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Arjun Sondhi
Wayne State University,

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ARJUN SONDHI

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DEDICATION

For my parents and family, who supported me unconditionally and sacrificed much throughout this process,

and to my grandmother, the most wonderful person I have ever known.

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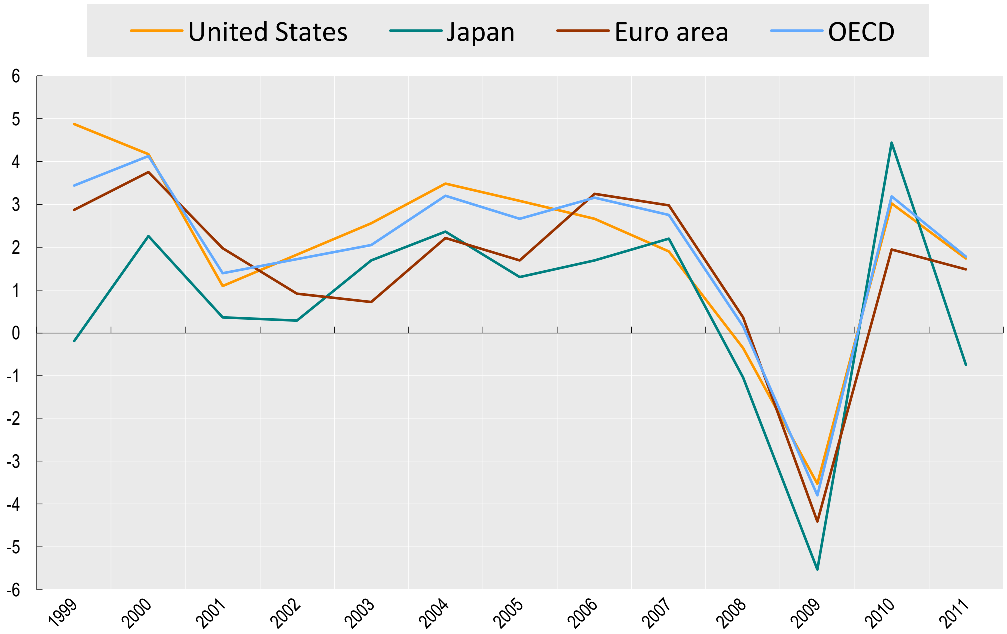
CHAPTER 1: INTRODUCTION

The global nature of the Great Recession led to the resurgence of literature trying to find a link between international channels and international business cycle synchronization. Understanding the impact of international channels on exaggerating fluctuations in macro variables is of paramount importance. Sharp decline in global output following the 2007 crash was the worst seen in decades. According to BEA estimates, U.S GDP fell by 6.2, consumption by 4.3 and investment by 22 percent during the last quarter of 2008. This behavior was experienced amongst most OECD countries, even though the source of the negative shock had its roots largely in the U.S. There was an unprecedented synchronous downturn amongst most developed countries. Figure 1 represents the global nature of the recent crisis and demonstrates a remarkable synchronous collapse in economic growth rates across the developed world. Furthermore, the synchronous behavior of output growth rates is stronger during the 2008 recession than in years prior or after. This provides some evidence, albeit anecdotal, that cross-country correlations do not exhibit symmetric behavior during expansions and recessions. In chapter 3, I investigate this asymmetric behavior using a two-country dynamic stochastic general equilibrium model. The biggest contribution of chapter 3 is to test how macro variables move across two countries by allowing for a switch between expansionary and recessionary phases. I find that variables move more synchronously during recessions than expansions.

An equally important question arising from the great recession was the impact of monetary policy on macro variables. Most central banks went beyond the normal limits of monetary policy. In that regard, I test the long run monetary neutrality, which states that money has no effect on real variables in the long run. I focus on testing how temporal aggregation affects the results. These tests are carried out in chapter 4 of this paper.

Figure 1: Real GDP growth in percent, annual

OECD database



To combat the global recession, most central banks used monetary and quantitative easing. This brings to the forefront a heavily researched, yet inconclusive macro phenomenon of money neutrality; which states that money only temporarily effects macro variables. I explore these two macroeconomic questions. First, I investigate how propagation of shocks through international financial channels asymmetrically affects output correlation. Second, I carry out statistical tests to test for money neutrality in G-7 countries.

The impact on an economy due to international interdependence can be due to either trade or financial linkages. Like the Great Depression of the 1930's, the financial crisis that plagued much of the developed world in 2007 has led to considerable research seeking to understand the causes and nature of such global phenomenon. Even though the source of the financial crisis of 2007 was limited to a few countries, the economic impact was unquestionably global.

Trade alone could not account for the severity of the synchronous downturn. Given that regional trade far exceeds that between regions, trade alone cannot explain such output correlation. Moreover, since U.S was the severest source for the financial crisis, the assumption for trade to be an important channel would imply that synchronization between the U.S and regional trade partners such as Canada or Mexico should be far greater. But we see a corresponding sharp decline in output for countries that are only marginally linked to the U.S. Hence, it is worth investigating the role financial channels play. To represent financial integration, an examination of total short-term claims of U.S reporting banks of claims on foreign economy is warranted. Table 1 shows total stock of U.S banks claims on other countries with up to and less than one year until maturity. The amount of new or near maturity claims issued contracted sharply following the recession. In normal times, new claims are regularly issued and many maturing ones are reissued quarterly. The countries included are the ones with which U.S has strong financial ties. Many OECD countries experienced a sharp fall in short-term claims of U.S banks during 2008. As the Deputy Governor of the Reserve Bank of India, Rakesh Mohan said: “Our problems are mainly due to the sell-off by foreign institutional investors in the domestic markets leading to a sharp reduction in net capital inflows and the sharp slowdown in global economic activity and external demand” (Mohan, 2009)

Table 1: Bank Assets

Short term claims of U.S banks on select OECD countries in $US millions			
	2008, Q1	**2008, Q4**	**Percent change**
Canada	168,565	145,010	-13.97%
France	69,098	55,287	-19.98%
Germany	65,933	39,266	-40.4%
Ireland	27,471	23,550	-14.27%
Italy	25,521	17,243	-32.43%
Netherlands	46,995	37,230	-20.77%
Spain	28,367	18,420	-35.06%
Data is from BIS International Banking Statistics			

To sum up my motivation to analyze financial links and their asymmetric effect on output correlation, I run some simple regressions before getting into the theoretical model. I use change in real GDP growth from year to year as the dependent variable. I run the same regressions across two time periods. One from 1996 to 2006 and another for just one year; December 2007 to December 2008. The latter period represents the financial crash. To measure sudden change in capital outflows in a country, I take total capital inflows from the U.S. as a percent of that countries' GDP using U.S Treasury International Capital data (TIC) in year t-1. To differentiate between financial and trade links, I take exports to the U.S as a percent of GDP, or variable X. To represent "flight to quality" by investors, I include credit rating of a country, representing their ability to raise more capital. Capital withdrawals will affect countries with lower sovereign credit rating more severely. Standard and Poor provides sovereign rating ranging from AAA to B for the countries in my sample and like Devereux and Yetman, I assign a numerical value to each rating as represented in Table 2. I interact the rating term (CR) with X and TIC to account for "flight to quality". The data is for 29 OECD countries with available data.[1]

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[1] The countries included are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico,

Table 2: Credit Rating conversion

S&P letter rating	My conversion	Meaning
AAA	0	Extremely strong
AA+	1	Very strong
AA	2	Very strong
AA-	3	Very strong
A+	4	Strong
A	5	Strong
A-	6	Strong
BBB+	7	Adequate
BBB	8	Adequate
BBB-	9	Adequate
BB+	10	Faces major future uncertainties
BB	11	Faces major future uncertainties
B	12	Faces major uncertainties
Standard and Poor sovereign credit rating of a country		

The results are presented in Table 3. There is strong evidence that not only does financial flows play a significant role in the financial crisis, but that the impact is stronger during recessions. Moreover, trade appears to be less important. The measure of capital flows is significant in all cases and has an adverse effect on GDP. This effect becomes stronger when capital inflows interact with credit rating. The interactive term between credit rating and capital inflows from the U.S is negative and statistically significant, supporting the notion of "flight to quality".

To summarize, financial channels are important in propagating shocks to output and more importantly those effects are stronger during recessions.

Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United State, United Kingdom

Table 3: Asymmetrical significance of financial channels on output growth

Financial impact during expansionary years 1996-2006					
X	0.04 (0.788)	0.009 (0.89)			0.05 (0.695)
CRX		−0.016 (0.76)			0.039 (0.144)
TIC			**−0.001 (0.045)**	**−0.001 (0.006)**	**−0.017 (0.005)**
CRTIC				**−0.046 (0.022)**	**−0.08 (0.009)**
Adjusted R^2	0.02	0.14	0.44	0.29	0.4
N	319	319	319	319	319

Dependent variable: change in real GDP growth rate between December 1996 and 2006
p values are in parenthesis and coefficients that are bold are significant at the 5% level
X represents exports to the U.S.
CR represents S&P sovereign foreign currency credit rating. Capital withdrawals are likely to affect more significantly countries with worse rating.
CRX is the interactive term between X and CR
TIC is gross capital inflows from the US as a percent of GDP in t-1. This measures a country's sudden outflow of capital using US Treasury data
CRTIC is the interactive term between TIC and CR

Financial impact on the 'Great Recession' 2007-2008					
Exports to US (X)	−0.024 (0.844)	0.003 (0.99)			−0.043 (0.665)
CRX		−0.006 (0.77)			0.039 (0.144)
TIC			**−0.005 (0.035)**	**−0.006 (0.006)**	**−0.047 (0.006)**
CRTIC				**−0.057 (0.012)**	**−0.1 (0.019)**
Adjusted R^2	0.036	0.07	0.14	0.3	0.33
N	29	29	29	29	29

Dependent variable: change in real GDP growth rate between December 2007 and 2008

The neutrality of money is amongst one of the most important research question in macroeconomics. Given how much emphasis was paid by the Federal Reserve, the European Central Bank and other central bankers around the world in combatting the recession of 2007, it is worth investigating the role of money in impacting macro variables. The Fed took the traditional measure of reducing the federal funds rate from 5.25 percent in September 2007 to between 0-0.25 percent by December 2008. (Rich, 2009). They also took several untraditional measures like buying long term debt worth $1.75 trillion in the form of mortgage backed securities and making direct loans to private corporations. AIG, for example got an emergency loan to the tune of $85 billion.

The ECB, Bank of England and other central banks took similar measures. Even though these policies had the desired results of providing stimulus in the short run, it is important to understand whether such policies have any long run effects on the economy.

Neutrality of money states that permanent movements in money supply do not effect real variables like real GDP, employment and real consumption. Any affect it has is temporary and disappears once rational agents adjust their behavior. There are two related concepts: the long run money neutrality (LMN) and the long run money super neutrality (LMSN). LMSN hypothesis states that permanent movements in the growth rate of money supply, rather than the level of money supply, has no effect on real variables. Given the importance of both LMN and LMSN on monetary policy, it is worth examining this considerably debated topic. Such tests provide several empirical complications and one must be careful in the kind of data and tests used.

