result will be self-reinforcing as more countries follow suit (Krugman, 1979, 1984). A common proxy for a country's role in international trade networks is its economic size, or share of world GDP (Chinn and Frankel, 2005).

Portes, Rey and Oh (2001) demonstrate the network effects of a currency by focusing on foreign exchange markets, assuming transactions occur through a financial intermediary, and modeling gains as those costs that would otherwise have to be spent on additional intermediary services if a vehicle currency was not used. She finds that a country's position in international trade networks largely determines whether its currency serves as a vehicle currency. Devereux and Shi (2013) confirm that Rey's results do not depend on the existence of a financial intermediary since vehicle currencies facilitate international trade by lowering the average cost of currency trade between countries.

Because the benefit of adopting a currency is partly owing to the network made up of other users, it is possible for the network to outlast its original generating source because

[15]This is essentially a restatement of the argument made in Krugman (1984).

the cost-benefit of ubiquity acts as a buffer against loss. That is, network effects may give a currency *inertia* or *persistence* (Triffin, 1960; Krugman, 1979, 1984; Eichengreen, Mehl and Chitu, 2017). To illustrate the dynamic, consider a simple thought experiment: let x be the benefit to country B from holding country A's currency owing to the latter's intrinsic characteristics and let y be the benefit from holding country A's currency simply because it is widely used. Then, country B will continue to hold country A's currency even if x declines, so long as $x \leq y$.[16]

Country B's willingness to continue holding country A's currency even after x declines indicates that a particular currency (or, in this analysis, US Treasury securities) exhibits inertia. Importantly, though network effects may elicit an inertial force in a currency, they are not unique in this regard. Inertia may also be caused by habit formation or lack of better alternatives (Eichengreen, Mehl and Chitu, 2017). We might even consider that the Safe Assets theory has added another reason that an asset may exhibit inertia: it is perceived to be "safe." Where some measure or share of a currency is a regressand in an empirical exercise, its inertia is typically captured through a lagged dependent variable included as a regressor (Chinn and Frankel, 2005; Chitu, Eichengreen and Mehl, 2014; Eichengreen, Mehl and Chitu, 2017).

One critique of explaining currency use by way of the latter's inertia is that inertia is exactly what is to be explained.[17] That is, practically speaking, including a variable representing inertia as a regressor simply captures whatever variation in the level or share of

[16]The continued dominance of the pound sterling as a global currency during World War II serves as a prime example of this phenomenon (Aliber, 1966; Krugman, 1979).

[17]Echoing this sentiment, Edwin M. Truman writes of Chinn and Frankel (2005), "The Chinn and Frankel results confirm the well-known observation that there is substantial inertia in international reserve holdings. The issue is what explains this inertia" (Chinn and Frankel, 2005, p.329). Similarly, Prem (1994) asserts, "We take issue with the convention[al] approach to inertia, on grounds that by dismissing anomalies as remnants of past conventions, it merely serves to justify the status quo and hardly offers any real explanation. It fails to specify the dynamics—how long before a break in the old convention might be expected, and in particular, what might cause this transition" (p.33).

currency holdings that cannot be explained by the variation in the explanatory variables. Nevertheless, empirical studies confirm that what has been designated inertia is indeed an important determinant of the currency composition of foreign exchange reserves. Chinn and Frankel (2005) empirically assess determinants of reserve currencies to determine whether the dollar would maintain its status as a key international reserve currency following the euro's introduction. The authors utilize a logistic model and test the following determinants of reserve currency status: inertia, income share and financial depth of an issuing country, the exchange rate, and network externalities (i.e., network effects). Their results suggest that inertia exercises a statistically significant ($p < 0.10$) and large effect on the currency composition of reserves; specifically, inertia propels forward approximately 90% of each currency in foreign exchange reserves from one year to the next.

It is also worth mentioning that Chinn and Frankel's (2005) findings also support the statistical significance at the 10% level of an issuer's income share and a currency's exchange rate as determinants. Interestingly, financial depth measured through a series of financial market capitalization to GDP ratios is not only statistically insignificant but also possesses an unexpected negative sign.

In sum, the demand for US Treasury securities can properly be modeled after the demand for the US dollar in foreign exchange reserves. This equivalency is owing to the stylized fact that that most foreign-held US Treasury securities are held by official institutions (i.e., central banks) as foreign exchange reserves. Generally speaking, foreign official institutions seek currencies as foreign exchange reserves that are stable and minimize transaction costs; thus, the determinants of the currency composition of foreign exchange reserves (or, equivalently, foreign demand for US Treasury securities) are those that signal these qualities in a currency. Empirical exercises testing whether a variable can be considered a determinant of the currency composition of foreign exchange reserves typically introduces the variable as a

regressor among standard determinants: financial depth of an issuing country, a currency's exchange rate, the issuer's position in international trade networks, and inertia of currency use.

2.3 Data and Descriptive Statistics

2.3.1 Dependent Variable: Foreign Holdings of Long-term US Treasury Securities ($USTS_{it}$)

Long-term US Treasury security holdings for country i at time t is the dependent variable in our empirical analysis and is represented by the variable $USTS_{it}$. To recall, our goal is to determine what motivates developing and emerging market economies to hold US sovereign debt where we hypothesize the reason to be demand for dollar credit. Thus, while it is not necessary that we focus on long-term Treasury securities since our analysis seeks to understand the motivations of holding US sovereign debt generally, doing so offers an advantage. Foreign holdings of Treasury securities are overwhelmingly in long-term securities and foreign official investors hold the largest proportion of the latter as foreign exchange reserves. Thus, focusing exclusively on long-term Treasury securities allows us to better account for unobserved heterogeneity across countries by controlling for the well-defined determinants of currency composition in foreign exchange reserves.[18]

The link between long-term Treasury securities and foreign exchange reserves can be made stronger still if we could focus exclusively on that portion of the former that are held by foreign official institutions. Unfortunately, however, country-level data on foreign official holdings of long-term Treasury securities is unavailable, likely reflecting the highly

[18]Specifically, we draw from the models of Chinn and Frankel (2005) and Eichengreen, Mehl and Chitu (2017).

confidential nature of currency compositions of foreign exchange reserves by country. Thus, we follow Terada-Hagiwara (2011) in using long-term Treasury securities as a proxy for foreign official holdings.

Data on US Treasury security holdings by country is from Bertaut and Judson (2017) which offers monthly U.S. cross-border securities holdings for 92 countries and 6 regions. The Bertaut and Judson data is a substantial improvement from the more conventional source for this data, the Treasury International Capital (TIC) System. Most importantly, the Bertaut and Judson data reports country holdings of US Treasury securities adjusted for valuation effects, or changes in reported positions resulting from a simple change in the market price of a security. Despite this strength, however, it is important to point out that one weakness of the Bertaut Judson data (shared with its TIC counterpart) is that it suffers from custodial bias whereby custodians of an asset are assumed to be its owner (Bertaut and Judson, 2014, p.10). Because country-level positions in US Treasury securities are reported on a geographical basis (i.e., an asset is assumed to reside with its owner), a weakness of our data is that some country holdings may be underestimated.[19]

2.3.2 Independent Variable of Interest: Outstanding Dollar Credit ($CRED_{it}$)

Outstanding dollar credit for country i at time t is the independent variable of interest and is represented by the variable $CRED_{it}$. Dollar credit to developing and emerging market economies is specifically measured as total dollar credit to non-bank borrowers and is taken from the Bank for International Settlements (BIS).

Country-level data on outstanding credit is available at different frequencies and for

[19]Bertaut and Judson (2014) offer the following example to illustrate the problem of custodial bias: "If a Russian investor chooses to hold the securities with a custodian in the United Kingdom, the liability would be recorded against the United Kingdom rather than Russia. As a result, the total liability position worldwide is correct, but the geographic allocation is not" (Bertaut and Judson, 2014, p.10). Further, it is useful to point out that while some country positions may be underestimated, we do not anticipate any being overestimated as no country included in our data set houses large custodians.

a number of sources including the World Bank, the BIS, and the International Financial Statistics database published by the IMF. Data on the currency composition of this credit, however, is only provided by the BIS and for non-bank borrowers in each country. We utilize the most comprehensive measure on foreign-currency credit offered by BIS which combines international debt securities, cross-border bank loans and local bank loans.

Because country-level data on local bank loans in foreign currency is difficult to procure, BIS only reports outstanding foreign currency credit for fourteen developing and emerging market economies, one of which (Saudi Arabia) is only included from 2013 onwards.[20] Thus, data on outstanding dollar credit contributed the most to constraining the cross-sectional units of our first panel to thirteen countries.

2.3.3 Independent Control Variables

2.3.3.1 Relative Financial Depth of the US ($DEPTH_t$)

Financial depth of the US at time t relative to what we will call its *currency competitors*—the Euro Area (EA), the United Kingdom (UK), and Japan (JP)—is represented by the variable $DEPTH_t$.[21] Including this variable among our regressors controls for the possibility that the US attracts investment in its sovereign debt because it possesses the deepest financial markets among a set of feasible alternatives (Portes and Rey, 1998; Papaioannou and Portes, 2008; Chinn and Frankel, 2005; Eichengreen, Mehl and Chitu, 2017).

Financial depth for each currency competitor is defined and measured as the sum of a country j's domestic private credit ($DPRIV_{jt}$), stock market capitalization ($SCAP_{jt}$), and bond market capitalization ($BCAP_{jt}$) relative to GDP (GDP_t) at time t.[22] Domestic private

[20]These fourteen economies are: Argentina, Brazil, Chile, China, India, Indonesia, Malaysia, Mexico, Republic of Korea, Russia, Saudi Arabia, South Africa, Taiwan, and Turkey.

[21]See footnote 8 for our rationale in selecting these currencies to be the US' "currency competitors."

[22]To clarify, the subscript i will be used to denote a developing and emerging market economy and the

credit is operationalized using all credit to the private non-financial sector from banks.

Stock market capitalization typically refers to a specific company and is simply the product of a company's outstanding total shares and the current market price of one share. Broadened to the country or regional level (as it is in this analysis), stock market capitalization refers to the sum of outstanding shares listed on a stock exchange(s) multiplied by their respective current market prices. Stock market capitalization for the US, the UK, Japan, and the Euro Area is calculated using the New York Stock Exchange, the London Stock Exchange, Japan Exchange Group Inc., and Euronext, respectively.[23] Data on these stock market exchanges is obtained from the World Federation of Exchanges. Quarterly data on bond market capitalization proved difficult to secure so we operationalized this variable using the commonly utilized proxy of outstanding domestic debt securities issued by financial and non-financial corporations; data is from the BIS.

Once financial depth for the US and each of its currency competitors is ascertained, relative financial depth for the US is then measured by the difference between its measure for financial depth and the maximum value of financial depth found among its currency competitors. $DEPTH_t$ is therefore given by,

$$DEPTH_t = FIN_{US,t} - max\{FIN_{EA,t}, FIN_{UK,t}, FIN_{JP,t}\} \tag{2.1}$$

where

$$FIN_{jt} = \frac{DPRIV_{jt} + SCAP_{jt} + BCAP_{jt}}{GDP_{jt}}$$

The subscript j denotes one of the US' currency competitors (EA, UK, or JP). Thus, the

subscript j will be used to denote a country (or region) that is a US currency competitor.

[23]Japan Exchange Group, Inc. was formed by the merger of the Tokyo Stock Exchange and the Osaka Securities Exchange. Thus, prior to 2014, stock market capitalization for Japan was measured as the sum of stock market capitalization for the Tokyo Stock Exchange and the Osaka Securities Exchange.

proper way to understand, say, a positive value X for $DEPTH_t$, is as follows: in period t, the US financial depth to GDP ratio is X percentage points above the maximum financial depth to GDP ratio found between the Euro Area, the United Kingdom, and Japan.

Perhaps surprisingly, it should be noted that the values for $DEPTH_t$ are negative across all time periods. That is, the US is not the most financially developed country among its currency competitors during the observed time period; in fact, it is the least financially developed of this group for much of the observed period. This result remains if we utilize the ratio of broad money to GDP as a proxy for financial depth instead. Though it is clear that financial depth of the US is not significant as a determinant of US Treasury security holdings in an absolute sense, we still include the variable as a control in case *variations* in relative US financial depth can help to explain variations in holdings.

2.3.3.2 Stability ($EXCH_t$)

Stability at time t is represented by the variable $EXCH_t$ and refers to the stability of the currency in which a financial asset is denominated at time t. Stability is included in our empirical model to control for the possibility that developing and emerging market economies simply prefer to hold financial assets that are stable sources of value. We define $EXCH_t$ as the USD to SDR exchange rate at time t.

To capture the probable reality that changes in currency stability will not immediately yield changes in holdings of financial assets denominated in those currencies, we utilize a 5-year moving average of the USD to SDR exchange rate in our construction of this variable. Data is from the Federal Reserve Economic Data (FRED) database published by the Federal Reserve Bank of St. Louis.

2.3.3.3 Network Effects ($NETW_t$)

Network Effects is represented by the variable $NETW_t$ and is representative of the economic size of the US (operationalized by the ratio of US GDP to world GDP) relative to the economic size of its currency competitors (operationalized as the ratio of a country j's GDP to world GDP). The introduction of $NETW_t$ as a regressor in the model controls for the possibility that the variation in holdings of US Treasury securities in our sample of countries is owing to changes in the relative economic size of the US.

The relative advantage of the US in terms of its network effect is given by the difference between its economic size and the economic size of its currency competitors. That is,

$$NETW_t = RATIO_{US,t} - max\{RATIO_{EA,t}, RATIO_{UK,t}, RATIO_{JP,t}\} \tag{2.2}$$

where

$$RATIO_{jt} = \frac{\text{Country } j\text{'s GDP at time } t}{\text{World GDP at time } t}$$

Quarterly data on world GDP is unavailable and so had to be constructed by aggregating quarterly GDP at market exchange rates for individual countries, based on data availability. Data is taken from the International Financial Statistics database published by the IMF, the FRED database, and CEIC data. World GDP is comprised of 53 countries, 28 of which are classified as advanced economies by the International Monetary Fund.[24]

[24]The countries used to calculate world GDP are as follows: Albania, Australia, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Hungary, Iceland, India, Indonesia, Japan, Mexico, Morocco, New Zealand, Norway, Poland, Republic of Korea, Romania, Singapore, South Africa, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, the United Kingdom, the United States, and Euro Area countries.

2.3.3.4 Inertia ($USTS_{i,t-1}$)

Inertia or persistence in holdings of US Treasury securities for country i is represented by the $USTS_{it}$ variable lagged by one period (i.e, $USTS_{i,t-1}$). Including this variable among our regressors controls for the possibility that current holdings of US Treasury securities are simply reflections of past holdings.

One critique, mentioned previously, of our inclusion of a variable representing inertia of US Treasury securities holdings is that inertia is exactly what is to be explained. While we agree that $USTS_{i,t-1}$ is something of a catchall that is unsatisfactory for its vagueness, we also consider it plausible that at least some of the variation in US Treasury security holdings is owing to one if not more of the factors manifested in an inertial quality. Prudence therefore requires that these factors be controlled for, though to reconcile the conflict we first estimate a regression equation omitting $USTS_{i,t-1}$ as a control variable.