Empirical tests on monetary neutrality have been much less convincing than theory would suggest. Differences in statistical methods and data sources used in earlier studies might be a source of such disparity in results. Temporal aggregation of data and structural regime changes can also distort results. In chapter 4 I focus on testing the impact of temporal aggregation on results. I use monthly, quarterly and yearly data and find that VAR results are very sensitive to temporal aggregation. When aggregating data at the annual frequency, time series autocorrelations are driven down to zero. (Tiao, 1972) (Rossana & Hu, 2017) As in Rossana and Hu, I use I (1) data, which upon temporal aggregation of the data results in only on nonzero sample autocorrelation in the asymptotic limit. Rossana and Seater provide evidence that once data has been aggregated to annual frequency, asymptotic limits in Tiao (1972) are reached in every time series. This implies that any cyclical variation in the data is driven out by annual aggregation and estimated coefficients in time series regression can be wrongfully estimated to be zero. (Rossana & Seater, 1992) (Rossana & Seater, 1995) Hence, there is a potential bias towards time-series regression finding monetary neutrality by driving coefficients to zero. In chapter 4, I investigate the effects temporal aggregation might have on money neutrality tests. I use the Fisher and Seater framework to estimate the Bartlett estimator and the King and Watson VAR approach to test for neutrality and the effects of temporal aggregation for G-7 countries. The results are mixed but one very appealing feature of the F & S test is that the results are not biased with that temporal aggregation. There might still be biases from structural changes, which I do not address in this paper. Rossana and Hu investigate biases due to temporal aggregation and structural change for the U.S economy (Rossana & Hu, 2017).

CHAPTER 2: LITERATURE REVIEW

In this paper, I am investigating two important macro questions. The focus of my first question is to study the asymmetric role of financial linkages on international business cycle correlation. The second question focuses on considering the role of temporal aggregation on money neutrality tests. Regarding the first, there are two important phenomena to consider. First, international financial markets have seen a momentous increase in capital flow in recent decades. (Lane & Milesi-Ferretti, The external wealth of nations mark 2: Revised and extended measures of foreign assets and liabilities for industrial and developing countries, 2007) Cross border asset holdings have grown to such an extent that for some developed economies it exceeds their GDP. (Lane & Milesi-Ferretti, 2003). Various studies have analyzed welfare gains from international financial integration in a theoretical and empirical setting. (Bonfiglioli, 2008) (Kose, Prasad, & Terrones, Does financial globalization promote risk sharing?, 2009b) (Nicolo & Juvenal, 2012) (Devereux & Sutherland, Evaluating international financial integration under leverage constraints, 2011) Economic theory contends that countries allocate their resources to diversify risk across borders. We are moving toward an ever-increasing integration of financial markets because information technology is lowering transactions costs and of innovations in financial assets. One way to quantify financial integration is to look at bank portfolios and their claims on foreign countries' assets. Bank portfolios are a direct way to measure home bank's influence over foreign country's investment. As described later in this chapter, this is the mechanism through which financial propagation affects both home and foreign countries in my model.

A second phenomenon that has generated substantial research is measuring whether business cycles across countries have become more synchronized. The answer to this question is less conclusive and varies with the source of shocks, but does point towards an increase in synchronization. (Bordo & Helbling, 2003). Their findings indicate that global shocks are more important in driving this integration and that trade only plays a modest role. Bordo and Helbling find a trend towards increased synchronization across diverse exchange rate regimes. (Bordo & Helbling, International business cycle synchronization in historical perspective, 2011) Using a factor-structural VAR, Stock and Watson analyzed the structure of international business cycle dynamics and found that common shocks across countries increases volatility and synchronization. (Stock & Watson, 2005). They found BCS during the 2007 crisis to be significant amongst G-7 countries.

Even though evidence for global business cycle synchronization is inconclusive, one observes business cycles between certain countries and depending on nature of shocks to be more strongly correlated now than in past decades. And this leads to two fundamental questions that are addressed in this chapter; "does financial integration have any contribution to this synchronization?" and "whether these contributions have an asymmetric effect on macro variables like consumption and investment depending on the state of the economy?" A thorough understanding would enable policymakers to counter observable shocks through these channels. The goal of this chapter is to provide a simple, testable model for these assertions. I use an already developed theoretical model to test the first question. For the second question, I estimate a parameter via a Markov regime process that represents the two states of a business cycle. The parameter then enables me to measure cross-country behavior of consumption, investment, interest rate, asset portfolios and asset prices across recessions and expansions. I find that international synchronization during recessions is stronger than expansions. Guillermo Ordonez studies the asymmetries of financial frictions and finds it stronger amongst financially less developed countries (Ordonez, 2013) This paper tries to add to that answer. Specifically, I find that strong financial links cause asymmetric synchronous behavior.

A surge in global trade flows in recent decades is a potential candidate in causing business cycles to be more correlated. However, most of the increase in trade is inter-regional and not global. (Kose & Yi, Can the standard international business cycle model explain the relation between trade and comovement, 2006) And since international BCS is across continents, trade alone cannot be a significant factor. Hence it is worth investigating the role financial linkages plays both in transmitting shocks and magnifying the effects of those shocks. Empirical evidence is inconclusive. Using a panel of twenty countries Kalemli and his co-authors find there to be a negative correlation between financial links and transmission of shocks (Kalemli-Ozcan, Papaioannou, & Peydro, 2009). Imbs find that the correlation between the two is strongly dependent on the source of shocks where common shock tends to lower BCS and country-specific shock increases synchronization between countries that are more financially integrated (Cesa-Bianchi, Imbs, & Saleheen, 2016). There is also evidence that BCS is stronger for countries that have more financial linkages. (Imbs, The real effects of financial integration, 2006) (Imbs, Trade, finance, specialization and synchronization, 2004) However, many studies like these are purely empirical exercises and are not based on micro-founded models. Krugman points out that unlike trade literature, international financial studies lacks a multiplier effect (Krugman, 2008). One where financial shocks in one country affect macro variables in both home and foreign countries. This chapter uses the theoretical model developed by Devereux and Yetman and the solution technique developed by Devereux and Sutherland to test my hypothesis. (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010)

(Devereux & Sutherland, Country portfolios in open economy macro models, 2011). Devereux and Yetman develop a micro-founded model of balance sheet channel for international transmitted shocks. The financial multipliers pointed out by Krugman are incorporated through cross-country balance sheet connections distributed between investors and financial institutions (Krugman, 2008). For example, if asset prices fall in country A, independent of the nature of the shock, it will negatively impact balance sheets for institutions and the economy in country A. Since country B investors have investments in financial institutions of country A, their portfolio and thus consumption also deteriorates. In the crisis of 2007, a sharp decline in asset values led to balance sheet contractions and a fire sale of assets, perpetuating a further decline in balance sheets which resulted in a vicious downward spiral.

While this dynamic has been widely studied, the effect of these contractions on international transmission and macroeconomic activity has not received nearly as much attention. The model developed by Devereux and Yetman allows for financial frictions or distortions in credit markets, which is critical when evaluating financial meltdowns like the one in 2007. I describe the model in section 3. Their focus is to compare transmission of macro shocks across countries under different financial structures such as segmented and integrated equity and bond markets. They find that balance sheet constraints and portfolio interdependence can generate statistically significant impulse responses in both home and foreign countries. The model draws on (Kiyotaki & Moore, 1997), where leverage constraints are binding for the investors. The role of portfolio links in cross-country contagion due to financial shocks is also well established. (Rigobon, 2003) (Pavlova & Rigobon, 2008) The most salient contribution of the model developed by Devereux is that it allows for endogenous portfolio interdependence. (Devereux & Sutherland, Country portfolios in open economy macro models, 2011)

They conclude that financial integration in both bond and equity markets generates high positive co-movement in macro variables and has welfare gains.

The next step in refining this model is to evaluate results during expansionary and recessionary phases in a business cycle. The reasoning being that consumers and businesses react asymmetrically to a shock to their portfolio depending on the phase of the business cycle. I hypothesize that this asymmetry rests on the assertion that people react strongly when their portfolio loses value compared to an equivalent portfolio increase. One can argue that risk averse people will reduce spending by a larger percent with a loss in income than they will increase spending with an increase in income. To this effect my paper adds to the literature in a few different ways. Firstly, I add a source of shock in the theoretical model that is attributed to the financial sector. Devereux and Yetman have the usual productivity shock only. This provides insights into the impact of the financial sector on the macro economy. Secondly, I estimate the parameter that differentiates the ability for investors in a country to raise capital based on the state of the economy. I find that during recessions, investors find it harder to raise capital but Devereux and Yetman take this parameter to be fixed. A Markov-Switching regime model provides an array of toolkits to generate this estimation. (Hamilton, 1994) (Hamiton, 2005) In practice the two-step maximum likelihood estimation and a MATLAB customizable package developed by Marcelo Perlin for regime switching models provide the statistical basis for parameter. (Perlin, 2015)

Regarding monetary neutrality tests, a series of empirical tests have been designed by economists to test for long-run effects of changes in money supply. Fisher and Seater's ARIMA and King and Watson's VAR frameworks are among the most widely used econometric tools to test LMN. (Fisher & Seater, 1993) (King & Watson, 1997). Results differ considerably depending on data sources, aggregation techniques and empirical methods. Given the undisputed theoretical grounds for LMN, empirical studies have been equally discouraging. Fisher and Seater (93) consider annual post WWI German and annual U.S data from 1869-1975 and find little support in favor of LMN in the U.S and reject LMSN in German data. Fisher and Seater's results were on U. S data showed LMN by including dummy variables for the Great Depression period (Boschen & Otrok, 1994). King and Watson used post-war U.S data and found evidence in support of LMN and inconclusive evidence for LMSN. [2] Studies of LMN and LMSN for developing countries is even more inconclusive. Tests for LNM amongst African countries found that money has significant positive lasting effects in the long run (Ekomie & Jacques, 2013). Tests for Mexico between 1932-1992 supported the LNM when a time dummy was added for year domestic banks were nationalized in 1982 (Wallace, 1999). One very significant test in favor of LNM was for Turkey (Sulku, 2011). Using Turkish data for M1, M2 and M3 between 1987-2006, she found LNM to hold for all monetary measures. [3] The results for LNM seem to vary based on monetary aggregates used, countries, aggregation method and years chosen.

The rest of the paper is organized as follows: Section 3 develops the two-country model along with estimates from the Markov process to test for asymmetric effect of financial integration on macro variables, Section 4 includes tests and results for monetary neutrality and section 5 concludes this paper.

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[2] Some other examples of studies testing for LMN and LMSN include Weber (1994), Serletis and Koustas (1998) Leong and McAller (2000), Shelley and Wallace (2006)

[3] Studies for developing countries include Bae and Ratti (2000) for Argentina and Brazil, Chen (2007) for South Korea and Taiwan and they find some support for LNM.

CHAPTER 3: ASYMMETRIC EFFECT OF FINANCIAL MARKET INTEGRATION ON BUSINESS CYCLE DYNAMICS

3.1 The Model

In this section I describe a two-country Dynamic Stochastic General Equilibrium model (DSGE) with borrowers and lenders in each country. Countries are divided into home and foreign and are denoted by the subscripts 1 and 2 respectively. A variable with an asterisk represents foreign countries' choices. For example, k_{1t}^{I} and k_{2t}^{I} represents home and foreign assets held by home investors and $k_{1,t}^{I^*}$ and $k_{2,t}^{I^*}$ represents home and foreign assets held by foreign investors. Within each country there are investors and savers. This utilizes the two-country model developed by Michael Devereux and James Yetman. (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010)

Each country has fixed assets in home production for each period. Savers own the production resources and lend them to investors in each country. In return investors raise capital by issuing debt to the savers. Investors purchase the fixed assets from savers and rent it to firms that produce the final good, thus owning equity claims in production firms. Investors finance through debt and own equity portfolio in production firms that are interconnected across countries. Savers can lend to investors at home and foreign in an open international bond market. The most relevant case for my study occurs when savers can lend to investors in both countries and investors can lend to firms in both countries. These are the channels through which financial integration significantly impacts cross-country output. Investors get paid a risky return in exchange. This framework assumes that savers are more patient and less risky than investors. [4] (Devereux & Yetman, Leverage constraints and the international

[4] Due to the impatient and risky nature, investors will never accumulate enough resources to cover the cost of investment in any period

transmission of shocks, 2010) (Devereux & Sutherland, Evaluating international financial integration under leverage constraints, 2011)

Since investors are more risk prone than the savers, they face leverage constraints in that the maximum amount of debt they can issue depends on their net worth. They can trade claims with foreign investors to diversify their portfolio of equity holdings.

Finally, both investors and savers supply labor resource inelastically to firms that produce the final good. The model does not allow for endogenous capital accumulation and variable labor supply. The focus of the paper by Devereux and Yetman was to jointly analyze how binding and non-binding leverage constraints and international portfolio diversification induce shocks across countries. The focus of this chapter is to analyze the asymmetric effect of shock propagation in financially integrated countries on macro variables in home and foreign. Therefore, only the most globally integrated version of their model, one with integrated bond and equity markets and where leverage constraints are binding, is relevant to my analysis.

3.2 Investors

Each country has a measure of *n* investors and 1 – *n* savers where the population is normalized to unity. The representative investor, *I* in each country maximizes:

$$E_t \sum_{s=t}^{\infty} \theta_s^I \, U(C_s^I), where\ the\ discount\ factor\ is\ \ \theta_{s+1}^I = \beta^I(\bar{C}_s^I)\theta_s^I \qquad (1)$$

C_s^I is consumption of the final good by the investor. Since the focus of this paper is on international financial linkages I assume there to be one world good, as did the authors whose model I am using. (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010) $\bar{C}_s^I$ is the economy wide average consumption of investors and $\beta^{I\,\prime}(\bar{C}_s^I) \leq 0$. Hence the discount factor is defined such that the rate of time preference is increasing in consumption of the average investor and is subject to diminishing returns.[5] The investors maximize their utility function subject to the following budget constraints:

$$C_t^I + q_{1t}k_{1t}^I + q_{2t}k_{2t}^I + R_{t-1}B_{t-1}^I = W_t^I + (q_{1t} + R_{1Kt})k_{1t-1}^I + (q_{2t} + R_{2Kt})k_{2t-1}^I + B_t^I \quad (2)$$

$$B_t^I \leq \kappa_t(q_{1t}k_{1t}^I + q_{2t}\, k_{2t}^I\,) \quad (3)$$

where subscripts 1 and 2 denote home and foreign. The right-hand side of equation (2) represents the source of income; W_t^I, labor income from working in domestic firms, $q_{1t}(q_{2t})$, represents the price of equity assets in home (foreign), $R_{1Kt}(R_{2Kt})$ are dividends earned from holding home (foreign) assets k_{1t-1}^I (k_{2t-1}^I), that were bought in the previous period. Lastly the investor raises capital by issuing new debt B_t^I to savers.

They spend their income on consumption, C_t^I, home and foreign equity assets from final goods producing firms and pay back previously issued debt with interest to the savers.

As pointed out in the literature there is a reason why investors act as a middleman and savers cannot directly lend to firms. (Bernanke, Gertler, & Gilchrist, The financial accelerator in a quantitative business cycle framework, 1999) (Bernanke & Gertler, 1999) (Devereux & Yetman, 2010) Investors specialize in transforming fixed assets so they can be used by firms. Savers lend assets purely out of investment purposes and gain utility from those returns and producing home goods.

Investors face another constraint modelling their ability to raise debt given in equation (3). Savers will lend based on the ability of the investors to pay back. Total debt cannot be larger than κ times the market value of current equity assets. The

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[5] In a model with different kinds of consumers within and across countries the assumption of endogenous time preference is important in keeping stationary wealth distribution.

investors' value of assets to capital ratio or full leverage rate is 1/(1- κ) when equation (3) is binding. Equation (3) is a common way to model leverage constraints for borrowers in both closed and open economies. (Aiyagari & Gertler, 1999) (Mendoza & Smith, Quantitative implications of a debt-deflation theory of Sudden Stops and asset prices, 2006) (Uribe, 2006) (Iacoviello, 2005) (Kiyotaki & Moore, 1997) κ is assumed to be a fixed parameter by Devereux and Yetman, but I treat it differently in two ways. First, instead of treating it as a fixed parameter, I estimate it based on the state of the economy. My reasoning is that during recessions investors find it harder to borrow, making κ a smaller number. In turn this reduces funds available for final goods producing firms and further contracts the economy. The opposite is true during economic expansions. I incorporate a Markov Switching Regime change to estimate parameter κ using techniques developed by others. (Hamilton, 1994) (Hamiton, 2005) (Perlin, 2015) Thus, there will be two values for the leverage rate for investors. This process is described in section 5. Second, in addition to the usual productivity shock, I include an extra source of shock in this model emanating from κ, which differentiates the ability of investors to borrow. This shock follows an AR process. This can be thought of as a proxy for a shock to the financial sector.

The investor will maximize (1) subject to (2) and (3). The FOC's are summarized in Appendix A. Combining the FOC's, one can derive the optimal portfolio selection for investors.

$$E_t U'(C_{t+1}^I)\left(\frac{q_{1t+1} + R_{1kt+1}}{q_{1t}} - \frac{q_{2t+1} + R_{2t+1}}{q_{2t}}\right) = 0 \qquad \text{(4) and } (I\text{-}9)$$

Equation (4) is used to determine the optimal equity portfolio for investors between home and foreign investments. To obtain a unique solution for the optimal equity portfolio requires a little more consideration. The usual linear solution around the steady state leaves the investor indifferent between choosing home and foreign equity. I use the techniques developed in a different paper to solve for optimal portfolios (Devereux & Sutherland, Country portfolios in open economy macro models, 2011). I lay out the solution methodology in section 3.6. Following trade literature, it is useful to add transactions costs for international financial trade. Following (Tille & Wincoop, 2007) an 'iceberg' cost, $\exp(-\tau)$, is added to the term in equation (4) that represents foreign equity purchased by home investor. Equation (4) becomes:

$$E_t U'(C_{t+1}^I)\left(\frac{q_{1t+1} + R_{1kt+1}}{q_{1t}} - \frac{q_{2t+1} + R_{2t+1}}{q_{2t}} \exp(-\tau)\right) = 0 \qquad (4')$$

where $\exp(-\tau) \leq 1$. Even though transactions costs associated with foreign purchases are more prevalent when buying physical goods, fees involved in trading purely financial transactions are worth incorporating. (Tille & Wincoop, 2007) and (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010) assume τ to be small and a second order term. The fact that it is less than one does not impact the first order dynamics of the model except the portfolio choice of investors. Like the authors above, I set the transactions cost to ensure that domestic investors hold 75 percent of home equity portfolios. When analyzing the shocks to the economy, I calculate the impulse responses for both cases; $\tau = 0$ and when $\tau > 0$.

3.3 Savers

Savers' are modeled by the utility function

$$E_t \sum_{s=t}^{\infty} \theta_s^S\, U(C_s^S), \quad where\ \theta_{s+1}^S = \beta^S(\bar{C}_s^S)\theta_s^S \qquad (5)$$

Like for the investor the model assumes $\beta^{S\,\prime}(\bar{C}_s^S) \leq 0$ and $\bar{C}_s^S$ is the economy wide aggregate consumption of savers. To differentiate the fact that savers are inherently more patient than investors in terms of risk taking, the model assumes

$$\beta^S(x) > \beta^I(x) \text{ for all values of } x \tag{6}$$

Savers buy some of the fixed assets from the market and buy debt from investors. They supply labor in the final goods market and earn wealth from wages, and their returns on investment. Some of the fixed asset, k_{1t}^S, bought by savers is used in home production, $G(k_{1t-1}^S)$ which is subject to diminishing returns. The model assumes a saver to be indifferent between consumption of final good and buying fixed asset for home production. These are perfect substitutes. Hence the budget constraint for the savers is as follows:

$$C_t^S + q_{1t}\mathrm{k}_{1t}^S = W_t^S + q_{1t}\, k_{1t-1}^S + G(k_{1t-1}^S) + \mathrm{B}_t^S - B_{t-1}^S R_{t-1} \tag{7}$$

Savers do not have access to the same investment opportunities as the investors and only buy domestic fixed assets. FOC's are in Appendix A.

3.4 Production Firms

Profit maximizing final goods producing firms hire labor and fixed assets as inputs and operate in a competitive environment. The production function takes the form:

$$Y_t = A_t F(L_t\,, K_{t-1}) \tag{8}$$

where $K_{t-1} = n(k_{1t-1}^I + k_{1,t-1}^{I^*})$ (9)

represents total use of fixed asset in home final goods production and are constrained

by $W_t L_t + R_{1,K1t} K_{t-1} \leq P_t Y_t$ (10)

3.5 Equilibrium

In a two-country world, the market clearing exists in the market for the fixed asset as well as the debt market. In a world with a common bond market:

$$n\left(B_t^I + B_t^{I^*}\right) + (1-n)\left(B_t^S + B_t^{S^*}\right) = 0 \tag{11}$$

where the total debt issued by home and foreign investors must equal total debt held by home and foreign savers for any time-period t. The equilibrium for the fixed asset is where for each country the total amount of fixed assets is held between domestic and foreign investors and domestic savers (for home production).

$$nk_{1,t}^I + nk_{1,t}^{I^*} + (1-n)k_{1,t}^S = 1 \tag{12}$$

where $k_{1,t}^{I^*}$ represents the real holding of home assets by foreign country investors' at time $t+1$. The world clearing is then represented by:

$$n\left(C_t^I + C_t^{I^*}\right) + (1-n)\left(C_t^S + C_t^{S^*}\right) = A_t\, F(1, n(k_{1,t-1}^I + k_{1,t-1}^{I^*})) + A_t^*\, F\left(1, n\left(k_{2,t-1}^I + k_{2,t-1}^{I^*}\right)\right) + (1-n)\left(G\left(k_{1,t-1}^S\right) + G(k_{2,t-1}^{S^*})\right) \tag{13}$$

Equation 13 implies the following; worldwide consumption equals final goods and home good production, total labor supplied by savers and investors sum to unity, resources (fixed factor) used by final goods producing firms equals the holdings by home and foreign investors. (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010) They have four variants to their paper; first two has a world with segmented bond and integrated equity markets with and without binding leverage constraints, third and fourth has an international integrated bond market with binding leverage constraints with and without integration of equity markets. The variant with one international bond market has a single interest rate on bonds. In this paper, I work with the case where bond and equity markets are integrated and leverage constraint is binding. This represents full portfolio diversification and is the ideal setting to test my theory whether cross-country correlation is stronger during recessions.

The equilibrium conditions are described by two sets of equations 2, 3, 7,12, *I*-6, *I*-7, *I*-8, *S*-5, *S*-6, *F*-1, *F*-2. One that represents the outcome for home and another for foreign. Additionally, there a single global equation 11 and 13 that correspond to the global supply of debt and fixed assets. This gives us 24 equations in 23 variables C_t^I , C_t^S, $C_t^{I^*}$, $C_t^{S^*}$, $k_{1,t}^I$, $k_{1,t}^S$, $k_{2,t}^{I^*}$, $k_{2,t}^{S^*}$, $k_{1,t}^{I^*}$, $k_{2,t}^I$, B_t^I , B_t^S, $B_t^{I^*}$, $B_t^{S^*}$, $q_{1,t}$, $q_{2,t}$, W_t , W_t^* , R_t , $R_{1K,t}$, $R_{2K,t}$, μ_t , μ_t^* . Linear approximation around the non-stochastic steady state solves the model.

However, as pointed out earlier in section 3.2 there is a known problem in determining optimal portfolio choice in open-economy models with integrated equity markets. When equity holdings are traded across countries, steady state representation does not help determine the optimal portfolio in home and foreign equity. This occurs because the investor is indifferent between home and foreign equity in a non-stochastic steady state due to identical returns from home and foreign equity in equilibrium. I use the method developed in another paper by (Devereux & Sutherland, Country portfolios in open economy macro models, 2011) and (Devereux & Sutherland, Country Portfolio Dynamics, 2010) to approximate the equilibrium portfolio. They develop the technique by which a unique solution to the portfolio choice is made. This method uses a second order approximation of the portfolio equation (4) or (4') along with the first order approximation of the rest of the model to develop the steady state conditions. Then one can study how the stochastic structure of the model determines the portfolio allocation along with the economy's response to stochastic shocks. The equilibrium of the two-country model determines the distribution of consumption, distribution as assets, asset prices, interest rate, equity and debt holdings. The detail of this methodology is described in section 3.7.