2.3.3.5 Yield($YIELD_t$)

Yield at time t is represented by the variable $YIELD_t$. Including this variable among our regressors controls for the possibility that the variation in our dependent variable is simply owing to US Treasury securities offering investors a higher yield than other feasible alternatives (i.e., the yield on long-term sovereign debt of US currency competitors). Though return considerations of foreign official institutions are not typically included as a determinant of the currency composition of foreign exchange reserves in relevant empirical models, it is plausible that these considerations become important in the selection between safe assets. Data is obtained from FRED. To capture the yield of long-term US Treasury securities relative to feasible alternatives, $YIELD_t$ is calculated as the difference between the yield on long-term US Treasury securities and the maximum yield on long-term government bonds found among the Euro Area, United Kingdom, and Japan. $YIELD_t$ is therefore given by,

$$YIELD_t = GOV_{US,t} - max\{GOV_{EA,t}, GOV_{UK,t}, GOV_{JP,t}\} \tag{2.3}$$

where

GOV_{jt} = Nominal yield at time t for country j's 10-year government bond

2.3.4 Summary

Table 3.1 contains descriptive statistics for the main variables. The sample is a balanced panel for the period 2003-2016 at quarterly intervals. For country-variant variables ($USTS_{it}$, $USTS_{i,t-1}$, $CRED_{it}$), data is collected for 13 developing and emerging market economies based on data availability.[25]

[25]The countries included are Argentina, Brazil, Chile, China, India, Indonesia, Malaysia, Mexico, Republic of Korea, Russia, South Africa, Taiwan, and Turkey.

Table 1: Descriptive Statistics

	Panel A (China Included)				*Panel B (China Omitted)*			
Statistic	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
USTS holdings ($USTS_{it}$)	105.23	249.05	0.15	1293.57	43.64	57.37	0.15	246.67
Inertia ($USTS_{i,t-1}$)	102.92	246.40	0.15	1293.57	42.59	56.57	0.15	246.67
Dollar credit outstanding ($CRED_{it}$)	91.45	102.62	6.31	689.58	62.73	54.21	6.31	248.78
Exchange rate ($EXCH_t$)	1.49	0.07	1.33	1.56				
Relative financial depth ($DEPTH_t$)	−402.57	50.40	−509.10	−288.26				
Relative world GDP share ($NETW_t$)	31.99	3.21	26.28	39.49				
Relative yield on USTS ($YIELD_t$)	−0.45	0.64	−2.14	0.83				

Notes: USTS holdings ($B) is obtained from Bertaut and Judson (2017) and is adjusted for valuation effects. USTS holdings is lagged by one period to account for inertia (or persistence) in the level of holdings across countries. Dollar debt outstanding ($B) is from the Bank for International Settlements (BIS). The exchange rate ($/SDR) is a 5-year moving average of the USD per SDR exchange rate and data is from the Federal Reserve Bank of St. Louis (FRED). Relative financial depth (pp) is the percentage point difference between the financial depth of the US and the maximum financial depth found among the Euro Area, Japan, and the United Kingdom (henceforth referred to as currency competitors); data is from the BIS and the World Federation of Exchanges. Relative world GDP Share is the percentage point difference between the GDP share of world total GDP for the US and the maximum share found among its currency competitors; data is from the IMF International Financial Statistics and CEIC data . Relative yield on USTS is the percentage point difference between 10-year government bond yields for the US and its currency competitors; data is from FRED. Summary statistics for $EXCH_{it}$, $DEPTH_t$, $NETW_t$, and $YIELD_t$ do not change from Panel A to Panel B. For detailed definitions and sources, see Table 12 in Appendix A.

2.4 Econometric Model

The econometric model which will serve as the basis for the analysis when we do not include inertia of US Treasury security holdings ($USTS_{i,t-1}$) as an explanatory variable is given by,

$$USTS_{it} = \gamma CRED_{it} + \boldsymbol{x_t'}\boldsymbol{\beta} + \alpha_i + \mu_t + u_{it} \tag{2.4}$$

where $USTS_{it}$ is holdings of long-term US Treasury securities for country i in period t and $CRED_{it}$—our variable of interest—is total outstanding dollar credit to non-bank borrowers for country i in period t. The parameter γ therefore measures the magnitude of the relationship between outstanding dollar credit and holdings of US Treasury securities. Further, $\boldsymbol{x_t'}$ is a vector comprised of our control variables listed in Section 2.3.3, α_i is an unobserved effect capturing all unobserved, time-invariant factors affecting our dependent variable, and μ_t is a complete set of time effects accounting for secular changes in US Treasury security holdings. If our hypothesis that US Treasury securities serve as collateral to dollar credit is correct, then we would expect the coefficient on $CRED_{it}$ to be statistically significant and positive.

Further, given our efforts to tailor foreign holdings of US Treasury securities to a model of currency composition in foreign exchange reserves, it is perhaps useful at this point to clarify how a positive and statistically significant coefficient on $CRED_{it}$ relates to the public and private domains. To this end, consider Table 2 illustrating the distinction between private and public holdings of US Treasury securities and private and public dollar borrowing.

Using Table 2, we can say that our analysis practically applies to cases (A) and (B); that is, a statistically significant coefficient on $CRED_{it}$ will indicate that there is a statistically significant relationship between *private and public* dollar borrowing and *public* holdings of

Table 2: Public versus Private Borrowers and Holders

		Dollar Borrowers	
		Public	*Private*
Collateral Providers	*Public*	*A*	*B*
	Private	*C*	*D*

Notes: *Collateral providers* refers to holders of US Treasury securities. Case (A) refers to public dollar borrowers and public collateral providers. Case (B) refers to private dollar borrowers and public collateral providers. Case (C) refers to public dollar borrowers and private collateral providers. Case (D) refers to private dollar borrowers and private collateral providers.

US Treasury securities in the developing and emerging market economies included in our sample (all other factors held constant.)[26]

To continue explanation of our empirical model, when our inertia variable ($USTS_{i,t-1}$) is omitted, the model is best estimated simply using a first differences estimator. Given that the unit of analysis is developing and emerging market economies, we cannot reasonably adopt the crucial assumption needed for a random effects model that we have sufficiently controlled for all sources of variation in the dependent variable such that there exists no α_i whereby $Cov(\alpha_i, x_{it}) \neq 0$. For instance, perhaps the form of government in a developing or emerging-market economy is correlated with dollar credit and the currency denomination of financial assets and liabilities. The main point here is that though we cannot be certain of the omitted, country-specific factors that would bias our results, the fact that such factors are likely to exist given such large geographical units of observation renders the use of a

[26]We should note that because our data on US Treasury securities does not distinguish between public and private foreign holdings of US Treasury securities by country, our analysis technically also applies to cases (B) and (D). But, as previously mentioned, the overwhelming majority of long-term US Treasury securities are held by Central Banks in foreign exchange reserves, which we can exploit to restrict the practical application of our results to cases (A) and (B).

random effects estimator inappropriate for our current analysis.

A consideration in choosing between the fixed effects and first differences model is that the number of cross-sectional units (countries) is less than the time periods per cross-sectional unit (i.e., $N < T$), meaning that non-stationarity of the data presents a more serious challenge to the estimation process. We thusly stationarize our variables. A standard test for stationarity of a time series, say y, is the Augmented Dickey Fuller Test (ADF) which tests the estimated coefficient $\hat{\theta}$ in the model,

$$\triangle y_t = \alpha + \delta t + \theta y_{t-1} + \sum_{l=1}^{h} \gamma_l \triangle y_{t-1} + u_t \tag{2.5}$$

where $h = p - 1$ and δt are the deterministic components of the model. The goal is to determine whether stationarity of the series has been achieved for p lags of y. While the ADF is suitable for pooled cross-sections, panel data requires that we establish stationarity of the time series for each cross-sectional unit N. That is, equation (2.5) becomes,

$$\triangle y_{it} = \delta_i t + \theta_i y_{i,t-1} + \sum_{l=1}^{h} \gamma_{il} \triangle y_{i,t-1} + u_{it} \tag{2.6}$$

Both Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) consider equation (2.6) above and propose applying the ADF test to the null hypothesis $H_0 : \theta_{it} = 0$, or that the series has a unit root.[27] Table 3 presents our results from performing the ADF, Levin-Lin-Chu, and Im-Pesaran-Shin tests to all of our main variables in equation (2.4).

The test results presented favor adopting a first-differences model since our variables in both panels (with and without China included as an observation) are integrated of order one, or I(1), suggesting that first-differencing the series is likely to result in stationarity. Further, inspection of the residuals generated by estimating the original model given in equation (2.4)

[27]The main difference between the Levin-Lin-Chu and Im-Pesaran-Shin tests is that in the former, θ_i is assumed to be the same for all cross-sectional units whereas in the latter, θ_i is permitted to vary.

Table 3: Panel unit root tests

Level 1st Difference	Augmented Dickey Fuller Test Statistic	Levin-Lin-Chu Test Statistic	Im-Pesaran-Shin Test Statistic
USTS_{it}	-3.246	1.870	2.009
ΔUSTS_{it}	-3.960^{**}	-17.808^{***}	-13.938^{***}
CRED_{it}	-3.287	8.289	4.278
ΔCRED_{it}	-4.102^{***}	-14.553^{***}	-22.025^{***}
EXCH_t	-6.261^{***}	-0.716	-2.726
ΔEXCH_t	-6.537^{***}	-3.194^{***}	-14.766^{***}
DEPTH_t	-10.540^{***}	-2.132^{*}	-9.285^{***}
ΔDEPTH_t	-10.816^{***}	-20.918^{***}	-18.032^{***}
NETW_t	-9.484^{***}	1.994	1.068
ΔNETW_t	-9.728^{***}	-17.98^{***}	-14.663^{***}
YIELD_t	-5.855^{***}	-4.186^{***}	2.696
ΔYIELD_t	-5.729^{***}	-21.429^{***}	-18.867^{***}

Notes: Lag orders are chosen to minimize the Bayesian information criterion. Statistical significance of the test statistic indicates rejection of the null hypothesis that the series follows a unit root process.
***p<0.001; **p<0.01; *p<0.05

for panel A and B indicates that u_{it} in both cases follows a random walk process so that first differencing equation (2.4) is likely to remove serial correlation from our error term.

Thus, to determine the effect of dollar credit holdings on US Treasury security holdings when inertia of the latter is not included as an explanatory variable, we estimate the following model:

$$\triangle USTS_{it} = \gamma \triangle CRED_{it} + \triangle \boldsymbol{x_t'}\boldsymbol{\beta} + \triangle \mu_t + \triangle u_{it} \tag{2.7}$$

Equation (2.7) is simply the result of time-differencing equation (2.4), which necessarily removes the unobserved heterogeneity, α_i.

When inertia or persistence of our dependent variable, US Treasury security holdings ($USTS_{i,t-1}$), enters into our analysis, equation (2.4) becomes,

$$USTS_{it} = \theta USTS_{i,t-1} + \gamma CRED_{it} + \boldsymbol{x_t'}\boldsymbol{\beta} + \alpha_i + \mu_t + u_{it} \tag{2.8}$$

Naturally, transforming equation (2.8) by time-differencing prior to estimation may seem like an appropriate strategy given that panels A and B are first-difference stationary and that the residuals generated by estimating equation (2.4) follow a random walk process. While first-differencing equation (2.8) is certainly needed for the preceding reasons, introduction of a lagged dependent variable among our regressors requires that we slightly modify our former approach. To elucidate, consider first differencing equation (2.8) which results in the following model,

$$\triangle USTS_{it} = \theta \triangle USTS_{i,t-1} + \gamma \triangle CRED_{it} + \triangle \boldsymbol{x_t'}\boldsymbol{\beta} + \triangle \mu_t + \triangle u_{it} \tag{2.9}$$

Notice that using OLS to estimate equation (2.9) will not result in a consistent estimation since $USTS_{i,t-1}$ is used to generate the residuals u_{t-1} and, by extension, $\triangle u_{it}$; thus, the

requisite assumption that our residuals be uncorrelated with the regressors in the model, is violated. We therefore adopt the method proposed by Anderson and Hsiao (1982) whereby $\triangle USTS_{i,t-2}$ is used to instrument for $\triangle USTS_{i,t-1}$ in equation (2.9).[28]

2.5 Main Results

Our results are presented in Table 4 along with robust standard errors (clustered at the country level for estimates reported in columns [2]-[4]). Each specification uses a full set of time dummies among the explanatory variables to control for any variation in holdings of US Treasury securities among developing and emerging-market economies that is owing to a time-dependent effect.

[28]We follow the procedure outlined in Woodridge (2010) according to which we must confirm that the proposed variable ($\triangle USTS_{i,t-2}$) serves as a proper instrument for the variable in question ($\triangle USTS_{i,t-1}$). This determination can easily be made by estimating the model, $\triangle USTS_{i,t-1} = \beta \triangle USTS_{i,t-2} + u_{it}$ for $i = 1, 2, \ldots, N$. Results from estimation of the preceding model for panels 1 and 2 are reported in Table 16 of Appendix A and indicate that $\triangle USTS_{i,t-2}$ is indeed a good instrument for $\triangle USTS_{i,t-1}$ in both cases.

Table 4: Regression Results

	Dependent variable: $USTS_{i,t}$					
	Panel A (China Included)			*Panel B (China Omitted)*		
	Pooled	First Differences	Anderson-Hsiao	Pooled	First Differences	Anderson-Hsiao
	OLS	*OLS*	*IV*	*OLS*	*OLS*	*IV*
	(1)	(2)	(3)	(4)	(5)	(6)
$USTS_{i,t-1}$			0.724***			0.636***
			(0.115)			(0.153)
$CRED_{i,t}$	2.065***	0.278***	0.112**	0.442	0.216***	0.180***
	(0.40)	(0.05)	(0.05)	(0.32)	(0.05)	(0.05)
$EXCH_t$	23.796	74.416	−77.495	13.699	−22.283	−87.533
	(421.21)	(142.34)	(100.56)	(131.35)	(123.77)	(137.90)
$DEPTH_t$	−0.638*	−0.044	−0.046	0.030	−0.052**	−0.027
	(0.36)	(0.12)	(0.12)	(0.15)	(0.03)	(0.03)
$NETW_t$	−11.692	2.043	1.042	1.237	−0.534	0.295
	(8.499)	(2.41)	(1.80)	(3.92)	(0.54)	(0.56)
$YIELD_t$	−8.399	−5.300	−6.603	5.609**	3.76	4.194*
	(12.943)	(10.13)	(9.84)	(2.61)	(3.07)	(2.49)
Observations	728	715	689	672	660	636
R^2	0.640	0.184	0.580	0.257	0.205	0.319
Adjusted R^2	0.610	0.115	0.544	0.190	0.131	0.256

Notes: Pooled OLS regression in columns 1 and 4, with robust standard errors in parentheses. First-differences OLS regression in columns 2 and 5. Columns 3 and 6 use the instrumental variables method of Anderson and Hsiao (1982); we instrument for $USTS_{i,t-1}$ using a two-period lag. Year dummies are included in all regressions. Robust standard errors clustered by country in parentheses for First Differences OLS and Anderson-Hsiao IV. For detailed data definitions and sources, see Table 12 in Appendix A.
***p<0.001; **p<0.01; *p<0.05

Column (1) of Table 4 reports the results from estimating a standard pooled OLS regression including all explanatory variables except inertia ($USTS_{i,t-1}$) for panel A (where observations for China are included.) Though the pooled OLS estimates cannot technically be correct, they can still provide a useful baseline.[29] The coefficient on the main variable of interest, outstanding dollar credit ($CRED_{it}$), is statistically significant ($p < 0.001$) and positive, indicating that increases in holdings of US Treasury securities is associated with an increase in outstanding dollar credit. Specifically, a $1 billion increase in outstanding dollar credit is associated with a $2.1 billion increase in US Treasury security holdings, holding other factors fixed. This result supports our hypothesis but should be viewed with a considerable degree of skepticism for reasons outlined in Section 2.4.