3.6 Steady State

Combining equations I-6, I-8, S-5, S-6 and F-2 gives us the steady state condition to ensure that fixed assets are allocated efficiently between home production and final goods producing firms:

$$G'(k_1^S) = \left[\frac{\beta^I(1-\beta^S)}{\beta^S(1-\beta^I)-\kappa(\beta^S-\beta^I)}\right] AF_2(L, n\hat{k}_t^I) \quad (14)$$

where $n\hat{k}_t^I$ is the total quantity of the fixed asset used by firms in the production of final goods. $\hat{k}_1^I = k_1^I + k_1^{I^*}$ is the sum of home fixed assets owned by home and foreign investors. Finally, $n\hat{k}_1^I + (1-n)k_1^S = 1$. Equation (14) ensures that the marginal product of the asset used in home production and final goods production are equal. The binding restriction on how much debt investors can raise in equation (3) and their inherent impatience in equation (6) implies that $\beta^I(1-\beta^S)/[\beta^S(1-\beta^I) - \kappa(\beta^S-\beta^I)] < 1$. When investors can trade freely in equities between countries, the returns to must equalize across countries. And since the discount factors are endogenously determined and impact consumption behavior, returns for investors with trade in equities will inherently interact with consumption. Equation (14) encompasses that link and implies that division of assets between home and final goods production will be linked across countries as well. Productivity shocks to one country will affect the tightness of leverage constraints across home and foreign which in turn would impact output levels across countries.

3.7 Optimal Portfolio Choice and solution to the model

The steady state allocation of the fixed asset given by equation 14 determines the supply of equity in each country. Using the method in (Devereux & Sutherland, Country portfolios in open economy macro models, 2011), described in this section, I determine the share of each country's equity held by home and foreign investors $(k_1^I, k_1^{I^*}, k_2^I, k_2^{I^*})$; where the measure of total equity issued by home country and held by home and foreign investors is

$$\hat{k}_t^I = k_t^I + k_t^{I*} \quad (15)$$

To represent the net international position of investors (since only investors have access to foreign equity), $r_{xt} = [r_{1t} - r_{2t}]$, the equation representing the budget constraint for investors (2) can be rewritten as:

$$C_t^I + NFA_t = W_t^I + R_{1Kt}\hat{k}_{1t-1}^I - q_{1t}\left(\hat{k}_{1t}^I - \hat{k}_{1t-1}^I\right) + r_{2t}NFA_{t-1} + r_{xt}\left[q_{1t-1}\left(k_{1t-1}^I - \hat{k}_{1t-1}^I\right)\right] + B_t^I - R_{t-1}B_{t-1}^I \quad (16)$$

where net foreign asset, $NFA_t = q_{2t}k_{2t}^I - q_{1t}(\hat{k}_{1t}^I - k_{1t}^I)$ (17)

$$r_{1t} = \frac{q_{1t} + R_{1k,t}}{q_{1t-1}}$$

NFA represents a country's net foreign assets, or home investor's ownership in foreign equity relative to foreign investor's ownership in home assets. $r_{x,t}$measures excess return on home assets. The benefit of writing the budget constraint for the investor as equation (16) is that the term $q_{1t-1}\left(k_{1t-1}^I - \hat{k}_{1t-1}^I\right)$ describes the portfolio choice for a given NFA. Define

$$\alpha_t = q_{1t-1}\left(k_{1t-1}^I - \hat{k}_{1t-1}^I\right) \quad (18)$$

to represent the net holding of home equity by home investors. If no trade in equity is allowed and home owners held all the home equity, α_t would be zero. Conversely, if α_t is negative, it means home investors own less than 100 percent of all home equity and foreign investors own the remaining. $NFA_t - \alpha_t$ would then measure home investor's holding of foreign equity. In this model only equation (16) has the term for the optimal portfolio, α_t, present and the solution to which is obtained by taking the second order approximation of equation (4) or (4'). Substituting NFA_t and $\hat{k}^I_{1t}$ into equation (3), we get;

$$B^I_t \leq \kappa\left(NFA_t + q_{1t}\,\hat{k}^I_{1t}\right) \tag{19}$$

Thus, an increase in net foreign asset, NFA_t, will loosen the leverage constraint for home investors. But since $NFA_t + NFA^*_t = 0$, the leverage constraint for foreign investors will simultaneously tighten. To that affect the degree to which international linkages impact the transmission of shocks depends on the dynamics of net foreign assets held, which in turn are dependent on portfolio choices, α_t, made by home and foreign investors.

Next I describe the solution method used in this paper. To solve a DSGE model, one takes a linear approximation around the steady state of the model. However, models with international portfolios do not have a unique steady state because first order conditions lead the investor to treat home and foreign assets as perfect substitutes. I use the typical method to solve for DSGE models for equations 2, 3, 7, 12, *I*-8, *S*-5, *S*-6, *F*-1, *F*-2 for home and foreign, a single global equation 11 and 13 and use the method in (Devereux & Sutherland, Country portfolios in open economy macro models, 2011) to solve for equation (4) or (4') and obtain the optimal portfolio, α_t . This is done by combining a second order approximation of (4') along with the first order approximation of the rest of the equations. One must look at second order approximation when looking at international portfolios because up to the first order, investors are indifferent between home and foreign assets. Thus, portfolio allocation depends only on variance covariance of asset returns, which show up only in the second order components of optimality conditions.

I use Uhlig's method to take the second order approximation (Uhlig, 1999) (McCandless, 2008) For a set of variables X_t, define $\tilde{X}_t = ln(X_t) - ln(\bar{X})$ to be the difference between a variable from its steady state. Then rewrite $X_t = \bar{X}e^{\tilde{X}_t}$. After writing all variables in this form, take the Taylor expansion around of the exponential term around its stationary value. Thus, the second order Taylor expansion of equations $E_t U'(C^I_{t+1})[r_{1t+1} - r_{2t+1}] = 0$ and $E_t U'\left(C^{I^*}_{t+1}\right)[r_{1t+1} - r_{2t+1}] = 0$, $r_{xt} = [r_{1t} - r_{2t}]$ gives us:

$$E_t\left[\hat{r}_{x,t+1} + \frac{1}{2}\left(\hat{r}^2_{1,t+1} - \hat{r}^2_{2,t+1}\right) - U'\left(\hat{C}_{t+1}\right)\hat{r}_{x,t+1}\right] = 0 \qquad (20)$$

$$E_t\left[\hat{r}_{x,t+1} + \frac{1}{2}\left(\hat{r}^2_{1,t+1} - \hat{r}^2_{2,t+1}\right) - U'\left(\hat{C}^*{}_{t+1}\right)\hat{r}_{x,t+1}\right] = 0 \qquad (21)$$

Combining (20) and (21) yields

$$E_t\left[\left\{U'\left(\hat{C}_{t+1}\right) - U'\left(\hat{C}^*{}_{t+1}\right)\right\}\hat{r}_{x,t+1}\right] = 0 \qquad (22)$$

and $E_t\left[\hat{r}_{x,t+1}\right] = -\frac{1}{2}E_t\left(\hat{r}^2_{1,t+1} - \hat{r}^2_{2,t+1}\right) + \frac{1}{2}E_t\left(\left(U'\left(\hat{C}_{t+1}\right) + U'\left(\hat{C}^*{}_{t+1}\right)\right)\hat{r}_{x,t+1}\right)$ (23)

(Devereux & Sutherland, Country portfolios in open economy macro models, 2011) show that equations (22) and (23) are sufficient to derive the optimal portfolio choice for investors, α_t.

Having a unique solution to all parts of the model, I solve the state space representation of the model using Sims solution method.

3.8 Calibration, Estimation and Functional form

The goal of this chapter is to explore how international financial portfolio interdependence affects cross-country macro variables under the different phases of a business cycle. The macro variables to consider are asset prices, asset allocations, levered investments. In this section I lay out the parameterization of the model. I employ the parameters commonly used in open economy models rather than estimating it from the data generating process. Even though calibration might be less reliable, in the case of my model there are far too many variables to get accurate data for multiple countries to be able to estimate the parameters. Table 4 provides the calibrated parameters.

Table 4: Calibrated parameters

Parameter		**Value**
n	Proportion of investors	.5
$1-n$	Proportion of savers	.5
ζ^I	Discount function, Investors	0.99
ζ^S	Discount function, Savers	0.955
η	Discount function	0.022
σ	Coefficient of relative risk aversion	2
ε	Share of capital in final goods production	0.39
$1-\varepsilon$	Share of labor in final goods production	0.64
ω	Share of capital in home production	0.1
κ	Leverage, See section 5	0.28, 0.791
ρ	Productivity shock persistence	0.9
φ	Financial sector, de-leveraging shock persistence	0.9

Having equal number of savers and investors where investors face leverage constraints is taken from the estimates from U.S economy (Campbell & Mankiw, 1990). The discount factor, β^i, for investors and savers has the functional form;

$\beta^i(C) = \zeta^i(1+C)^{-\eta}, i = I, S$ where η is chosen to be 0.022 (Mendoza & Smith, Quantitative implications of a debt-deflation theory of Sudden Stops and asset prices, 2006) and (Mendoza, 2006) ζ should be defined differently for savers and investors to represent their difference in patience. For savers, it is chosen to match an annual interest rate of 4 percent and for investors it is chosen to reflect an interest premium on borrowed funds of 2 percent. This premium on investors matches the typical spread on corporate debt. (Bernanke, Gertler, & Gilchrist, The financial accelerator in a quantitative business cycle framework, 1999)

The value for leverage constraint, κ, has important quantitative implications on the model. Total investment relative to capital or total leverage ratio is 1/(1- κ). There are two alternatives that I analyze for κ; one during a recession and another during expansions. I estimate the parameter, κ during the two regimes using a markov switching model using data for U.S from 1995-2012 (Hamiton, 2005) (Hamilton, 1994). This is done in section 5. The estimate during recessions is 0.28 and 0.79 during expansions. Devereux and Yetman use the value of 0.5 following other studies (Bernanke & Gertler, 1999). But given that investors enjoyed high leverage in years prior to the 2007 crisis, I look at both possibilities. I would expect that the case with high leverage, shocks would have a larger impact.

The utility function has the function form $U(C) = \frac{C^{1-\sigma}}{1-\sigma}$ with elasticity of substitution equaling 0.5 implying relative risk aversion, $\sigma = 2$.

The production function is a typical Cobb-Douglas function with technology: $F(L, K) = A\, L^{1-\varepsilon} K^{\varepsilon}$, where the share of capital is chosen using the conventional economic measure of 0.36, which matches the percent of capital in GDP for G-7 countries. The home production sector is represented by $G(k^S) = Z(k_1^S)^{\omega}$. The share of fixed assets used in a country is more heavily used by the final goods producing firms. (Benhabib, Rogerson, & Wright, 1991) calibrated the share of capital in home production to be 0.09. In this paper, in steady state, 90 percent of the fixed assets in a country are used in final goods production.

Finally, there are two shocks experienced by both countries. First shock from the standard macro business cycle literature emanates from productivity shocks in the final goods sector. The stochastic process for the above shock is:

$$\log(A_t) = \rho \log(A_{t-1}) + \upsilon_t \qquad (24)$$

where $\rho = 0.9$, and the error term has mean zero and variance 0.005 (Devereux & Sutherland, 2011) (Jermann & Quadrini, 2009, 2012) Jermann and Quadrini estimate the variance in productivity shocks in the U.S economy over the sample 1984-2009.