In addition to the main variable of interest, the financial depth of the US relative to its currency competitors ($DEPTH_t$) is significant at the 5% level but the coefficient estimate has the "wrong" sign. Our coefficient estimate for $DEPTH_t$ indicates a negative relationship between relative US financial depth and developing and emerging economy holdings of US Treasury securities; specifically, a 1 percentage point increase in the relative financial depth of the US is associated with a $0.64 billion *decrease* in US Treasury security holdings among developing and emerging economy countries. Indeed, the coefficient estimates on all of our control variables suggest counterintuitive relationships, though with the exception of $CRED_{it}$ and $DEPTH_t$, no other coefficient estimates from the pooled OLS are statistically different from zero.

These counterintuitive results can be owing to a number of reasons including the omission of an important explanatory variable, multicollinearity among regressors, and measurement error. In our analysis, it is likely that the direction of the relationship between our control

[29]When stationarity of the variables is either achieved or not a concern in the case of a short panel, then pooled OLS is especially useful: when compared to first differences or random effects, pooled OLS estimates provide insight into the degree of bias arising from unobserved heterogeneity.

variables and $USTS_{it}$ indicated is possibly owing to non-stationarity of the series (the consequences of which are discussed in detail in Section 2.4), non-inclusion of a persistence effect of US Treasury security holdings (represented by our variable $USTS_{i,t-1}$), the inclusion of China in our first panel which is an outlier both in terms of its holdings of US Treasury securities and outstanding dollar credit, failure to remove unobserved heterogeneity, and/or misguided economic theory. Before commenting further, we continue to our results from estimating a first-differenced version of equation which necessarily resolves some of these issues.

Column (2) presents our results from estimating equation (2.7) with robust standard errors clustered by country. The coefficient on $CRED_{it}$ indicates that there is a positive, statistically significant ($p < 0.001$) relationship between changes in a country's outstanding dollar credit and holdings of US Treasury securities; specifically, a \$1 billion increase in outstanding dollar credit is associated with a \$0.28 billion increase in US Treasury security holdings, all other factors held constant. Thus, our results from estimating equation (2.7) confirm that the relationship between outstanding dollar credit and US Treasury securities estimated by pooled OLS holds even after removing unobserved heterogeneity. Importantly, compared to the results from pooled OLS, differencing has reduced the sensitivity between changes in holdings of outstanding dollar credit and US Treasury securities by about \$0.7 billion; that is, the same increase in outstanding dollar credit is associated with less of an increase in US Treasury security holdings after unobserved heterogeneity is removed from the estimating equation.

The first-differenced equation yields no statistically significant control variables and this includes our formerly significant variable $DEPTH_t$. While the coefficient estimates on most of our control variables continue to have the "wrong" sign, the expected sign on our variable $NETW_t$ is yielded through first-differencing. That is, the difference between the ratio of

GDP to world GDP for the US and its currency competitors is associated with an increase in US Treasury Security holdings among developing and emerging economies included in our sample. One final observation is that, though not statistically significant, the coefficient estimate on our stability variable $EXCH_t$ is relatively large and in an unexpected direction, indicating that an increase in the weakness of the dollar relative to the SDR is associated with an increase in US Treasury security holdings among developing and emerging economy countries in our sample.

Results from introducing a persistence effect of US Treasury Securities are presented in column (3). As discussed earlier, we instrument for the representative variable $USTS_{i,t-1}$ with a second lag of $USTS_{it}$ to avoid a violation of the requisite assumption that our regressors be uncorrelated with our error term. The coefficient on $USTS_{i,t-1}$ indicates that holdings of US Treasury security holdings indeed demonstrate strong and statistically significant ($p < 0.001$) inertia. Specifically, a \$1 billion increase in US Treasury security holdings is associated with a \$0.72 billion increase in the next time period, all other factors held constant.

Importantly, our results demonstrate that even after controlling for inertia in US Treasury Security holdings, the coefficient on our main variable of interest, $CRED_{it}$, continues to be positive and statistically significant. However, $CRED_{it}$ displays slightly less statistical significance, indicating that inertia has absorbed some of the variation in $USTS_{it}$, formerly attributed to outstanding dollar credit. Our variable $CRED_{it}$ is also reduced in magnitude when a persistence effect of US Treasury securities is added to the model; specifically, the estimated increase in US Treasury security holdings resulting from a \$1 billion increase in outstanding dollar credit is \$0.11 billion, or approximately \$0.17 billion lower than the first-differences estimates, all other factors held constant.

The relationship between outstanding dollar credit and US Treasury security holdings

in our sample of developing and emerging market economies is non-trivial. Our descriptive statistics reported in Table 1 indicate that, on average, countries in our sample hold approximately $91.5 billion dollars in outstanding dollar credit. Even when China is omitted from the sample, the mean level of outstanding dollar credit is still large at approximately $62.7 billion. More telling, however, is the growth rate of outstanding dollar credit over the sample period. From 2003Q1-2016Q4, outstanding dollar credit in our sample of developing and emerging market economies has grown by approximately $115 billion ($84.7 billion when China is omitted). This growth has occurred at a higher rate in the later part of the sample period (2010-2016) with countries in the sample adding on average about $14.5 billion per year to their stock of outstanding dollar credit ($9.16 billion when China is omitted).

In 2016, developing and emerging market economies held roughly $3 trillion in US Treasury securities. Our results indicate that if outstanding dollar credit among developing and emerging market economies in our sample continues to grow at its more recent pace, then the collateral needed to secure this credit will be roughly $188.5 billion in US Treasury securities over the next decade.[30] That is, holdings of US Treasury securities among developing and emerging market economies will increase by roughly 6% over the next decade.

Echoing previous studies, the statistically significant coefficient on our lagged dependent variable indicates that inertia or persistence in US Treasury security holdings is of considerable magnitude: a $1 billion increase in US Treasury security holdings in the previous time period is associated with a $0.64 billion increase in the current time period.[31] To put it simply, about half of US Treasury security holdings carried forward from one time period to the next in developing and emerging market economies are propelled by inertia.

[30]To get this number, we simply multiply $14.5 billion in increased outstanding dollar credit per year by 13 (for the number of countries in the sample).

[31]Chinn and Frankel (2005) find that inertia explains approximately 90% of the currency composition of reserves. Eichengreen, Mehl and Chitu (2017) estimate a considerably lower but statistically significant effect of inertia that is closer to our estimate, at about 60%.

With the exception of our variable representing inertia, our control variables continue to be statistically insignificant, though now the coefficient on our variable representing stability ($EXCH_t$) possesses the conventionally expected sign. Interpreted causally, our results indicate that a weaker dollar (measured against the SDR) yields a decrease in US Treasury security holdings. Our coefficient estimates for the variables representing relative US financial depth ($DEPTH_t$) and relative US yield of long-term government bonds ($YIELD_t$), however, continue to indicate an unexpected negative relationship with US Treasury security holdings.

If conventional economic theory is to be our guide, the reasons underlying our unexpected estimated signs on $DEPTH_t$ and $YIELD_t$ are possibly owing to a mistake in our specification, empirical strategy, and/or data set. We consider those factors that are plausibly related to the current undertaking. Inspection of the correlation coefficients and variance inflation factors (VIF) for the variables in our sample suggest that multicollinearity is unlikely to be the cause of our unexpected signs on $DEPTH_t$ and $YIELD_t$.[32]

Simultaneous-equations bias may be another reasonable concern if $YIELD_t$ and $DEPTH_t$, respectively, are determined simultaneously with the dependent variable. That is, if foreign-held US Treasury security holdings are determined by *and determine* $YIELD_t$ and/or $DEPTH_t$, then our estimates will be biased and inconsistent. That portion of our variable $DEPTH_t$ which might reasonably be determined by foreign-held, long-term US Treasury securities is bond market capitalization. But, because we have proxied for this dimension of $DEPTH_t$ with outstanding debt securities issued by the private sector, it is quite unlikely that relative US financial depth would be determined by our dependent variable.

With regard to our variable $YIELD_t$, while we recognize that the yield on long-term US

[32]A formal presentation of our correlation matrix and variance inflation factors can be found in Tables 14 and 15, respectively, in Appendix A.

Treasury securities is determined by demand for the latter (i.e., by holdings of US Treasury Securities), recall that our variable $YIELD_t$ represents the yield of long-term Treasury securities relative to the yield on long-term government bonds of US currency competitors. Additionally, to the extent that holdings of US Treasury securities may in fact determine the yield on long-term US Treasury securities, it is plausible that it does so with a lag whereas in our model the variables $DEPTH_t$ and $YIELD_t$ are contemporaneous with each other.

Nevertheless, as an additional precautionary measure, we employ a Granger causality test to assess whether the relative yield of US Treasury securities is determined by foreign holdings of the same. Generally speaking, the Granger causality statistic allows us to test whether past values of one variable, say X_t, is a significantly useful addition to a model using past values of Y_t to forecast Y_t. If X_t is indeed a significantly useful addition (i.e., possesses predictive content useful in forecasting Y_t) beyond past values of Y_t, then we conclude that X_t "Granger causes" Y_t. More specifically, consider the following time-series regression model with one predictor, X_t:

$$Y_t = \beta_0 + \beta_i \sum_{i=1}^{p} Y_{t-i} + \delta_i \sum_{i=1}^{q} X_{t-i} + u_t \tag{2.10}$$

where p and q are the lag order of Y_t and X_t, respectively. Then, the Granger causality statistic is simply an F-statistic generated to test the null hypothesis that the coefficients δ_i in equation (2.10) are all zero.

As is well-known, the Granger causality test cannot determine contemporaneous causality between two variables; that is, it cannot reveal information on whether the value of X_t in period t is related to Y_t in period t. But, applied to the current circumstance, it can provide some useful insight because if $YIELD_t$ is potentially determined by $USTS_t$, then we would reasonably expect past values of the latter to provide predictive content to forecast the

former.

Our results from performing the Granger causality test are reported in Table 5 and indicate that while the relative yield on US Treasury securities *Granger causes* foreign holdings of long-term US Treasury securities, the reverse is not true. Because past values of $USTS_{it}$ do not provide useful predictive content to forecast $YIELD_t$, we are unconvinced that simultaneity between the two is the cause of the unexpected estimated coefficients on our control variables.

Table 5: Panel Granger Causality Test

Alternative Hypothesis	F-statistic	Direction of *Granger-causality*
USTS Granger-causes YIELD for at least one country	1.487	$USTS \rightarrow YIELD$
YIELD Granger-causes USTS for at least one country	2.297*	$YIELD \rightarrow USTS$
Δ*USTS Granger-causes* Δ*YIELD* for at least one country	1.432	$\Delta USTS \rightarrow \Delta YIELD$
Δ*YIELD Granger-causes* Δ*USTS* for at least one country	2.629**	$\Delta YIELD \rightarrow \Delta USTS$

Notes: Significance of the F-statistic reported in the second column supports rejection of the null hypothesis in favor of the alternative hypothesis. For detailed data definitions and sources, see Table 12 in Appendix A. ***p<0.001; **p<0.01; *p<0.05

Another reason that can possibly explain why our coefficient estimates on our variables $DEPTH_t$ and $YIELD_t$ do not possess the expected sign is the presence of outliers. Indeed, Figure 5 clearly illustrates that China is an outlier in our sample in both its level of outstanding dollar credit and holdings of US Treasury securities. Moreover, Figure 5 also seems to indicate a strong positive relationship between the level of outstanding dollar credit and

US Treasury securities for China; thus, we should be concerned that the presence of China in our sample is not only driving unexpected signs in our coefficient estimates but also the statistical significance of our main variable of interest, $CRED_{it}$.

Thus, in the next section we remove China from our dataset and repeat our empirical exercise to determine how sensitive our results are to the exclusion of this outlier. As an additional precautionary measure, we also repeat the empirical analysis outlined in section 2.4 using an alternative definition of financial depth: the ratio of broad money (M3) to GDP.

2.6 Robustness Checks

Our first robustness exercise entails the removal of China as an observation in our sample and estimating equations (2.4), (2.7), and (2.9) again following the same procedure outlined in section 2.4. Our results are reported in columns (4)-(6) of Table 4.

A first observation is that while the estimated coefficient on our main variable of interest $CRED_{it}$ is not significant in the pooled OLS regression reported in column (4), estimating the first-differenced equation results in statistical significance being gained at the .1% level. Thus, it seems that when China is removed from the sample, unobserved heterogeneity biases our pooled OLS results to a considerably larger extent than when it is included. Interestingly, comparison of the IV estimates presented in columns (3) and (6) indicate that when China is omitted from our sample, $CRED_{it}$ gains in statistical significance ($p < 0.001$) and magnitude by approximately \$.07 billion. Specifically, when China is removed from the sample, a \$1 billion increase in outstanding dollar credit is associated with a \$0.18 billion increase in US Treasury security holdings, all other factors held constant.

The gain in statistical significance of our outstanding dollar credit variable indicates that though China holds a disproportionately high level of US Treasury securities and outstanding

dollar credit, the *link* between the two is less strong for China than it is for other countries included in our sample (i.e., outstanding dollar credit explains less of the variation in holdings of US Treasury securities for China than it does for our other cross-sectional units.) Relatedly, because the inertia of US Treasury security holdings seems to absorb more of the variation in our dependent variable when China is included in the sample, it is possible that inertia of US Treasury security holdings is relatively stronger for China.

The IV estimate of the coefficient on $YIELD_t$ is now not only positive but also statistically significant at the 5% level.[33] Specifically, our results indicate that a 1 percentage point increase in the relative yield of long-term US Treasury securities is associated with a sizeable $4.2 billion dollar increase in holdings of the same among developing and emerging market economies countries included in the sample. Coupled with the potential that inertia plays a larger role in motivating Chinese holdings of US Treasury securities, the significance of the coefficient on $YIELD_t$ for panel B hints that China's motivation for accumulating US Treasury securities is potentially unique and warranting of further research.

Notwithstanding $YIELD_t$, the IV estimates of the coefficients on our other control variables, reported in column (6), are not statistically significant. Moreover, the coefficient on $DEPTH_t$ continues to be negative, indicating that increases in relative US financial depth continue to be associated with decreases in US Treasury security holdings, even after omitting outliers from the sample. The prevailing view argues that if the existence of a safe asset is taken as given (i.e., we do not concern ourselves with what makes an asset "safe" but, rather, simply accept that investors believe certain assets possess this characteristic), then the selection between safe assets is explained by the financial depth of an issuing coun-

[33] A negative coefficient on our variable EXCH reported in column (6) indicates that increases in the dollar to Special Drawing Rights exchange rate (i.e., dollar depreciation) is associated with a decrease in US Treasury security holdings. A positive coefficient on $NETW_t$ indicates that increases in the US network (measured as the ratio of US GDP to world GDP) relative to the network of its currency competitors is associated with an increase in US Treasury security holdings among countries included in Panel B.

try. The sign on the estimated coefficient of our variable $DEPTH_t$ coupled with its lack of statistical significance challenges the prevailing view.

A natural concern is whether an unexpected, negative sign on $DEPTH_t$ is perhaps owing to the way we have defined the variable. To account for this possibility, we estimate equations (2.4), (2.7), and (2.9) again using an alternative but commonly used proxy for financial depth: the ratio of broad money (M3) to GDP. Inspection of the correlation coefficients indicates that while our original measure of financial depth (the sum of a country's domestic private credit [$DPRIV_{jt}$], stock market capitalization [$SCAP_{jt}$], and bond market capitalization [$BCAP_{jt}$] relative to GDP) is very weakly correlated with our new measure, the latter is highly correlated with our variable $EXCH_{it}$ (r=-0.903).[34] Thus, we follow the same procedure outlined in section (2.4) to estimate equations (2.4), (2.7), and (2.9) with and without $EXCH_{it}$ included as a regressor. Our results are presented in Table 6.

[34]A formal presentation of our correlation matrix using an alternative definition of financial depth can be found in Table 17 of Appendix A.

Table 6: Regression Results - Alternative Measure of Financial Depth (M3/GDP)

	Dependent variable: $USTS_{i,t}$											
	Panel A (China Included)						*Panel B (China Omitted)*					
	Pooled		First Differences		Anderson-Hsiao		Pooled		First Differences		Anderson-Hsiao	
	OLS		*OLS*		*IV*		*OLS*		*OLS*		*IV*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$USTS_{i,t-1}$					0.724***	0.724***					0.636***	0.636***
					(0.11)	(0.11)					(0.15)	(0.15)
$CRED_{i,t}$	2.065***	2.065***	0.278***	0.278***	0.112**	0.112**	0.442	0.442	0.216***	0.216***	0.179***	0.179***
	(0.40)	(0.40)	(0.05)	(0.05)	(0.05)	(0.05)	(0.32)	(0.32)	(0.05)	(0.05)	(0.05)	(0.05)
$EXCH_t$	−186.83		116.224		−86.901		23.760		27.373		−162.63	
	(355.43)		(176.88)		(121.47)		(108.52)		(120.27)		(376.40)	
$DEPTH_t$	1.156*	1.472**	−0.115	−0.126	−0.181	−0.265	−0.056	−0.095	−0.136**	−0.139**	−0.39	−0.203*
	(0.65)	(0.67)	(0.309)	(0.32)	(0.49)	(0.59)	(0.28)	(0.29)	(0.067)	(0.07)	(0.41)	(0.10)
$NETW_t$	3.440	2.842	2.940	3.285	2.334	1.808	0.514	0.590**	0.533	0.614	0.818**	0.838**
	(3.03)	(2.59)	(2.97)	(3.33)	(1.78)	(1.25)	(0.47)	(0.30)	(0.41)	(0.24)	(0.39)	(0.40)
$YIELD_t$	46.284*	63.849**	−9.331	−11.902	−13.132	−13.086	2.997	0.763	1.027	1.632	10.367	3.260
	(27.70)	(26.15)	(6.63)	(8.64)	(11.16)	(11.11)	(12.87)	(13.80)	(3.04)	(1.77)	(15.82)	(2.32)
Observations	728	728	715	715	689	689	672	672	660	660	636	636
R^2	0.640	0.640	0.184	0.184	0.580	0.580	0.258	0.258	0.205	0.205	0.319	0.319
Adjusted R^2	0.610	0.610	0.115	0.115	0.545	0.545	0.190	0.190	0.131	0.131	0.256	0.256

Notes: The financial depth variable ($DEPTH_t$) is measured as the ratio of broad money (M3) to GDP. Pooled OLS regression in columns 1,2,7 and 8 with robust standard errors in parentheses. First-differences OLS regression in columns 3-4 and 9-10. Columns 5-6 and 11-12 use the instrumental variables method of Anderson and Hsiao (1982); we instrument for $USTS_{i,t-1}$ using a two-period lag. Year dummies are included in all regressions. Robust standard errors clustered by country in parentheses for First Differences OLS and Anderson-Hsiao IV. For detailed data definitions and sources, see Table 12 in Appendix A .***p<0.001; **p<0.01; *p<0.05

Importantly, the coefficient on our variable of interest, $CRED_{it}$, is robust to an alternative measure of financial depth. Our results also indicate that the estimated coefficient for $DEPTH_t$ continues to be negative when first differences and IV estimation strategies are adopted and remains so when China is omitted as an observation and $EXCH_t$ is removed as a control variable. The estimated coefficient on $DEPTH_t$ is not statistically significant when $EXCH_t$ is included in the model as a control variable but becomes significant at the 1% level when $EXCH_t$ is omitted. While we favor the more comprehensive definition of financial depth that was utilized in the original empirical analysis (the results of which are reported in Table 3.3), the persistence of a negative sign on the estimated coefficient on $DEPTH_t$ serves to confirm the robustness of our original result.

Additionally, while an alternative operationalization of financial depth has not changed the direction in which our independent variables influence $USTS_t$, the magnitudes and statistical significance of some coefficients have indeed changed. Namely, $YIELD_t$ is no longer statistically significant and increases in magnitude when $EXCH_t$ is included as a control variable, suggesting that perhaps those elements of a more robust definition of financial depth (utilized in the first set of estimations reported in Table 3.3) serve to artificially reduce the correlation between $YIELD_t$ and $USTS_t$. Further, the coefficient on our variable representing network effects, $NETW_t$, is now statistically significant, indicating that perhaps those elements of a more robust definition of financial depth are correlated with $NETW_t$.

2.7 Concluding Remarks

The prevailing view is that the persistent foreign demand for US Treasury securities (i.e., persistent lending to the US) is owing to favorable investor perception of US economic fundamentals, namely financial depth. In this paper, we rely on the sovereign debt literature

to argue that perception alone cannot motivate sovereign lending. Rather, sovereign lending requires the existence of an endogenous enforcement mechanism to secure repayment. This mechanism cannot plausibly be said to exist in the current lending environment given the disparity in strength between developing and emerging market economy lenders and advanced economy borrowers.

In this essay, we provide evidence that US Treasury securities act as collateral to dollar credit. Additionally, while perception is impossible to capture empirically, our results indicate that variation in the relative financial depth of the US does not explain the variation in holdings of US Treasury securities. Our results imply that the continued financing of the US deficit and the dollar's global role are not solely dependent on investor perception and so cannot be entirely vulnerable to the latter.

This research has generated possibly fruitful areas for future inquiry. Naturally, the analysis could be improved dramatically with a panel dataset that includes more cross-sectional units and time periods. This possibility, however, necessarily relies on factors beyond the researcher's control, so we offer suggestions that can feasibly be undertaken.

Our research has shed light on the contemporaneous relationship between outstanding dollar credit and holdings of US Treasury securities among developing and emerging market economies. Future research may try to determine whether and how our results might change when lags are introduced into the estimating equation (i.e., how current *and past* values of outstanding dollar credit are related to holdings of US Treasury securities, given current and past values of our control variables. It may also be interesting to test whether the relationship between outstanding dollar credit and holdings of US Treasury securities in developing and emerging market economies was more or less pronounced during different time periods.

Future research could also be devoted to investigating the determinants of inertia in a reserve asset. Our research has demonstrated that at least part of the variation in holdings

of US Treasury securities that would otherwise be resigned to inertia, is actually owing to the asset's role as collateral to dollar borrowing. While we do not claim that inertia plays no role in the persistence of an asset in foreign exchange reserves, the empirical research thus far (including our own current endeavor) has shown that it is quite substantial and in the order of at least 50% (i.e., at least 50% of the level of US Treasury securities in foreign exchange reserves from time period to the next is explained by way of the latter's inertia). While this may indeed reflect reality, the reflection does not seem to have been rigorously challenged in light of other possibilities.

Guidance in what these other possibilities or determinants of inertia might be is provided by the key highlights and results of this essay. Sovereign immunity threatens virtually any contract where a sovereign nation is a counterparty whose compliance is required. Thus, it may be the case that US Treasury securities act to collateralize other contracts between sovereign nations and future endeavors may empirically test whether this is the case.

Another avenue for future research is investigation of our unexpected negative coefficient on the variable representing the financial depth of the US relative to its currency competitors ($DEPTH_t$). This negative coefficient persisted after the estimating equation was transformed to account for unobserved heterogeneity, the outlier China was removed, and an alternative definition of financial depth was adopted. This result also echoes Chinn and Frankel's (2005) findings whereby the financial depth of a currency issuer is found to be statistically insignificant and negatively related to the currency composition of foreign exchange reserves. Future work could seek to explain the mechanisms that underlie these counterintuitive results.

Finally, our results demonstrate that though China has a disproportionate amount of outstanding dollar credit and US Treasury securities, the relationship between these two variables is less pronounced for China than it is for other developing and emerging market economies in our sample. Future research could therefore be devoted to investigating what

seems to be a unique set of determinants of the currency composition of China's foreign exchange reserves.

CHAPTER 3

THE COST OF A SWIFT KICK: ESTIMATING THE COSTS OF FINANCIAL SANCTIONS ON IRAN

3.1 Introduction

The reality of one country (or city-state) sanctioning another has been in existence at least since the time of Ancient Greece.[1] Since that time, this reality has also generated an accompanying discussion on sanction effectiveness; that is, whether sanctions achieve their desired impact, what negative externalities they occasion, what costs are borne by sender countries, and so on.[2] Over time, the accompanying questions have not changed as much as the sanctions themselves. Prior to 2000, most sanctions took the form of trade sanctions: those banning imports from or exports to a state (Kirshner, 1997). But, these sanctions came to be viewed as not only inefficient but also devastatingly heavy-handed. The response to the bluntness and poor performance of trade sanctions was a targeted (i.e.,"smart") financial sanction.

In this paper, we argue that the existence of global financial networks has enabled a unique potential for financial sanctions to be comprehensive in effect. To illustrate, we measure the

[1]Pericles levied sanctions against nearby Megara in 432 B.C. (Hufbauer, Schott and Elliott, 1990)

[2]In this paper, we adopt the convention of referring to the sovereign nation imposing a sanction as the *sender* and that receiving the sanction as the *target*

cost on Iran's economy of a unique financial sanction requiring its removal from the Society for Worldwide Interbank Financial Telecommunications (the "SWIFT sanction"). In so doing, we demonstrate how global financial networks enable ostensibly targeted financial sanctions to resemble the heavy-handed tools of compliance they were meant to replace.

The SWIFT sanction presents a unique opportunity to investigate the impact of global financial networks wielded as a sanctioning tool. First, Iran is the first and only nation to be punitively excluded from SWIFT. Second, because the Iranian economy has operated under a host of sanctions for nearly half a century, the impact of the SWIFT sanction provides insight into how its unique form compares with its predecessors.

To evaluate the impact of the SWIFT sanction on Iran's economy, we utilize quarterly data on Iran's real gross domestic product (in purchasing power parity [PPP] adjusted, 2015 international dollars) during the period 1988-2016. This data is obtained from the Central Bank of Iran and the Statistical Center of Iran. We employ a time-series forecasting technique to measure the cost of the SWIFT sanctions to Iran's real gross domestic product (GDP), where cost is measured by the difference between forecasted and actual real GDP. We further perform a robustness check using a distributed lag model to control for potential confounders. We find that the average quarterly cost of the SWIFT sanction to Iran's real GDP is approximately $204.3 billion (PPP-adjusted, 2015 international dollars) which represents approximately 14.7% and 13.8% of Iran's average quarterly actual and forecasted GDP, respectively.

The paper proceeds as follows. Section 3.2 describes the development of financial sanctions. Section 3.3 outlines how financial sanctions have evolved with the existence of global financial networks. Section 3.4 describes the empirical analysis employed and results obtained, including a robustness check to control for potential confounders. Section 3.5 concludes.

3.2 The Development of Financial Sanctions

A sanction or punishment levied by one sovereign nation onto another can take many forms: a sovereign nation and/or a coalition of countries might intervene against another militarily, sever diplomatic ties, close its borders to citizens of a target country, and/or restrict membership to international organizations. When sanctions specifically affect the flow of resources—whether trade or financial —to and from a target country, then sanctions are considered *economic sanctions.*

A more specific and widely-accepted definition of what constitutes an economic sanction does not exist. That is, groups of theorists have arrived at separate conclusions and this has long been a point of frustration for researchers (Nossal, 1989). Broad characterizations of definition-groupings are possible, however. Generally speaking, definitions of sanctions are filed into two broad categories depending on whether the objective of sanctions is believed to be to *punish* or *express*. The *punishment perspective* of sanctions can be further broken down into two groups: *means-ends* and *retributive*. In the means-ends perspective, the goal of sanctions is to elicit compliance from a target; that is, sanctions are the *means to the end* of amending the target's behavior (Daoudi and Dajani, 1983; Askari, Forrer,Teegan and Yang, 2002; Davis and Engerman, 2003; Early, 2012).

In the *retributive perspective*, the goal of sanctions is simply to punish with no necessary requirement that a target comply with a sender's demands. In other words, a sanction can be retribution for violating an international norm and can thusly be successful even if the target does not amend objectionable behavior. Whereas the goal of sanctions in the punishment perspective is to mete out a sentence for the violation of some law or norm, the *expressive* view of sanctions holds that sanctions can be used as a signaling mechanism to demonstrate support or disfavor (Galtung, 1967). For instance, Klotz (1995) argues that US sanctions against apartheid in South Africa operated against US material interests but were imposed

to signal to the global community that the US supports racial equality.