During the financial crisis of 2007, it was apparent that the shocks to the countries were to the financial sector itself. (Kollman, Enders, & Mueller, 2011) In response to risky behavior, bank portfolios deteriorated leading to de-leveraging amongst investors. In this model, a negative shock to the variable κ could represents forced de-leveraging by investors. A shock to κ can be thought as borrower or investor specific and constraints the ability of investors to borrow. This enables one to study responses in an economy emanating directly from the financial sector. This is useful since productivity shocks effect the financial and non-financial sector simultaneously. That makes it hard to understand whether the effects on consumption and investment are directly from productivity or a lagged effect of productivity on financial links. The shock process to the financial sector follows:

$$\ln(\kappa_t) = \varphi \ln(\kappa_{t-1}) + \varepsilon_t \tag{25}$$

with $\varepsilon_t \sim N(0, \sigma_t^2)$, where $\sigma_t^2 = 0.011^2$ following (Jermann & Quadrini, 2009, 2012), who estimate the standard deviation of financial shock.

3.9 Markov Switching Regime

An important contribution of my paper is to test whether macro variables have a stronger correlation during economic recessions than expansions. The model laid out in (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010) provides a useful environment to test my theory. Now that I have summarized the appropriate parts of that model, I can test the impact of balance sheet contractions on countries during the two phases of a business cycle. I use the parameter κ in equation 3 to explicitly incorporate recessions and expansions into the model. κ

represents leverage constraints faced by investors and ensures that investors can borrow some percent of the value of their assets. This lowers the ability of investors to issue bonds without any risk consequence. This ability must be more limiting during recessions for the following reasons. First, savers will want to hold on to safer assets even at the cost of lower returns due to the uncertainty in the economy. Due to increased unemployment, they will not be looking for new investment opportunities. This is especially true amongst risk averse savers. Second, lower interest rates by central bankers during recessions would lower investment opportunities in the economy in general. These reasons would ensure that investors will not be able to leverage out their capital as much. The reverse would be true during expansionary phase.

I employ a markov-switching regime to estimate this effect. This technique enables me to incorporate the two phases of the business cycles by estimating two values for leverage ratio. Since κ impacts investors directly, I can then analyze the effect of a shock to κ on home and foreign country during the two regimes of the model, business expansions and contractions. Consider equation (26):

$$\kappa_{ijt} = \beta_{0i} + \beta_{1i} S_t Z_{ijt} + \beta_{2i}\, \kappa_{ijt-1} + \beta_{3i} X_{ijt-1} + \varepsilon_{ijt} \tag{26}$$

$$\varepsilon_{ijt} \sim N(0, \sigma_{st}^2)$$

where κ_{ijt} represents the leverage ratio in period t of bank i headquartered in country j. This ratio is measured as the ratio of Tier 1 capital to total assets of banks. Tier 1 capital is the bank's core capital as defined by the Basel III accord, which is the international regulatory accord designed to supervise bank risk. It includes shareholders' equity and retained earnings. The lagged term for leverage ratio represents short term adjustments costs for banks arising from rigidities in the capital markets. Such rigidities make it hard for them to raise capital at short notice due to negative capital shocks. (Myers & Majluf, 1984) The coefficient on this term is what I estimate to be the leverage constraint parameter, κ for the model in previous sections. Using the coefficient on the lagged variable makes sense since most borrowing has already happened when the economy goes into a recession. Bond market loans takes time to reach maturity and a lag of one period gives savers and investors time to adjust their behavior. Thus, if after a loan matures, savers do not wish to renew their loans, they can choose not to.

Variable Z_{ijt} is the measure for real GDP for the U.S. S_t is the switching parameter, taking on a value of 0 if the economy is in the state of a recession and 1 for expansions. I use the NBER data to determine the state of the U.S. economy between 1995-2012. Ideally, I would like to include data for the two states for all countries, but that is not possible given the two states do not necessarily coincide every year for every pair of country. However, since U.S is typically, and certainly during the 2007 crisis, the biggest source of financial turmoil that propagates globally, it proves useful to use U.S business cycles to estimate the transition matrix. Lastly, X_{ijt-1} is a vector with bank specific characteristics like bank size (log of total bank assets) and bank profitability (return on assets, ROA). Defining X_{ijt-1} to isolate bank specific characteristics is used by other authors as well. (Ayuso, Perez, & Jesus, 2004) (Gropp & Heider, 2009).

$z_t = \Delta \ln (y_t) = ln\, y_t - ln\, y_{t-1}$ is the transformation of output into its first logged difference to adjust for the unit root observed in annual output data. Unit root tests and data details and characteristics are presented in appendix B. ADF and PP unit root tests reject the presence of unit root in either data after appropriately adjusting the data. The years are chosen to encompass multiple business cycles across the countries. I estimate the parameters using maximum likelihood procedure, which takes on the log likelihood function:

$$ln\, L = \sum_{t=1}^{T} ln \sum_{j=1}^{2} \left(f(\kappa_t | S_t = j, \Phi) Pr(S_t = j) \right) \quad (27)$$

where j represents the two states, $f(\kappa_t | S_t = j, \Phi)$ is the likelihood function for state j conditional on the set of parameters Φ in equation (26).

The dynamics of the switching process is driven by the transition matrix; $P = \begin{pmatrix} p_{1,1} & p_{2,1} \\ p_{1,2} & p_{2,2} \end{pmatrix}$, where $p_{i,j}$ is the probability of switching from state j to i. The results are presented in table 5. The transition probabilities represent the usual persistence observed in output data. Given that the economy is in a recessionary (expansionary) phase, it is very likely that we will stay in that phase. The parameter of note is β_2, which is what I use as a proxy for κ. Parameter κ is almost three times higher in expansions, which mean the ability of investors to raise capital in expansions is higher, as I had expected. The coefficients are statistically significant at the 1% level.

These results suggest that a negative shock in home country will have a more severe effect on macro variables during recessions. One should also expect to see the correlation between home and foreign to be stronger during recessions than expansions. Using the estimated values for κ, in the next section I analyze the impulse responses of shocks to both productivity and financial sector.

Table 5: Estimated results of the Markov Switching model on Leverage Ratio

Maximum Likelihood Estimates		
Dependent variable: κ_t	Leverage ratio of banks: Tier 1 capital to total assets	
	coefficient	standard error
β_{00}	0.19	.8
β_{01}	0.895***	0.249
β_{10}	-0.152***	0.019
β_{11}	-0.046**	0.023
β_{20}	0.28***	0.009
β_{21}	0.791***	0.057
$p_{0,0}$	0.9	
$p_{1,1}$	0.78	
AIC	382	
BIC	449	
Sample period is from 1995-2012 ***, **, * represents significance at the 1%, 5% and 10% level		

3.10 International transmission of shocks

In this section I look at the effect of productivity and financial shocks to both home and foreign countries. When looking at negative productivity shock in home country, I calculate the responses using κ=0.28 and κ=0.791 for both with and without transactions costs τ. This exercise will enable me to test whether cross country correlations are stronger during recessions. With transactions costs, I would expect home investors to not diversify completely causing the effect on foreign country to be smaller. When imposing a shock to the leverage parameter, κ (equation 25), I calculate the responses without transactions costs. The responses in both home and foreign are to consumption of final goods by investors and savers, asset prices, investor borrowing, asset allocation, home country trade surplus and the global lending rate.

3.11 Productivity shock

First I concentrate on the impact of a one percent negative productivity shock in the home country. Figures 2 through 5 illustrates these effects. Figures 2 and 3 represent the case where the leverage constraint is high, κ=0.791 and figures 4 and 5 assumes κ=0.28. The case where κ=0.791 would imply that investors can leverage their capital more easily. This was the behavior observed in the decade prior to the crash of 2007 where investors could borrow without much capital requirement. I am using such environment as a proxy for good economic times, or business cycle expansions. The case where κ=0.28 would then imply that borrowing is tougher representing economic downturns.

Figure 2 assumes that investors can borrow unrestrictedly from home and foreign without any transactions fees. Investors satisfy condition in equation 4. Figure 3 includes such international fees. Transactions costs are incorporated in the model by ensuring that investors hold seventy-five percent of home equity.[6] (Devereux & Yetman, Leverage constraints and the international transmission of shocks, 2010) A fall in A_t causes an immediate fall in home output and thus reduces wages for savers and investors and asset prices in home country. This reduces home consumption. Lower demand for foreign assets reduces foreign asset prices, wages and consumption in foreign country. However, the degree of reduction is more severe at home than in foreign. In the case with transactions costs (figure 3), consumption in home falls by more. This happens because due to transactions costs, cross country channels are

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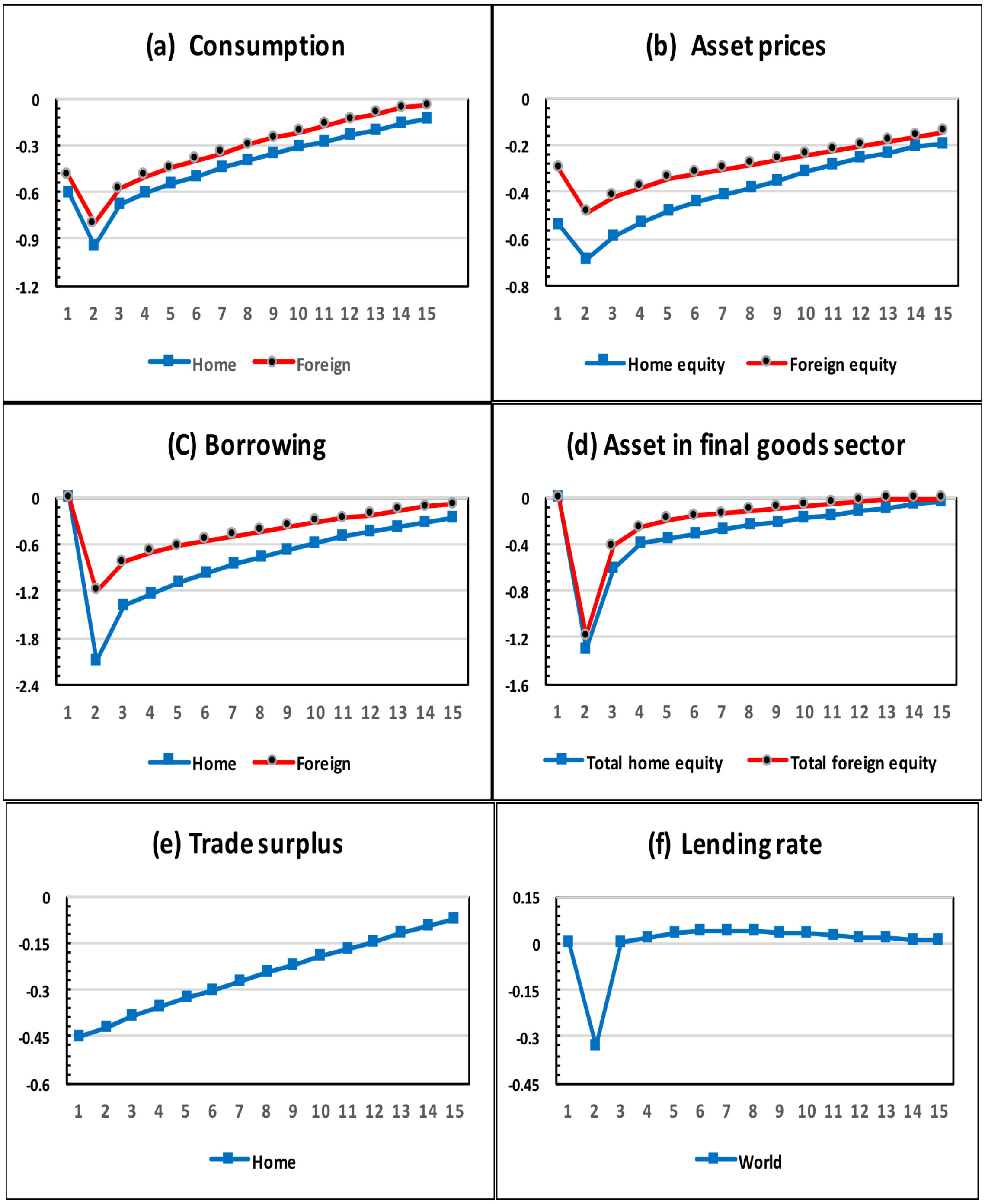
[6] Investors chose values for $k_1^I$and k_2^I to satisfy equation 4' such that $k_1^I = .75\widehat{k_1^I}$

slightly subdued. With a diversified portfolio, the shock also generates a valuation effect for home investors, causing home investor's net foreign assets to rise. Simultaneously, this reduces foreign investor's net foreign asset and a tightening of foreign leverage constraint. This leads to a reduction in borrowing by foreign investors as well. Thus, both home and foreign investment falls sharply. This is a result of financial links between countries since there was no productivity shock in foreign country. Thus, fall in foreign investment takes place purely through balance sheet linkages.