In addition to different definitions of economic sanctions, there are also two generally different types: trade and financial. Though both types of sanctions aim to stop the flow of resources to and from a target country, their difference lies in the nature of the flows they aim to stop. The goal of trade sanctions is to stop the flow of *goods*, thereby hindering a target nation from earning gains from trade. Financial sanctions, however, aim to stop the flow of *funds* to and from a target country. Thus, the methods of financial sanctions include but are not limited to freezing a target's assets; cutting off sources of credit, aid, and/or payment facilitation; and imposing monetary pressures onto a target economy (Drezner, 2011). Until recently, most sanctions have taken the form of trade sanctions.

For roughly the past two decades, however, trade sanctions have increasingly come to be viewed as blunt and inefficient tools of coercion, primarily owing to their performance in Iraq. In August 1990, four days after Saddam Hussein's invasion of Kuwait, the United Nations Security Council levied comprehensive trade sanctions onto Iraq.[3] The sanctions required that members and non-members of the United Nations refrain from exporting to or importing from Iraq or Kuwait. Given the likelihood of a military intervention, the sanctions were easily seen as a more humane alternative to outright war, but some researchers argued the consequences were just as harmful (Normand, 1996; Lopez and Cortright, 1997). Shortages of medicine, clean water and food were widespread, risks of child mortality increased four-fold, and infant mortality jumped 6.1 percentage points (Ali and Shah, 2000; Daponte and Garfield, 2000; Garfield, 2002). By the time sanctions were lifted, they had levied a cost onto Iraq's economy equaling 54% of its gross national product (Hufbauer, Schott, Elliott and Oegg, 2007).

The sanctions levied onto Iraq in 1990 not only elicited a humanitarian crisis but were also

[3]United National Security Council Resolution 661

counterproductive. Lopez and Cortright (1997) argue that in targeting the civilian population, the sanctions imposed onto Iraq spared government elites who possessed the means to circumvent them. Indeed, the evidence suggests that the potential for circumvention of key groups within a target country is at least partly exacerbated in a non-democracy. Exercising a relatively larger degree of control over the economy, key groups in non-democracies are better capable of diverting sanction costs, extracting rents from the citizenry, and orchestrating smuggling efforts to circumvent sanctions (Kaempfer and Lowenberg, 1999). Additionally, the sanctions were also counterproductive because they deprived opposition groups of crucial resources needed to mount a viable campaign against the Iraqi government (Lopez and Cortright, 1997).

Sanctions did not only disable opposition groups, however. They also enabled the Iraqi government to play the hero to its citizenry which facilitated political integration in the target (Lopez and Cortright, 1997). Galtung (1967) calls this phenomenon a *rally around the flag effect*: sanctions foster the target's political integration because its citizenry collectively blames a common enemy (the sender) for their economic hardship. In non-democracies, this effect has the perverse result that sanction costs are more easily diverted to the citizenry at the same time that the existence of sanctions provides a scapegoat for their adverse effects. In such a context —as characterized Iraq in 1990 —any aid given by a target government to its citizenry is viewed by the latter sympathetically as a rescue effort.

The general response to the failures of comprehensive trade sanctions was to increasingly employ financial sanctions, argued to be "smarter" because they could be applied in a more targeted fashion: individual financial assets could be frozen, select loans could be refused for debt rescheduling, financial assistance for particular individuals could be rejected, etc. Thus, targeted or "smart" financial sanctions promised to accomplish the seemingly unachievable

goal of being both more humane and successful.[4] Specifically, by targeting financial sanctions to a specific elite, civilian populations would be spared —thereby sidestepping humanitarian impacts and removing the potential for target governments to facilitate a *rally around the flag* effect —and pivotal target groups would be prevented in their effort to circumvent sanctions.

Owing to their theorized advantages, financial sanctions have become increasingly popular as a tool of compliance. Indeed, the use of sanctions surged following the events of September 11, 2001, and targeted financial sanctions were utilized almost exclusively. So far, their relative effectiveness is supported by the results: the success rate of financial sanctions relative to trade sanctions is found to be 41% and 25%, respectively (Lopez and Cortright, 1997).

3.3 The Evolution of Targeted Financial Sanctions

The adoption of targeted financial sanctions also coincided with an important development: the enhancement of US capabilities to monitor and influence global financial transactions. Most notably, in 2006 the CIA, overseen by the Treasury department, secretly subpoenaed and won access to the financial records database of SWIFT.

SWIFT is a private, Brussels-based global financial messaging network. Because it is simply a messaging network, the company neither maintains deposit accounts nor transfers actual funds; rather, it simply delivers a standardized financial message (Lichtbau and Risen, 2006). To gain a more concrete sense of how SWIFT operates, consider a simple thought experiment: imagine three individuals—Q, R, and S —residing in the same town of the United States. Suppose that Q wants to give \$10 to R but that instead of walking to R's house and handing it to her, Q opts to employ the services of S. For a fee, S will ask Q

[4]In this context, "success" is meant to indicate a change in the target's policies.

to complete a form for deposit (we might properly consider it to be a simple check) that S created in consultation with Q and R's banks (in this way, S's financial message is convenient to and therefore preferred by Q and R's banks.) Once Q completes the form, S delivers it to R's banking institution and upon its receipt, a process is initiated whereby \$10 is removed from Q's banking account and deposited into R's. In this simple example, S essentially performs the same function as SWIFT: S simply delivers a financial message (i.e., a form or check).

Given the ease with which two individuals residing in the same town can transact, Q's use of a messenger service is perhaps only justified by her own laziness. But in the global financial arena, the movement of funds is naturally quite complex, and so it is in this context that SWIFT provides a crucial service, all the more because it is unique. That is, SWIFT is the *only* common infrastructure through which global financial institutions can transact.[5] To continue our previous hypothetical, we might imagine a circumstance whereby the *only* way Q and R's banks can interact is through S's form for deposit. In this case, S becomes not only a messenger but also a network since she possesses a unique platform through which people and funds are connected. In the same way, SWIFT is also a network (i.e., it is also a platform through which financial institutions communicate.)

The ability to monitor SWIFT transactions represented a significant breakthrough in the US capacity to monitor global financial transactions not only because of the function SWIFT serves but also because of its ubiquity. When it was founded in the 1970s, SWIFT could claim as members 518 different institutions from 22 different countries and it processed roughly ten million messages annually. Today, it claims as members 11,000 institutions from over 200 countries and processes approximately 26 million messages in one day (SWIFT

[5]It should be noted that in response to the advent of a SWIFT sanction, some alternatives to the SWIFT platform were initiated (e.g., Russia's System for Transfer of Financial Messages or China's Cross-Border Interbank Payment System), though none can reasonably be said to compete with SWIFT.

Annual Review, 2016). It is believed that the dollar-value of SWIFT transactions in 2001 was more than $7.7 trillion annually, or more than one-third of total world exports of goods and services in 2016 (Scott and Zachariadis, 2014).

In 2012, the US used its access to the SWIFT network strategically as a sanctioning tool.[6] In March of that year, the Islamic Republic of Iran became the first sovereign nation to be removed from the SWIFT platform. Though new in form, the sanction was touted as being identical to its predecessors in effect and benefit. For instance, David Cohen —Under Secretary of the Treasury for Terrorism and Financial Intelligence from 2011 to 2015 —made a number of assurances that the SWIFT sanctions were targeted, allowed for the import of food and medicine, and minimized damage to the Iranian people (Faucon, 2012). Cohen's 2014 statements published by the Treasury are illustrative:

> We have been able to move away from clunky and heavy-handed instruments of economic power...Sanctions that focus on bad actors within the financial sector are far more precise and far more effective than traditional trade sanctions. And the trade restrictions that we continue to employ today are also smarter and more surgical, targeting specific classes of products rather than cutting off entire economies. (Remarks of Under Secretary, 2014)

Given the vast literature on sanctions, this sanction episode has received a great deal of attention.[7] Seemingly unnoticed, however, is what a radical departure from the standard sanction a SWIFT cutoff has the potential to be. Throughout much of the nineties, the terms targeted *financial sanctions*, *smart sanctions* and *financial sanctions* were used interchangeably. And this makes sense. Some thirty years ago, there did not exist any other option but to make financial sanctions targeted. Sovereign-to-sovereign transactions occurred, for the

[6]It is worth mentioning that being a private company, SWIFT was and continues to be reluctant to be used as a sanctioning tool. The ability to leverage SWIFT strategically was therefore the product of an active lobbying effort, namely by United Against Nuclear Iran.

[7]A sanction *episode* is the period of time between sanctions implementation and removal.

most part, in a dyadic setting so that there were natural limits to the kind of financial cutoff a single country could impose onto another. That is, the US acting unilaterally could only freeze financial assets *in US banks* or stop payments from a target to *specific US businesses*.

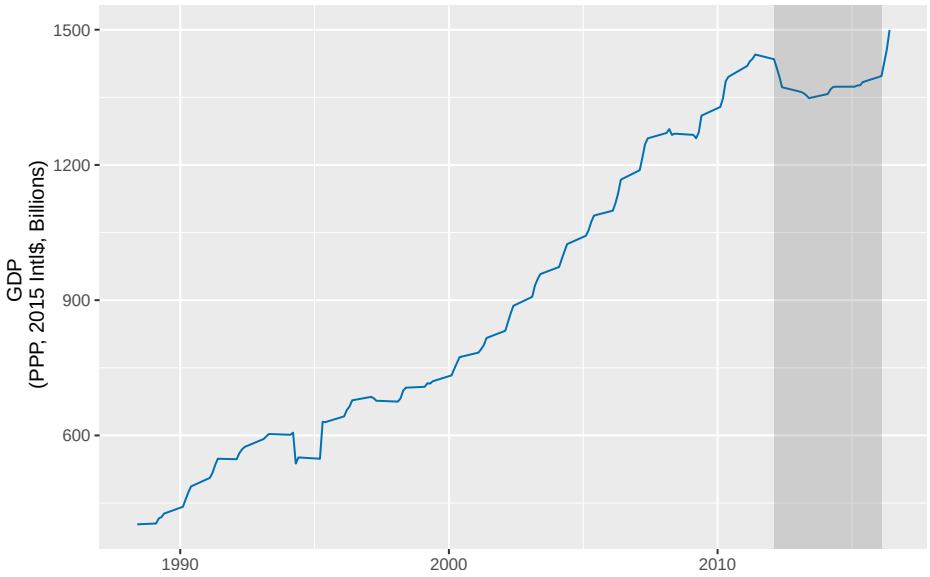
Today's global environment is quite different, however. The existence of SWIFT demonstrates that countries are increasingly capable of interacting within a financial network and the platform's ubiquity demonstrates the importance of maintaining unimpeded access to it (Davis and Engerman, 2003; Joshi and Mahmud, 2016, 2018). Together, what these developments imply for financial sanctions is that the latter now have the potential to become comprehensive in nature. That is, by depriving a sovereign nation of access to the only platform available to receive and send payments in a globalized economy, it is likely that the effect will reflect a comprehensive approach; indeed, we argue that the impact of the SWIFT sanction to its first recipient, Iran, serves to substantiate the point.

3.3.1 Targeted Financial Sanctions in Iran

The Islamic Republic of Iran has been the target of a consistent barrage of sanctions since the Islamic Revolution in 1979. Prior to 2007, most sanctions levied against Iran were trade-based and aimed against Iran's energy sector. In 2007, however, the Bush Administration imposed its first targeted financial sanction (i.e., "smart" sanction) against Iran's fourth largest bank, Bank Sepah, for its alleged support of entities affiliated with Iran's nuclear program. Under Executive Order 13382, the Bank's assets under US control were frozen and US entities were banned from engaging in business with Bank Sepah. Thus, consistent with the general form of a targeted financial sanction, the punitive measure was contained to the Bank and its chairman.

Measured against the Bank Sepah sanctions, the SWIFT sanction is notably different in scope and correspondingly dealt an unprecedented blow to Iran's general economy. Figure

Figure 6: Real GDP for Iran 1988-2016



Notes: The figure plots Iran's quarterly GDP in billions of PPP-adjusted 2015 international dollars. The shaded vertical bar represents the duration of the SWIFT sanction. Data is from the Central Bank of Iran and the Statistical Center of Iran.

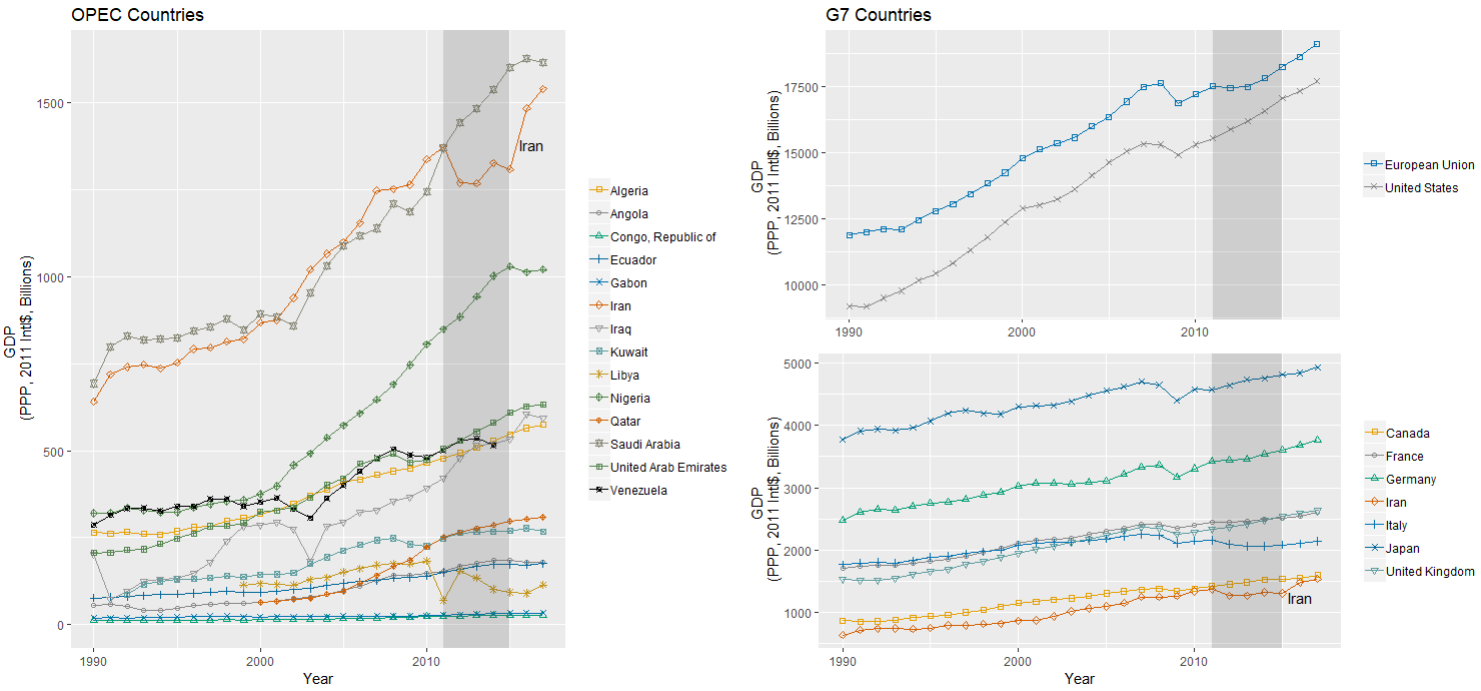
6 plots quarterly data on Iran's real GDP in purchasing power parity (PPP) adjusted, 2015 international dollars during the period 1988Q4-2016Q4. The shaded vertical bar indicates the SWIFT sanction episode.