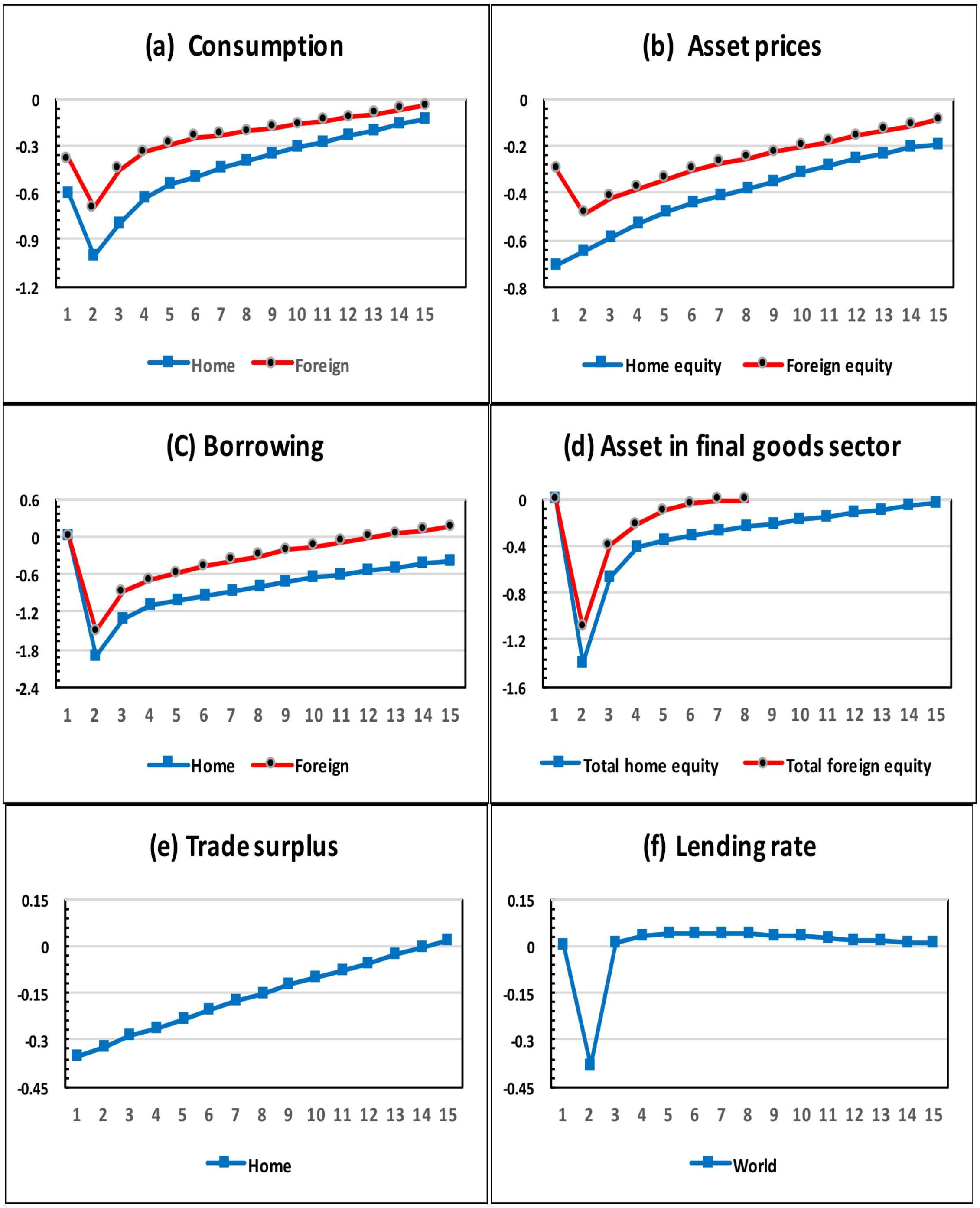
Adding transactions costs reduces the cross-country effects due to home investors bias towards home assets. Greater portfolio diversification leads to greater sensitivity of foreign balance sheets to domestic asset price, and thus a larger balance sheet contraction to a negative home productivity shock. This means that the country where the shock occurs is less important than the pattern of equity holdings of investors for business cycle responses.

Figure 2: High leverage constraint, no transactions costs



Impulse responses of a one percent negative productivity shock with leverage constraint being high κ=0.791, integrated bond markets ($R_t = R_t^*$), and integrated equity markets with complete portfolio diversification ($\tau = 0$)

Figure 3: High leverage constraint, with transactions costs



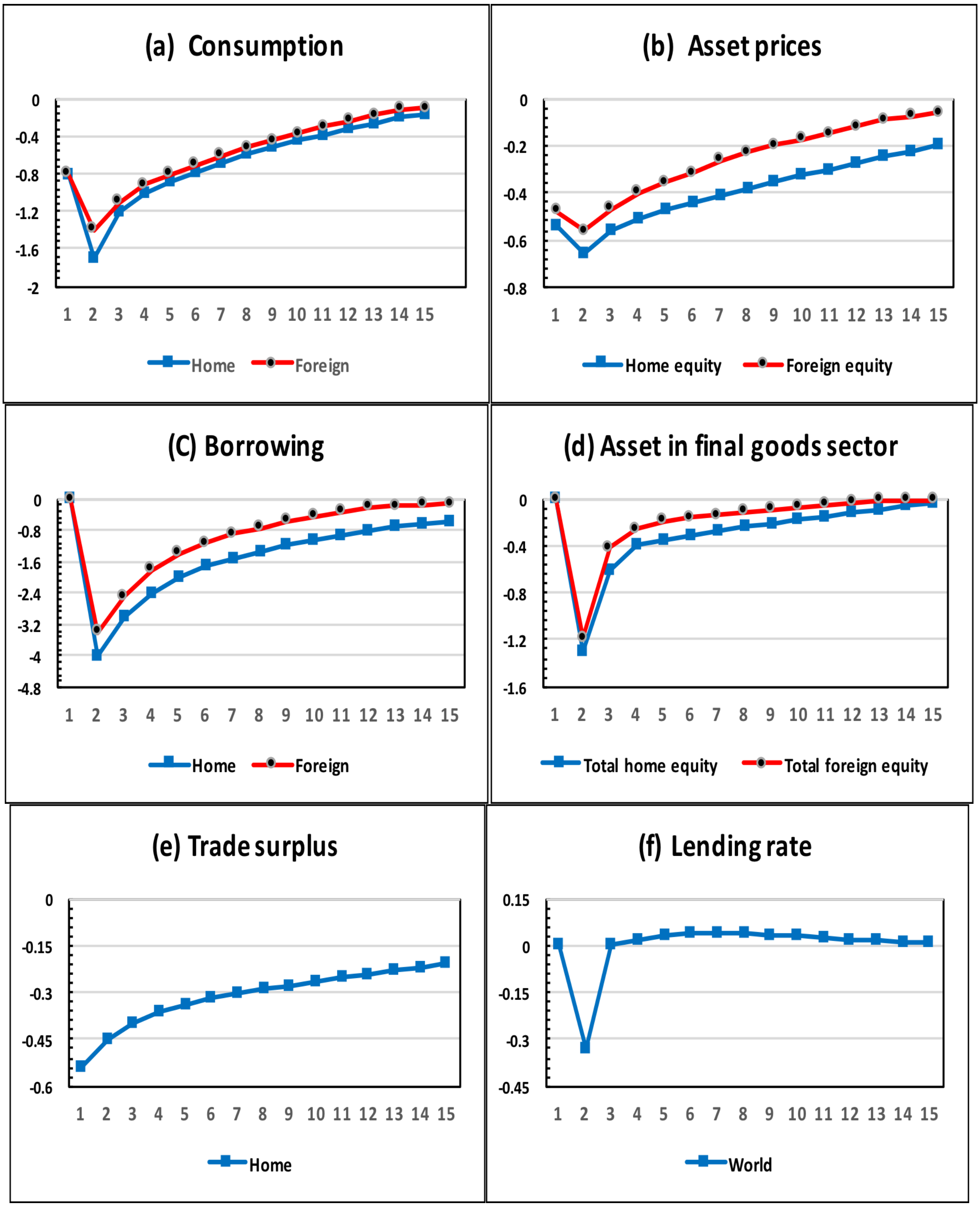
Impulse responses of a one percent negative productivity shock with leverage constraint being high, κ=0.791, integrated bond markets ($R_t = R_t^*$), and integrated equity markets with incomplete portfolio diversification ($\tau > 0$)

Figures 4 and 5 look at the case where κ=0.28 and figure 6 measures the difference in home and foreign consumption based on the value for κ. A lower estimate for κ from the markov switching model represents times of economic downturn as measured by NBER. The impulse responses under a lower κ implies how home and foreign economies would react to a negative productivity shock during recessions. As hypothesized earlier, both consumption and borrowing fall by a larger percent with a lower κ. Moreover, the degree to the synchronous behavior of reduced consumption and investment is greater during recessions. As illustrated in figure 6, the difference in fall in consumption between the countries is far smaller during recessions than expansions. There is clearly a positive co-movement of economic activity across countries with integrated equity and bond markets.

These results support the fact that during recessions, consumers reduce spending and investors reduce borrowing by more than they increase during expansions, as I had suspected. And these affects are more severe due to the financial linkages and cross-country spillovers. Thus, it is no surprise that during the 2007 crisis, global economic contraction was more severe and synchronous than the increase in economic activity before and since the crisis.