The figure demonstrates that when the SWIFT sanction was first imposed in 2012Q1, there is a sharp decline in Iran's real GDP and when it was removed in 2016Q1, there is a sharp uptick in the same. The figure also shows that between the SWIFT sanction's initial implementation (2012Q1) and the period when Iran's real GDP reached its lowest level in the sanction period (2013Q4), real GDP declined by $86.35 billion.

Comparing Iran's real GDP during this time to the real GDP of other oil-exporting and advanced economies suggests that the sharp movements in Iran's GDP during the SWIFT sanction episode is not owing to macroeconomic conditions affecting oil-exporters or the global economy generally. Figure 7 plots GDP in billions of purchasing power parity (PPP)

adjusted, 2011 international dollars for all Organization of the Petroleum Exporting Countries (OPEC) and Group of Seven (G7) member-countries. The shaded vertical bar represents the duration of the SWIFT sanction episode.

Figure 7: GDP Comparison



Notes: The figure in the left panel plots the GDP in billions of PPP-adjusted, 2011 international dollars for all fourteen member-countries of OPEC during the period 1990-2017. The figures in the right panel illustrate GDP in billions of PPP-adjusted, 2011 international dollars for all G7 member-countries, the European Union, and Iran during the period 1990-2017. The shaded vertical bar in all figures represents the duration of the SWIFT sanction. Data is from the FRED database and CEIC data.

Figure 7 demonstrates that the countries sampled did not experience a sharp increase and decrease at the beginning and end of the SWIFT sanction, respectively. Libya seems to be the only OPEC member-country to experience a sharp downturn in real GDP near the start of the SWIFT sanction episode, but this is more likely owing to the 2011 US-led military intervention into Libya.

In this paper, we interpret the sharp decline in Iran's real GDP in 2012Q1 as being a direct result of the SWIFT sanction imposed onto the economy during that time. Accordingly, we argue that the magnitude of the SWIFT sanction's impact to Iran's real GDP provides evidence to our claim that the use of global financial networks as a sanctioning tool has caused "targeted" financial sanctions to behave more like comprehensive trade sanctions in effect. We focus on the impact to Iran's real GDP because a targeted financial sanction is one that is *contained* to a financial and governmental elite within the target country. By definition, then, any spillover effects impacting the level of goods and services in the target's real economy naturally constitute a failure of any targeted objective. Accordingly, Pape (1997) comments, "Economic sanctions characteristically aim to impose costs on the economy as a whole...Accordingly, the most important measure of the intensity of economic sanctions aggregate gross national product (GNP) loss over time" (p.4).

Though the sharp movements in Iran's GDP correspond exactly to the application and removal of the SWIFT sanction, care should be taken when making a causal claim. To this end, in the next section we evaluate the impact of the SWIFT sanction on Iran's real GDP by controlling for potential confounders. Then, we calculate the annual cost to Iran's real GDP of the SWIFT sanction using a time-series forecasting method and discuss our results. To the best of our knowledge, this undertaking constitutes the first empirical analysis of the impact to Iran's real GDP of the SWIFT sanction.

3.4 Empirical Analysis

3.4.1 Causality Test

To further support the notion that the sharp movements in Iran's GDP can be interpreted as measuring a causal effect of the SWIFT sanction, we provide a time-series analysis to control for potential confounders. Specifically, we control for the following: the international price of crude oil (*OIL*) to control for the possibility that a change in Iran's real GDP during the SWIFT sanction is due to fluctuations in the global price of crude oil; Iran's government expenditure (*EXP*) to control for the possiblity that a change in Iran's real GDP during the SWIFT sanction is due to changes in the level of domestic government expenditure; and global economic conditions (*G20*) to control for the possibility that any change in Iran's real GDP during the SWIFT sanction is simply owing to more general global economic conditions.

The frequency of the data for all of our variables is quarterly and spans the time period 1988Q4-2016Q4, giving us 116 observations for each variable. Owing to data availability issues, data on Iran's real GDP and government expenditure is obtained from two sources. For data prior to and including 1990Q4, GDP data on Iran's real GDP is obtained from the Central Bank of Iran; after 1990Q4, real GDP data is obtained from the Statistical Center of Iran. For Iran's government expenditure, data prior to and including 1991Q4 is obtained from the Central Bank of Iran and data after 1991Q4 is obtained from the Statistical Center of Iran. In both cases, the data has been rebased in billions of purchasing power parity adjusted, 2015 international dollars. That is, $1 of government expenditure or real GDP has the same purchasing power as $1 in the US in 2015. The Average Petroleum Spot Price (APSP) Crude Oil Index is used to represent the international price of crude oil and data is

retrieved from the Federal Reserve Bank of St. Louis.[8] Finally, data on the GDP for G20 countries is obtained from OECDStat. Table 1 provides summary statistics on the variables that serve as our potential confounders.

Table 7: Descriptive Statistics

Statistic	Mean	St. Dev.	Min	Max
GDP Iran (GDP_t)	943.19	347.00	402.75	1499.20
APSP Index (OIL_t)	84.90	61.16	21.81	227.26
GDP G20 ($G20_t$)	2788.47	488.69	1965.91	3597.19
Government Expenditure (EXP_t)	133.24	36.87	66.77	205.57

Notes: GDP Iran is obtained from the Central Bank of Iran and the Statistical Center of Iran. APSP Index is from the Federal Reserve Bank of St. Louis Economic Database (FRED). G20 is from the OECD Statistics database (OECDStat). Government Expenditure for Iran is from the Central Bank of Iran and Statistical Center of Iran

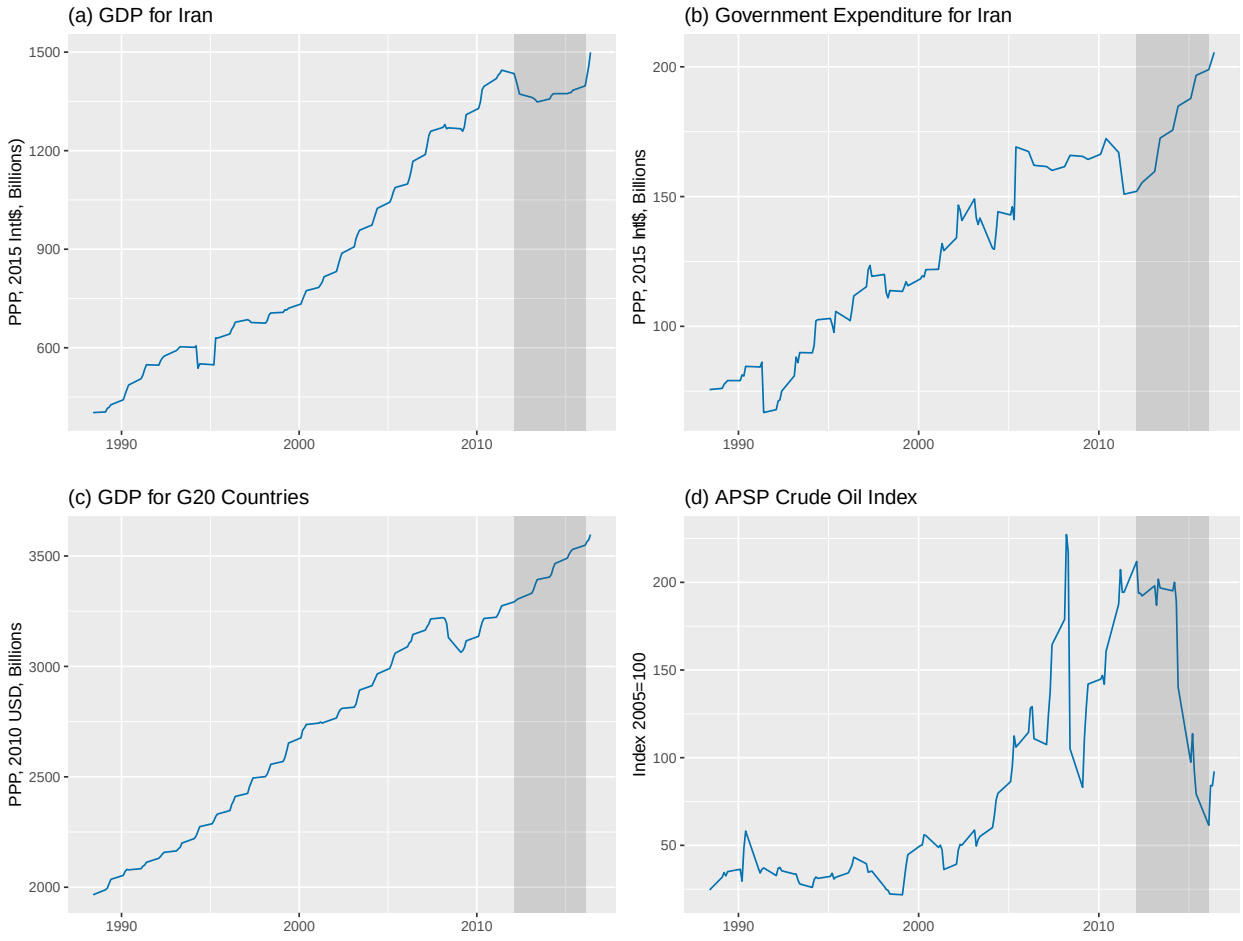
Our goal is to determine whether any of these potential confounders has a substantial effect on Iran's GDP during the SWIFT sanction. Figure 8 compares plots of our confounder variables during the period 1988Q4-2016Q4, where the shaded vertical line corresponds to the SWIFT sanction (the event of interest). At first glance, it does not seem that the movements in our potential confounder variables would have impacted Iran's real GDP during the SWIFT sanction in a substantive way.

The behavior of our potential confounders during the SWIFT sanction episode seems to conform to their respective trends, making it unlikely that they would have contributed to the movements of Iran's real GDP during this periods in a significant way. The only exception is perhaps the price of crude oil which, as panel (d) in Figure 8 depicts, dropped precipitously beginning in the second quarter of 2014.

In theory, it is possible that this sharp decline in crude oil prices impacted the Iranian economy in one of two ways, depending on whether demand for Iranian oil was the cause of

[8]The APSP Crude Oil Index is a simple average of three spot prices for oil: Dated Brent, West Texas Intermediate, and Dubai Fateh.

Figure 8: Confounders



Notes: Panel (a) plots Iran's quarterly real GDP in billions of purchasing power parity (PPP) adjusted 2015 international dollars. Data for panel (a) is obtained from the Central Bank of Iran and the Statistical Center of Iran. Panel (b) plots government expenditure for Iran in billions of PPP-adjusted 2015 international dollars. Data for panel (b) is from the Statistical Center of Iran. Panel (c) plots real GDP for the Group of Twenty (G20) countries in billions of PPP-adjusted 2010 US dollars. Data is obtained from the Organisation for Economic Co-operation and Development Statistics database (OECD.Stat). Panel (d) plots values for the APSP Crude Oil Index where 2005=100. Data for Panel (d) is obtained from the Federal Reserve Bank of St. Louis Economic Data (FRED) database. The shaded vertical bar in Panels (a)-(d) represents the duration of the SWIFT sanction.

decline in global crude oil prices. If the precipitous decline in global crude oil prices occurred irrespective of demand for Iranian crude oil, then we might reasonably expect the decline to correspond with a decrease in Iran's real GDP since a lower global price of crude oil would lessen the appeal of a cheaper alternative.[9]

Panel (a) in Figure 8 depicts a slight increase in Iran's real GDP beginning in roughly the third quarter of 2015. Given the delayed and seemingly negligible change in Iran's real GDP, it is unclear whether the sharp movements in the global price of crude oil had any meaningful impact.

To more accurately assess the impact of our potential confounders on Iran's real GDP, we estimate a distributed lag model which allows us to understand how current and past values of our potential confounders affect Iran's real GDP. Specifically, we use quarterly data during the period 1988Q4-2016Q4 and estimate the following regression after first-differencing our variables to obtain stationarity:

$$\triangle GDP_t = \alpha + \sum_{j=0}^{p} \delta_j \triangle OIL_{t-j} + \sum_{j=0}^{p} \theta_j \triangle EXP_{t-j} + \sum_{j=0}^{p} \gamma_j \triangle G20_{t-j} + \beta D_t + \triangle \epsilon_t \qquad (3.1)$$

where p is the lag length chosen on the basis of the BIC criterion; GDP_t is Iran's quarterly real GDP at time t in billions of PPP-adjusted, 2015 international dollars; OIL_t is the global price of oil at time t based on the APSP Crude Oil Index in US dollars per barrel; EXP_t is the level of Iran's government expenditure at time t in billions of PPP-adjusted, 2015 international dollars; $G20_t$ is the average GDP for a subset of Group of Twenty (G20) member countries in billions of PPP-adjusted, 2010 international dollars; and D_t is a dummy

[9]This point is related to a strand of the sanctions literature arguing that the existence of a third-party nation who will trade with a target (i.e., a *sanctions buster*), has substantial impact on whether a sanction will be successful. Crucially, the willingness of a third-party nation to help a target circumvent sanctions is higher the more profitable the arrangement. Applied to the present case, this argument logically implies that the higher the global price of crude oil, the higher the likelihood that nations will be willing to incur the risk of acting as a *sanctions buster* to purchase a cheaper alternative. (Hanlon, 1986; Early, 2013)

variable at time t for the SWIFT sanction set to one for each quarter during the SWIFT sanction episode and set to zero otherwise.[10] Table 8 shows our results from estimating equation (3.1).

Table 8: Robustness Time-Series Regression

	Dependent variable: ΔGDP_t			
	(1)	(2)	(3)	(4)
SANCTION (D_t)	-14.527^{***}	-15.339^{***}	-14.327^{***}	-13.454^{***}
	(3.601)	(3.349)	(3.352)	(3.547)
$\Delta APSP_t$	-0.019	-0.012		0.055
	(0.067)	0.067		(0.052)
$\Delta G20_t$	0.199^{**}	0.193^{**}	0.190^{***}	
	(0.080)	0.081	(0.067)	
ΔEXP_t	-0.452		-0.450	-0.434
	(0.383)		(0.383)	(0.393)
Observations	678	678	678	678
R^2	0.558	0.155	0.175	0.147
Adjusted R^2	0.521	0.132	0.152	0.123

Notes: The dependent variable in all four specifications is Iran's real GDP in billions of PPP-adjusted, 2015 international dollars. Columns (1)-(4) reports results from estimating the distributed lag model specified in equation 3.1 when all potential confounders are included (Column [1]), $\Delta\ EXP$ is omitted (Column [2]), $\Delta\ APSP_t$ is omitted (Column [3]), and $\Delta\ G20_t$ is omitted (Column[4]), respectively. All regressions include robust standard errors. ***p<0.001; **p<0.01; *p<0.05

Given our potential confounders, the coefficient estimate for our sanction dummy variable (D_t) is statistically significant at the .1% level and large, indicating that the quarterly change in Iran's real GDP (in PPP-adjusted, 2015 international dollars) was approximately $14.5 billion lower when the SWIFT sanction was in effect than when it was not. The sanction dummy variable (D_t) remains nearly unchanged across the four specifications of our model (reported in Columns [1]-[4], respectively), suggesting that failure to control for our potential

[10]G20 member countries included in the calculation of this variable were selected based on data availability and include Australia, Canada, France, Germany, Italy, Japan, Korea, South Africa, Turkey, the United Kingdom, and the United States.

confounders in forecasting Iran's real GDP will have no meaningful effect on our results.[11] We thus proceed to forecasting Iran's GDP in the next section.

3.4.2 Univariate Time-series Forecasting Method

In this section, a univariate time-series forecasting model is used to determine what Iran's GDP would have been if the SWIFT sanction had not been imposed in 2012. Students of econometrics will recall that a key assumption needed to develop estimators for a classical regression model is that there is no covariance between disturbances of different observations (i.e., the disturbances are non-autoregressive). Though violation of this assumption poses a distinct problem for regression analysis, the correlation between data can be harnessed in time-series analysis to make predictions. Applied to forecasting, time-series models use past data values to predict future values and so are unlike structural macroeconomic models that attempt to define a trend through causal relationships between variables that is informed by economic theory. Though unable to explain causation, time-series forecasting techniques are particularly useful tools when the movement of values is thought to be influenced by a complex set of relationships. With regard to these complex dynamics (as naturally underlies movements in macroeconomic indicators), structural macroeconomic models are vulnerable to misspecification, endogeneity, and omitted variable bias, thus making time-series forecasting techniques an especially effective alternative (Marcellino, 2008; Keck, Raubold and Truppia, 2010; Wang, 2016).

The dynamics that underlie movements in Iran's GDP are complex, indeed. The econ-

[11] It should be noted, however, that the average GDP of G20 member countries ($\Delta G20$) has a positive and statistically significant effect ($p < 0.01$) on Iran's real GDP given changes in the market price of oil and Iran's government expenditure, as well as the SWIFT sanction episode. Yet, a convincing case emerges for pursuing a simple forecast of Iran's real GDP using its own structural processes when we consider that to the extent that failure to control for $\triangle G20$ biases our forecast estimates, our results indicate that the direction of bias is downward. Note, for instance, that when $\Delta G20$ is omitted from equation 3.1, the coefficient estimate for our sanction dummy variable (reported in Column [4]) is approximately \$1.1 billion *lower* in absolute value terms than when $\Delta G20$ is included in equation 3.1.

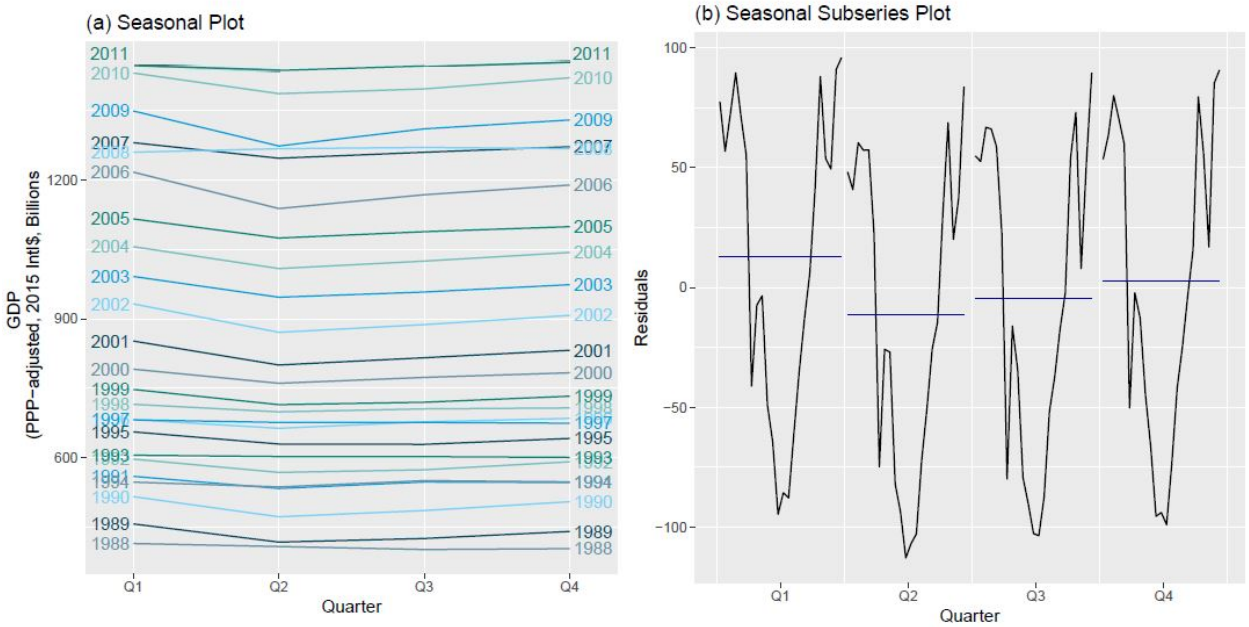
omy has operated under a host of sanctions since 1979 that are different in scope, effect, and duration. A significant literature exists theorizing the effect of sanctions on economies, governments, and citizenries, but there does not exist a wide-ranging consensus view on the effect of individual sanctions, much less on the dynamics of multiple and variable sanctions (Hufbauer, Schott, Elliott, and Oegg, 2007; Eriksson, 2016; Haidar, 2017). In short, the sanctions regime imposed on Iran since the Revolution makes it difficult to understand the dynamics of Iranian GDP in a way that would readily lend itself to forecasting using a structural macroeconomic model. Use of a structural macroeconomic model is also complicated by a common problem that is only exacerbated in the case of a pariah state: data availability (Valadkhani, 2003; Alaedini and Ashrafzadeh, 2016).

In this analysis, we circumvent these difficulties by using Iran's own structural processes to predict what real GDP would have been if the SWIFT sanctions had not been imposed. Accordingly, we follow the Box and Jenkins methodology (1976) to fit a seasonal, autoregressive integrated moving average (seasonal ARIMA) model to forecast Iran's GDP during the time-period 2012Q1-2016Q4 (the entire duration of the SWIFT sanction implementation). We are prompted to use a seasonal ARIMA because the periodic fluctuations in Iran's GDP prior to the SWIFT episode illustrated in Figure 6 suggest that the series possibly possesses a seasonal component which, if present, must be accounted for in our time-series model.

That the time series variable representing Iran's GDP possesses a seasonal component is more clearly seen in Figure 9 which presents a seasonal plot of Iran's GDP prior to the SWIFT sanction episode in panel (a) and a seasonal subseries plot of the residuals of a linear model relating Iran's GDP and the time period in panel (b).

By plotting each observation against each quarter (or season), panel (a) in Figure 9 suggests that the series indeed possesses a seasonal component: Iran's GDP typically peaks in Q1, declines slowly into the second quarter, and then slowly increases.

Figure 9: Seasonal Component of Iran's GDP



Notes: Panel (a) plots Iran's quarterly real GDP in billions of PPP-adjusted 2015 international dollars against each quarter. Panel (b) plots the residuals of a linear model relating Iran's GDP (in billions of PPP-adjusted, 2015 international dollars) and the time period.

Panel (b) of Figure 9 also confirms the existence of a seasonal component. The seasonal subseries plot featured plots the residuals of a linear model relating Iran's GDP and the quarterly time period (to detrend the data prior to plotting), where the horizontal blue line delineates the mean for each quarterly subseries. The plot demonstrates that, on average, the series reaches a maximum in the first quarter, a minimum in the second quarter, and then slowly increases. Thus, an ARIMA model that accounts for a seasonal component in our time series variable to be forecasted is necessitated.

A seasonal ARIMA model forecasts a time-series based on the assumption that it is a multiplicative combination of its non-seasonal and seasonal components. Its general form in backshift notation (for conciseness) is expressed as,

$$\Phi_P(B^s)\phi_p(B)\nabla_s^D\nabla^d Z_t = \theta_q(B)\Theta_Q(B^s)a_t \tag{3.2}$$

where p, d, and q represent the order of the autoregressive (AR), integrated (I), and moving average (MA) processes, respectively, for the non-seasonal component representing the time series; P, D, and Q represent the order of the AR, I, and MA processes, respectively, for the seasonal component representing the time series; s is the period of seasonality; B is the backshift operator; $\Phi_P(B^s)$ and $\phi_p(B)$ are the seasonal AR operator of order P and the non-seasonal AR operator of order p, respectively; $\Theta_Q(B^s)$ and $\theta_q(B)$ are the seasonal MA operator of order Q and the non-seasonal MA operator of order q, respectively; ∇_s^D is the seasonal backward difference operator for D differences and s periods and ∇^d is the non-seasonal backward difference operator for d differences and s periods; Z_t is the time-series to be forecasted; and a_t is a white noise process. In simplified form, the seasonal ARIMA model is written as ARIMA$(p,d,q)(P,D,Q)_s$.

Fitting an ARIMA $(p,d,q)(P,D,Q)_s$ model requires that the underlying time series be

stationary. Figure 6 demonstrates that Iran's GDP exhibits a strong upward trend; thus, the data is first-differenced (d=1) and an Augmented Dickey-Fuller (ADF) test — a standard formal test for stationarity — is used to confirm stationarity. The results from performing an ADF test on our variable for Iran's real GDP are presented in Table 1.3 and confirm our series is integrated of order 1.

Table 9: ADF Test

	ADF Test Statistic
GDP_t	-0.920
ΔGDP_t	-4.656^{***}

Notes: The variable GDP_t represents Iran's GDP (PPP-adjusted, 2015 International dollars) in time period t. Lag orders are chosen to minimize the Bayesian information criterion. Statistical significance of the test statistic indicates rejection of the null hypothesis that the series follows a unit root process. ***p<0.001; **p<0.01; *p<0.05

To account for the seasonal component of our quarterly time series for Iran's GDP, we apply a seasonal difference where s, the period of seasonality, equals 4.[12]

The auto.arima() function in R is utilized to select an ARIMA$(p,d,q)(P,D,Q)_s$ model based on minimizing the Bayesian information criterion (BIC).[13] The result is an ARIMA $(1,1,1)(0,0,1)_4$ model with drift. Thus, our model takes the following form where GDP_t

[12]The resulting autocorrelation function (ACF) and partial autocorrelation function (PACF) of the transformed series (i.e., the seasonal difference of the first difference of Iran's GDP) is shown in Figure 13 of Appendix B. The ACF plots the correlation between the variable being forecasted (here, Iran's real GDP) and its past values. The PACF plots the correlation between the variable being forecasted and its past values that is not the result of previous correlations.

[13]The BIC offer one solution to the challenge of choosing parameter values for an ARIMA $(p,d,q)(P,D,Q)_s$ model. The problem arises from the fact that if too high a value is chosen, forecasts may suffer from increased estimation error whereas if too low a value is chosen, forecasts may ignore relevant information contained in past values. The BIC penalizes increases to the parameter values so that the true parameter values can be determined.

represents Iran's GDP (in billions of PPP-adjusted, 2015 international dollars) at time t and μ is a constant.

$$\phi_1(B)(1-B)GDP_t = \mu + \theta_1(B)\Theta_1(B^4)a_t \tag{3.3}$$

Table 10 displays our results from estimating equation (3.3) and the calculated Ljung-Box statistic through 8 lags is 4.40 and statistically insignificant, indicating that the residuals of our estimated model follow a white-noise process.

Table 10: Forecast Summary

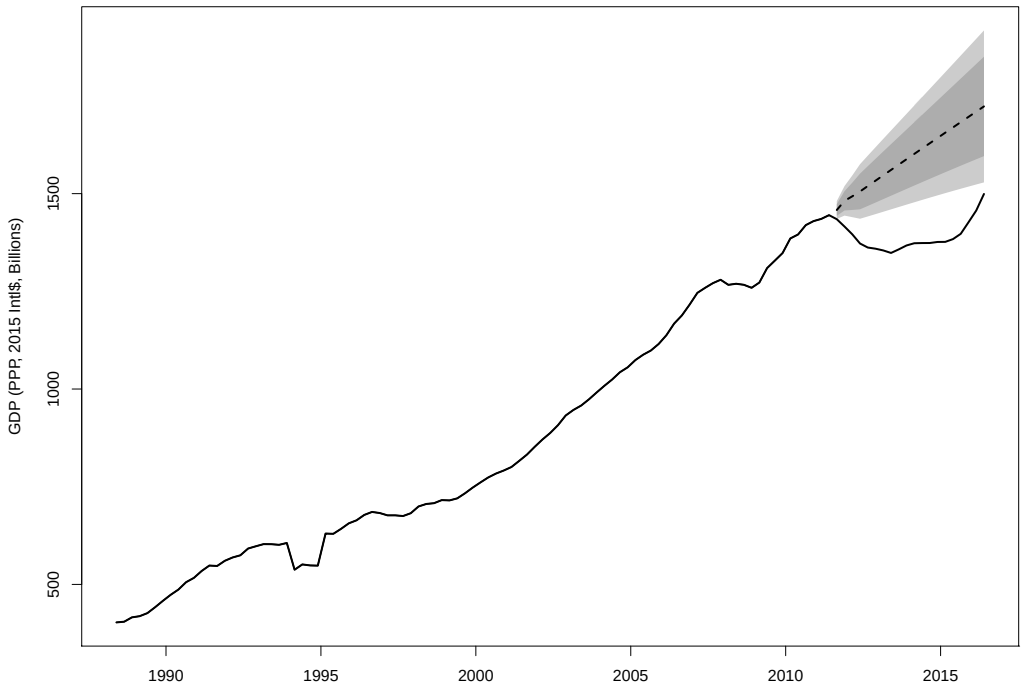
ARIMA(1,1,1)(0,0,1)$_4$ with drift	Estimate
Constant	11.47
	(2.19)
AR(1)	0.96
	(0.04)
MA(1)	-0.65
	(0.09)
SMA(1)	-0.79
	(0.09)
N	113
Log-likelihood	-356.88
AIC	723.75
BIC	736.36

Notes: Standard error in parenthesis

Using our ARIMA $(1,1,1)(0,0,1)_4$ model with drift, we forecast values for Iran's real GDP over the entire SWIFT sanction episode (2012Q1-2016Q1). Figure 10 illustrates our results.