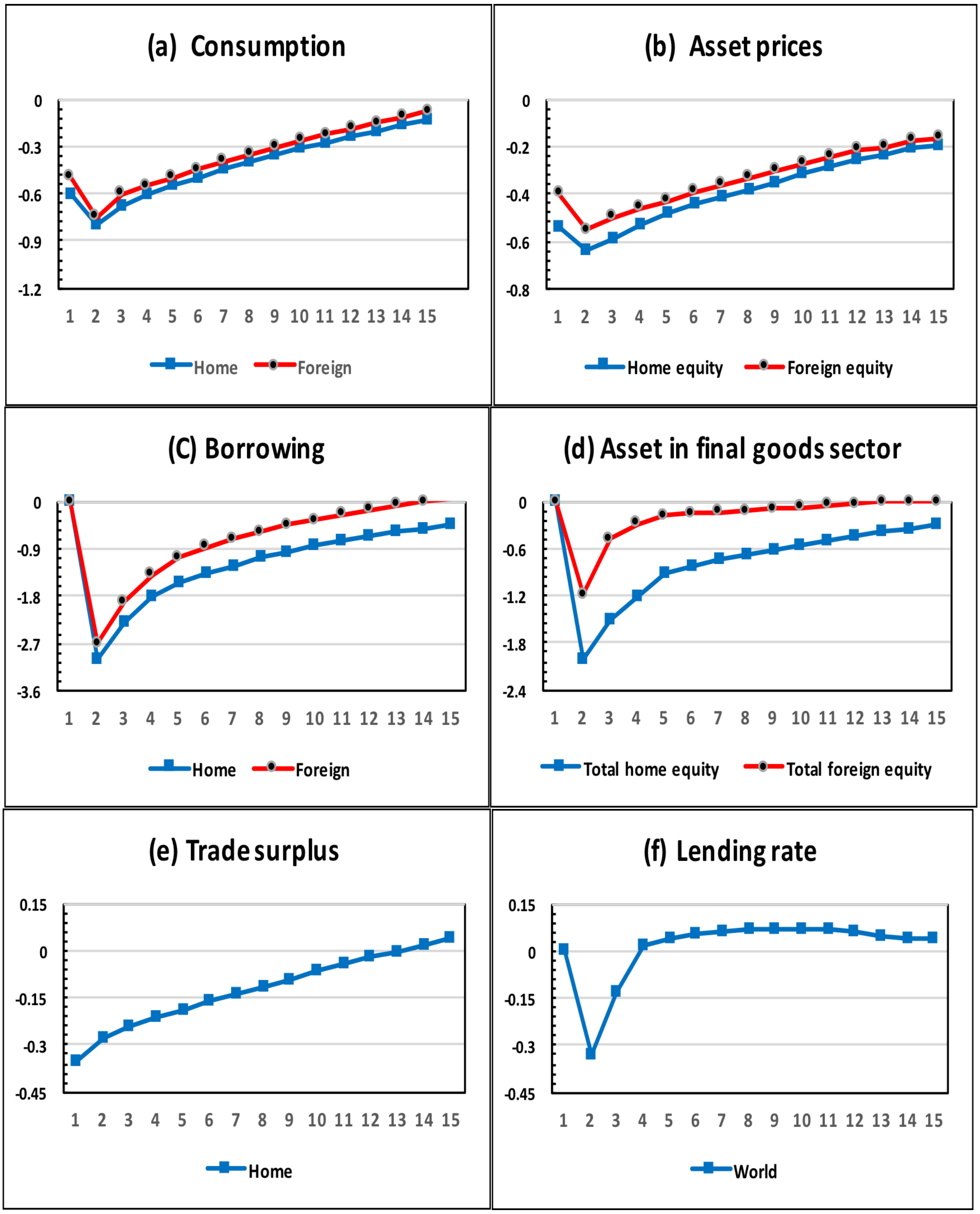
Financial integration in equity and bond markets allow for cross-country risk-sharing. But as seen in this chapter, it also generates a “contagion” effect, which is more severe during recessions than expansions. The ease with which investors can diversify their portfolio has certainly increased the degree of macroeconomic co-movement.

Figure 4: Low leverage constraint, no transactions costs



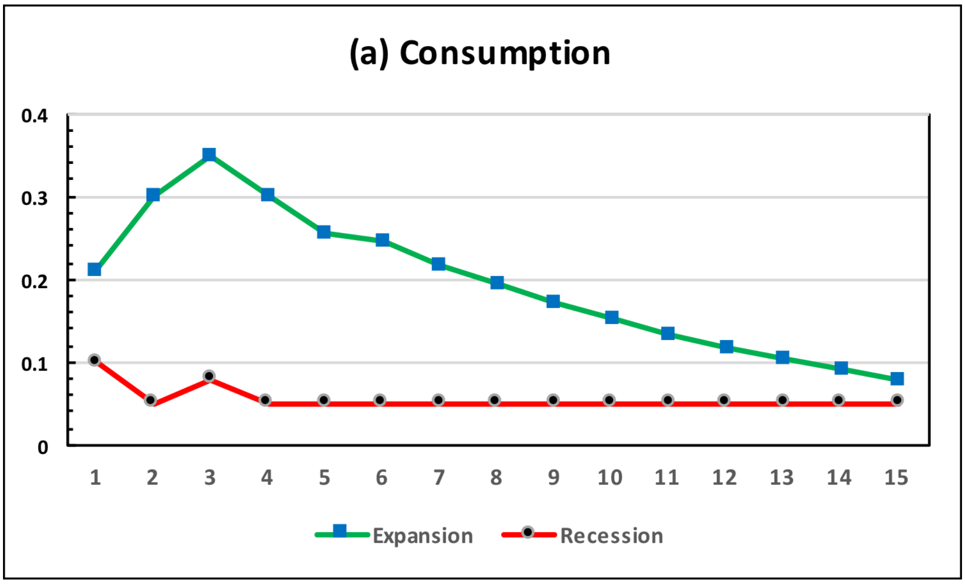
Impulse responses of a one percent negative productivity shock with leverage constraint being low, κ=0.28, integrated bond markets ($R_t = R_t^*$), and integrated equity markets with complete portfolio diversification ($\tau = 0$)

Figure 5: Low leverage constraint, with transactions costs



Impulse responses of a one percent negative productivity shock with leverage constraint being low, κ=0.28, integrated bond markets ($R_t = R_t^*$), and integrated equity markets with incomplete portfolio diversification ($\tau > 0$)

Figure 6: Difference in variables across business cycles



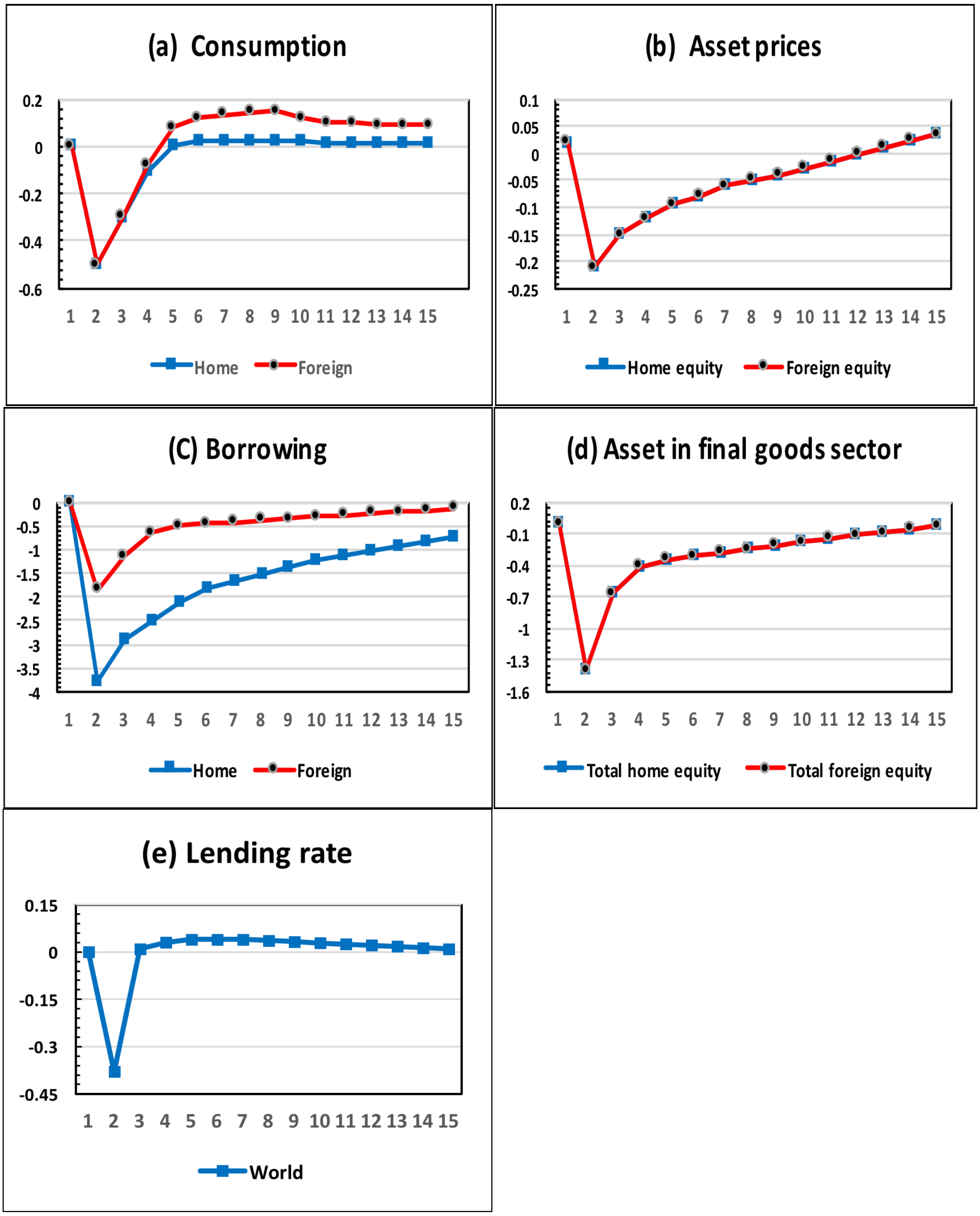
Difference in impulse responses from a one percent negative productivity shock across low and high leverage constraints, κ=0.28, 0.791, integrated bond markets ($R_t = R_t^*$), and integrated equity markets with complete portfolio diversification ($\tau = 0$)

3.12 Financial sector shock

Another contribution of this chapter is to study negative financial sector shock on home and foreign countries. This shock is governed by equation (25). Again, the most globally integrated version of the Devereux and Yetman model is used. A one percent fall in κ represents a negative financial sector shock. Figure 7 shows the effect of such a shock to home and foreign consumption, asset prices, borrowings by investors, asset holdings and lending rate.

There is perfect co-movement between asset prices and fixed assets between the two countries, which is very different to earlier shocks. Since there is no direct productivity shock in either country, investors allocate fixed assets identically across countries, leading to identical asset prices. Despite the financial shock affecting only home country investors, the shock leads to a perfect co-movement of asset prices and

Figure 7: Financial sector shock, without transactions costs



Impulse responses of a one percent negative financial shock with integrated equity and bond markets ($R_t = R_t^*$), with complete portfolio diversification ($\tau = 0$)

allocation. The level of borrowing however, contracts much sharply for home investors than foreign investors. This might signify a loss in faith due to uncertainty in financial home markets. Consumption in both countries falls sharply, but increases temporarily beyond the steady state for foreign investors and savers. The global interest rate declines sharply due to low investments but start to rise as borrowings increase.

CHAPTER 4: TEMPORAL AGGREGATION AND MONEY NEUTRALITY TESTS FOR G-7 COUNTRIES

The function of money in an economy has been a central question for policy makers. In this chapter, I perform the Fisher and Seater (1993) and King and Watson tests for G-7 countries using different frequency data to test for biases arising from temporal aggregation. Temporal aggregation can bias neutrality test results because of its impact upon the sample autocorrelations in the data. The contribution of my work is to test whether temporal aggregation biases the results in any way. VAR-based tests results in the finding of neutrality when data is temporally aggregated. For countries with monthly data available, those tests strongly reject money neutrality, where non-neutrality gets rejected at quarterly and annual frequency. Results from single equation Fisher and Seater (F&S) tests point towards money to be not neutral and are not affected by temporal aggregation. Those tests, however do find that effect of money dissipates over time for most countries.

The next section sets the framework for the F&S tests with section 4.2 doing the same for VAR based K&W tests. Section 4.3 examines the results.