The dashed black line above the noticeable plunge in Iran's real GDP starting in 2012Q1 is the forecasted value of Iran's real GDP in billions of purchasing power adjusted, 2015 international dollars. That is, the dashed line represents what Iranian GDP would have

Figure 10: Forecast of Iran's real GDP



Notes: The dashed line in the figure represents a forecast of Iran's GDP during the period 2012Q1-2016Q4 generated from an ARIMA$(1,1,1)(0,0,1)_4$ model. The lightly and darkly shaded areas represents the 80% and 95% prediction intervals, respectively.

been if the SWIFT sanctions had not been imposed and real GDP had continued to follow the pre-2012Q1 trend. Table 11 compares quarterly forecasted values to actual values for Iran's real GDP.

Table 11: Forecast and Cost Estimates

Date	Actual GDP	Forecasted GDP	Lo95 CI	Hi95 CI	Forecast-Actual
2012Q1	1434.57	1458.13	1435.36	1480.91	23.56
2012Q2	1415.68	1481.63	1443.80	1519.46	65.95
2012Q3	1395.85	1493.17	1439.82	1546.53	97.32
2012Q4	1372.37	1505.57	1435.75	1575.39	133.20
2013Q1	1362.09	1519.38	1441.62	1597.14	157.29
2013Q2	1359.12	1533.16	1447.61	1618.71	174.04
2013Q3	1354.66	1546.92	1453.67	1640.16	192.26
2013Q4	1348.22	1560.64	1459.75	1661.54	212.42
2014Q1	1357.38	1574.34	1465.82	1682.87	216.96
2014Q2	1367.37	1588.02	1471.87	1704.16	220.65
2014Q3	1373.09	1601.66	1477.88	1725.44	228.57
2014Q4	1373.54	1615.28	1483.83	1746.73	241.74
2015Q1	1373.64	1628.87	1489.72	1768.01	255.23
2015Q2	1376.33	1642.43	1495.54	1789.32	266.10
2015Q3	1376.55	1655.96	1501.29	1810.64	279.41
2015Q4	1383.70	1669.47	1506.95	1831.99	285.77
2016Q1	1397.17	1682.95	1512.53	1853.37	285.78
2016Q2	1426.65	1696.41	1518.03	1874.78	269.76
2016Q3	1456.74	1709.83	1523.44	1896.23	253.09
2016Q4	1499.20	1723.23	1528.76	1917.71	224.03

Notes: Figures are in billons of purchasing power adjusted 2015 international dollars. Forecasted GDP is an average of the low and high 95% prediction interval values.

3.4.3 Discussion

The impact to Iran's real GDP of the SWIFT sanction is sizeable. We calculate that the average quarterly cost of the SWIFT sanction to Iran's real GDP is approximately $204.3 billion (PPP-adjusted, 2015 international dollars), or 14.7% and 13.8% of Iran's average

quarterly actual and forecasted GDP, respectively. This impact is striking given the steady upward trend of Iran's real GDP since roughly 1996, suggesting a resilience to the variety of sanctions levied against it before SWIFT sanctions were imposed.

One reason why a seemingly targeted financial sanction levied such a substantial cost onto the Iranian economy is owing to the unique form financial sanctions take when access to global networks becomes a tool for compliance. By using access to a unique global financial network as a sanction, targets are selectively removed from an edifice upon which international economic relations take place. In practice, therefore, ostensibly targeted financial sanctions wielding access to global financial networks will resemble the comprehensive trade sanctions they were intended to replace, with all the latter's attending humanitarian impacts.

Indeed, and perhaps unsurprisingly given the shock to Iran's economy, journalistic accounts began to emerge in and around 2012 reporting shortages of crucial medicines, foodstuffs, and medical devices in Iran (Bozorgmehr, 2012; Mohammed, 2012; Gladstone, 2013). Also reported were higher poverty levels owing to rising food prices, high inflation, and increasing unemployment (Warrick and Ball, 2012; Bozorgmehr, 2013; Nasseri and Motevalli, 2015). Formal empirical analyses also confirm journalistic reports; for instance, Setayesh and Mackey (2016) find that of the 73 drugs in shortage in Iran during the period when the SWIFT sanction was levied, 44% are classified as essential medicines according to the World Health Organization.

3.5 Concluding Remarks

In this paper we have argued that the development of global financial networks has enabled financial sanctions—sanctions aimed at stopping the flow of funds to and from a

target country—to have a more comprehensive effect. As a result, financial sanctions are coming to resemble the heavy-handed and inefficient trade sanctions they were meant to replace. To provide evidence in support of our argument, we focus on a unique set of financial sanctions levied against the Islamic Republic of Iran.

In 2012, Iran was the first country to have been removed from the Society for Worldwide Interbank Financial Telecommunications (SWIFT), a global financial messaging service. Though advertised at the time to be targeted to Iran's governmental and financial elite, the financial sanction delivered a sizeable negative shock to Iran's real economy. To analyze the impact of this shock, we employ a time-series forecasting model to measure the cost of exclusion from the SWIFT network on Iran's real GDP.

By calculating the difference between Iran's forecasted and actual real GDP, we find that the cost of the SWIFT sanctions to Iran's real GDP was, on average, approximately $204.3 billion (PPP-adjusted 2015 international dollars), which represents approximately 14.7% and 13.8% of Iran's average quarterly actual and forecasted GDP, respectively. We conclude that the SWIFT sanctions made a considerable impact to Iran's real GDP which belies the claim that these sanctions are targeted or "smart."

How the development of global financial networks has changed the nature of financial sanctions has been, to the best of our knowledge, unnoticed in the sanctions literature. This is at least partly because the latter largely still conceptualizes the global arena through a dyadic framework (that is, sanctions are analyzed on a sovereign-to-sovereign basis rather than on a network-sovereign basis.)[14] Given the potential for financial sanctions to demonstrate the heavy-handedness and inefficiency characteristic of comprehensive trade sanctions, however, we conclude that more research is warranted.

[14]Exceptions include Joshi and Mahmud (2016, 2018).

A P P E N D I X A

ADDITIONAL TABLES AND FIGURES FOR CHAPTER 2

Table 12: Data and Sources

Variable	Description	Source
$USTS_{it}$	Foreign holdings of long-term US Treasury securities. Monthly data available for 92 countries and 6 regions during the period 1984-2017. Data adjusted for valuation effects.	Bertaut and Judson (2017)
$CRED_{it}$	Outstanding dollar credit. Quarterly data available for fourteen developing and emerging market economies during the period 2000Q1-2018Q4.	Bank for International Settlements
$EXCH_t$	5-year moving average of the US Dollar to Special Drawing Rights exchange rate. Quarterly data is available from 1975Q1-2019Q1.	Federal Reserve Bank of St. Louis (FRED Economic Data)
$DEPTH_t$	Financial Depth of the US relative to the Euro Area, United Kingdom and Japan. Financial depth is the sum of a country's domestic private credit, stock market capitalization, and bond market capitalization	World Federation of Exchanges. Bank for International Settlements
$DEPTH2_t$	Financial Depth of the US relative to the Euro Area, United Kingdom and Japan. Financial depth is the ratio of broad money (M3) to GDP.	FRED Economic Data. CEIC data. Bank for International Settlements.
$NETW_t$	Economic size of the US relative to Euro Area, United Kingdom and Japan. Economic size is the ratio of country GDP to world GDP.	International Monetary Fund. CEIC data
$YIELD_t$	Yield on long-term US Treasury securities relative to yield on long-term government bonds for Euro Area, United Kingdom and Japan. Quarterly data for all regions is available during the period 1989Q1-2019Q1.	Federal Reserve Bank of St. Louis (FRED Economic Data)

Table 13: Country Codes

Country	Code
Argentina	AR
Brazil	BR
Chile	CL
China	CH
India	IN
Indonesia	ID
Malaysia	MY
Mexico	MX
Republic of Korea	KR
Russia	RU
South Africa	ZA
Taiwan	TWN
Turkey	TR

Table 14: Correlation Matrix

	$USTS_{it}$	$CRED_{it}$	$EXCH_t$	$DEPTH_t$	$NETW_t$	$YIELD_t$	$USTS_{i,t-1}$
$USTS_{it}$	1						
$CRED_{it}$	0.783	1					
$EXCH_t$	0.199	0.399	1				
$DEPTH_t$	−0.036	−0.079	−0.176	1			
$NETW_t$	0.004	0.099	0.025	−0.034	1		
$YIELD_t$	−0.010	0.076	−0.040	−0.196	0.722	1	
$USTS_{i,t-1}$	0.999	0.794	0.205	−0.036	0.009	−0.006	1

Notes: See Table 12 in Appendix A for data sources and definitions.

Table 15: Variance Inflation Factors

	Model: Equation 2.9	
Dependent	Tolerance	VIF
Variable	(1)	(2)
$\Delta USTS_{i,t-1}$	0.939	1.065
$\Delta CRED_{it}$	0.945	1.058
$\Delta EXCH_{it}$	0.926	1.080
$\Delta DEPTH_{it}$	0.832	1.202
$\Delta NETW_{it}$	0.831	1.203
$\Delta YIELD_{it}$	0.898	1.114

Notes: Columns (1) and (2) report the level of tolerance and VIF for each regression of the dependent variable on a linear combination on the remaining independent variables in equation 2.9, respectively. $\Delta USTS_{i,t-2}$ is used as an instrument for $\Delta USTS_{i,t-1}$.

Table 16: First Stage for $\Delta\text{USTS}_{i,t-1}$

	Dependent variable: $\Delta USTS_{i,t-1}$	
	Panel A	Panel B
	China included	*China Omitted*
	(1)	(2)
$\Delta\text{USTS}_{i,t-2}$	0.710***	0.475***
	(0.029)	(0.077)
ΔCRED_{it}	0.089***	0.071
	(0.025)	(0.075)
ΔEXCH_{it}	234.998	141.789
	(433.145)	(248.297)
ΔDEPTH_{it}	0.017	0.044
	(0.062)	(0.049)
ΔNETW_{it}	1.181	0.208
	(0.979)	(0.902)
ΔYIELD_{it}	3.061	1.019
	(6.550)	(2.885)
Observations	689	
R^2	0.558	
Adjusted R^2	0.521	

Notes: Column 1 is the first-stage regression for Panel A where China is included in the sample. Column 2 is the first-stage regression for Panel B where China is omitted from the sample. Both regressions include time dummies and robust standard errors clustered by country in parentheses. For detailed data definitions and sources, see Table 12 in Appendix A. ***p<0.001; **p<0.01; *p<0.05

Table 17: Correlation Matrix- Alternative Measure of Financial Depth

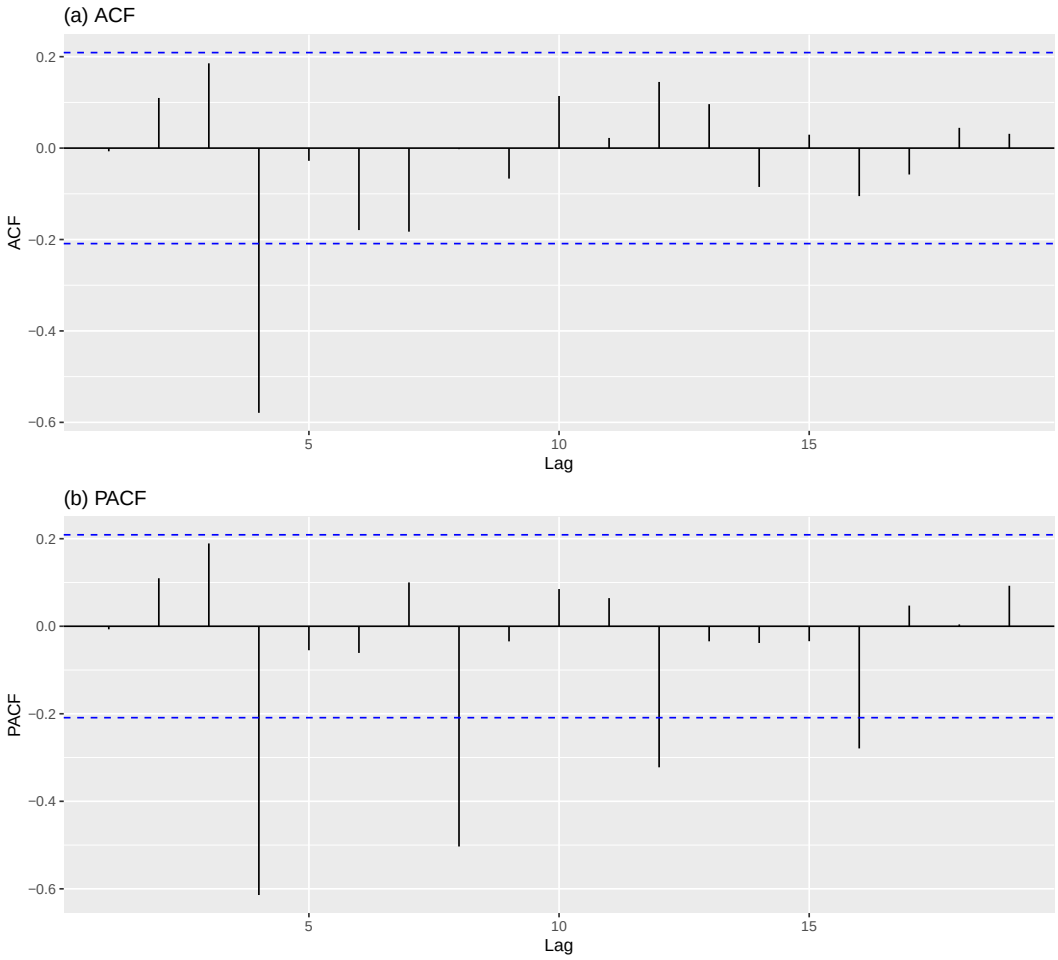
	$USTS_{it}$	$CRED_{it}$	$EXCH_t$	$DEPTH1_t$	$DEPTH2_t$	$NETW_t$	$YIELD_t$	$USTS_{i,t-1}$
$USTS_{it}$	1							
$CRED_{it}$	0.782	1						
$EXCH_t$	0.174	0.272	1					
$DEPTH1_t$	−0.039	−0.084	−0.098	1				
$DEPTH2_t$	−0.162	−0.227	−0.915	0.002	1			
$NETW_t$	0.003	0.096	0.188	−0.032	0.242	1		
$YIELD_t$	−0.010	0.076	−0.287	−0.197	0.345	0.722	1	
$USTS_{i,t-1}$	0.999	0.793	0.175	−0.040	−0.160	0.007	−0.005	1

Notes: $DEPTH1_t$ represents financial depth defined as the sum of a country's domestic private credit, stock market capitalization, and bond market capitalization relative to GDP. $DEPTH2_t$ represents financial depth defined as the ratio of broad money (M3) to GDP. See Table 12 in this Appendix A for data sources and definitions.

A P P E N D I X B

ADDITIONAL TABLES AND FIGURES FOR CHAPTER 3

Figure 11: ACF and PACF Patterns of Transformed GDP for Iran



Notes: Panels (a) and (b) illustrate the autocorrelation function (ACF) and partial autocorrelation function (PACF), respectively, of the seasonal difference of the first difference of Iran's GDP (in billions of PPP-adjusted, 2015 international dollars).

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