4.1 Fisher and Seater's ARIMA framework

Fisher and Seater develop a framework of log linear, stationary ARIMA model with log of nominal money supply m_t and log of real GDP y_t as the two variables. The ARIMA framework provides a convenient setting where one can test nonstructural tests. They find that order of integration of both money and the macro variable used is important when testing for long run neutrality (LRN) and long run super-neutrality (LRSN). Specifically, the relative order of integration matters. To test for LRN they derive the long run derivative of money on macro variable of interest. To start, the two equations of interest are:

$$a(L)\Delta^{\langle m\rangle}m_t = b(L)\Delta^{\langle y\rangle}y_t + u_t \qquad (1)$$

$$d(L)\Delta^{\langle y\rangle}y_t = c(L)\Delta^{\langle m\rangle}m_t + w_t \qquad (2)$$

where $\langle m\rangle$ and $\langle y\rangle$ are the orders of integration for m_t and y_t respectively. The difference operator Δ ensures that the variables are integrated of order zero, I(0) . They assume a_0=d_0=1 and b_0, c_0 are not restricted. The LRN experiments will depend on a shock to the exogenous money supply disturbance u_t and how that impacts macro variables. The treatment of the disturbance u_t requires appropriate identification restrictions described later. The vector of errors $(u_{t,}w_t)'$ are independent and identically distributed with zero mean and variance covariance matrix Σ, to be

$$\sum = \begin{bmatrix} \sigma_{uu} & \sigma_{uw} \\ \sigma_{wu} & \sigma_{ww} \end{bmatrix}$$

If one assumes $x_t = \Delta^i m_t$ and $z_t = \Delta^j y_t$ where i and j are equal and either 0 or 1, then to test LRN and LRNS one needs to define the long run effect of a permanent change in x_t on z_t. This long run effect is measured by the long run derivative of z with respect to x, LRDz,x;

$$LRD_{z,x} = \lim_{k\to\infty} \frac{[\partial(z_{t+k})/\partial(u_t)]}{[\partial(x_{t+k})/\partial(u_t)]}$$

The numerator measures the effect of an exogenous money disturbance on the macro variable of interest through time and the denominator looks at that same effect on money itself. As stated in Fisher and Seater, if the limit of the denominator term $\partial(x_{t+k})/\partial(u_t)$ approaches zero, LMN and LMSN cannot be tested (Fisher & Seater, 1993). In other words, when there are no permanent changes in monetary variables, there is nothing to test.

Therefore $\lim_{k\to\infty} \partial(x_{t+k})/\partial(u_t) \neq 0$ and $\langle m\rangle \neq 0$

As in F&S, equations (1) and (2) can be written using the Wold representation of

$$\begin{bmatrix} \Delta m_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} a(L) & -b(L) \\ -c(L) & d(L) \end{bmatrix}^{-1} \begin{bmatrix} u_t \\ w_t \end{bmatrix} = \begin{bmatrix} \alpha(L) & \beta(L) \\ \gamma(L) & \lambda(L) \end{bmatrix} \begin{bmatrix} u_t \\ w_t \end{bmatrix} \tag{3}$$

where;

$\alpha(L) = d(L)/[a(L)d(L) - b(L)c(L)]$

$\gamma(L) = c(L)/[a(L)d(L) - b(L)c(L)]$

$\beta(L) = b(L)/[a(L)d(L) - b(L)c(L)]$

$\lambda(L) = a(L)/[a(L)d(L) - b(L)c(L)]$

F&S show that for $(x) \geq 1$ the long run derivative, LRDz,x can be rewritten as;

$$LRD_{z,x} = \frac{(1-L)^{\langle x \rangle - \langle z \rangle} \gamma(L)/_{L=1}}{\alpha(1)}$$

and the derivative will depend on $\langle x \rangle - \langle z \rangle$. F&S examine various cases for the order of integration of x and z to get the LRD. To consider the I(1) property observed for money and output, as in Rossana and Hu, I look at the case where $\langle x \rangle = \langle z \rangle = 1$. (Rossana & Hu, 2017)[7] This restriction also implies that changes in both money and output are permanent thus allowing us to test for LRN. Certain very broad measures of money (M4) are found to be I(2), but I use M2 for all tests and do not run into that problem. With the case where $\langle x \rangle = \langle z \rangle = 1$, LRN is equivalent to testing whether the long run derivative equals zero when using real variables or one when using nominal variables. Thus, from equation (3) testing for neutrality is equivalent to testing the restriction

$c(1)/d(1)$ = 0 or 1

where $b(1) = \sigma_{uw} = 0$. This makes only estimating equation (2) relevant of the two equations system.

[7] This is following the work by Nelson and Plosser (1982), that find most macro variables including output and money to be I(1).

4.11 Identification and Estimation

To deal with the identification problem, there are two specific schemes under which one can consistently estimate equation (2), as pointed in F&S and Rossana & Hu.

$d(L)\Delta^{\langle y\rangle}y_t = c(L)\Delta^{\langle m\rangle}m_t + w_t$

Under the first one, the covariance term in equation (2) $c_0 = \sigma_{uw}$ is assumed to be zero. The current value of change in money does not enter equation (2). This is appropriate when using real output, which does not respond to a change in money contemporaneously when using short measurement period i.e. monthly. Since most of my data are quarterly and yearly, this scheme will not be relevant. The other scheme involves assuming $b_0 = \sigma_{uw}$ to equal zero. In this case money is predetermined in equation (1). It is possible, however, that neither schemes are acceptable. But as pointed by F&S, $c(L)/d(L)$ are structural and not of interest. Only the reduced form $c(1)/d(1)$ are of relevance, which can be estimated directly in the frequency domain.

A General Scheme

The reduced form representation $c(1)/d(1)$ is of importance in conducting these statistical tests. The autocovariance generating function for the vector $\begin{bmatrix}\Delta m_t \\ \Delta y_t\end{bmatrix}$ can defined to be $M(z) = H(z)\sum H(z^{-1})'$, and the spectrum at frequency ω is then $S\ (\omega) = M(e^{-i\omega})/2\pi$. When $\Delta^{\langle y\rangle}y_t$ is regressed on $\Delta^{\langle m\rangle}m_t$ at frequency zero $\omega = 0$, the estimated coefficient equals $S_{21}(0)/S_{11}(0) = M_{21}(1)/M_{11}(1)$. This equals $c(1)/d(1)$ if the following restriction is met:

$$b(1) = \sigma_{uw} = 0 \qquad (4)$$

Thus, testing LRN involves estimating and testing $S_{21}(0)/S_{11}(0)$. Condition (4) implies that a permanent change in output has no effect on money in the long run and allows for both b_0 and c_0 to be non-zero. Thus, money is exogenous in the long run, which is crucial in neutrality tests.

Estimation Under the General Scheme

By regressing change in output on change in money at zero frequency, the coefficient $S_{21}(0)/S_{11}(0)$ is the LRN under the general identification scheme, which implies exogeneity of money supply. Frequency zero spectrums $S_{21}(0)\ and\ S_{11}(0)$ need to be estimated.

$$S_{21}(0) = \frac{1}{2\pi}\sum_{h=-\infty}^{\infty}\gamma_{ym}(h) \quad (5)$$

$$S_{11}(0) = \frac{1}{2\pi}\sum_{h=-\infty}^{\infty}\gamma_{mm}(h) \quad (6)$$

where $\gamma_{mm}(h)$ is the h-th order autocorrelation for change in money and $\gamma_{ym}(h)$ is the h-th order cross-correlation between change in output and change in money. Nonparametric estimation needs to be used for estimating the spectrums since the sample periodograms for $S_{21}(0)\ and\ S_{11}(0)$ obtained by replacing the sample cross-correlations and autocorrelations in (5) and (6) are inaccurate, albeit unbiased estimators with large sample size. Therefore, Bartlett kernel of the zero-frequency regression coefficient is used, which can be calculated using moving averages of the observations. This is because as pointed in Priestley, the Bartlett estimator smooths the periodogram using linearly decreasing weights. (Priestley, 1981) As pointed out in F&S, the Bartlett estimator of the frequency-zero regression coefficient can be seen by writing the covariance of the moving averages of the observations in terms of the aotocovariances:

$$cov(m_t - m_{t-k}, y_t - y_{t-k}) = \left(cov \sum_{i=0}^{k-1} \Delta\, m_{t-i}, \sum_{i=0}^{k-1} \Delta\, y_{t-i} \right)$$

$$= \sum_{i=0}^{k-1} \sum_{j=0}^{k-1} \gamma_{ym}(i-j) = k_{\gamma_{ym}}(0) + 2 \sum_{i=0}^{k-1} (k-i)\, \gamma_{ym}(i)$$

and the Bartlett estimator of the zero-frequency ratio $S_{21}(0)/S_{11}(0)$ can be estimated as $\lim_{k\to\infty} b_k$, where b_k is the slope coefficient from the regression

$$\sum_{i=0}^{k} \Delta^{\langle y \rangle} y_{t-i} = a_k + b_k \sum_{i=0}^{k} \Delta^{\langle y \rangle} m_{t-i} + e_{kt} \quad (7)$$

For the case where $\langle m \rangle = \langle y \rangle = 1$, which is what I look at here, equation (7) becomes:

$$(y_t - y_{t-k}) = a_k + b_k(m_t - m_{t-k}) + e_{kt} \quad (8)$$

The assumption of m and y to be of order 1 is a common practice in this literature. (Sulku, 2011) (Ekomie & Jacques, 2013) The estimator: $c(1)/d(1)$ is obtained from equation (8) as $\lim_{k\to\infty} b_k$. In this case, b_k is the slope scatterplot of output and money growth rates and the Bartlett estimator is the limit of that slope as the span over which those growth rates are computed goes to infinity.

Hence, testing for LRN involves only estimating equation (8). Next section develops the VAR tests for LRN and the following section summarizes the data and results from both the Fisher and Seater single equation and King and Watson bivariate VAR tests.

4.2 Bivariate VAR Test

VAR tests for neutrality and superneutrality developed by King and Watson (1997) provides another common toolset. The VAR equations modeling output and money are:

$$\Delta y_t = \lambda_{ym} \Delta m_t + \sum_{j=1}^{p} \alpha_{j,yy} \Delta y_{t-j} + \sum_{j=1}^{p} \alpha_{j,ym} \Delta m_{t-j} + \varepsilon_t^{\eta} \quad (9)$$

$$\Delta m_t = \lambda_{my}\Delta y_t + \sum_{j=1}^{p} \alpha_{j,my}\Delta y_{t-j} + \sum_{j=1}^{p} \alpha_{j,mm}\Delta m_{t-j} + \varepsilon_t^m \tag{10}$$

where the VAR is of order p. To test for contemporaneous money and output effects, I use the augmented VAR framework of K&W. The framework used is:

$$\begin{bmatrix} \Delta y_t \\ \Delta m_t \end{bmatrix} = \begin{bmatrix} \lambda_{ym} & o \\ o & \lambda_{my} \end{bmatrix} \begin{bmatrix} \Delta m_t \\ \Delta y_t \end{bmatrix} + \begin{bmatrix} \beta_{y\varphi}(L) & \beta_{ym}(L) \\ \beta_{m\varphi}(L) & \beta_{mm}(L) \end{bmatrix} \begin{bmatrix} \xi_t^{\varphi} \\ \xi_t^{m} \end{bmatrix} \tag{11}$$

where contemporaneous effects of money and output is allowed, Δ is the differencing operator, the matrix $\beta(L)$ contains lag polynomials that transmit the effects of iid shocks, ξ_t^m and ξ_t^{φ}. If the fraction:

$$\gamma_{ym} = \frac{\beta_{ym}(1)}{\beta_{mm}(1)} = 0$$

then money is neutral since a permanent shock to money has no effect on output. $\beta_{ij}(1)$ is the sum of the coefficients in the lag polynomial $\beta_{ij}(L)$. Since I will be using monthly data for my estimations, following Rossana and Hu (2017), I will be assume $\lambda_{ym} = 0$. Without making such an assumption one must estimate λ_{ym} and λ_{mm}. King and Watson provide a possibility of estimating one of these parameters in a reduced form VAR using GMM since it is not possible to identify both λ_{ym} and λ_{mm}. They do not use high frequency data and as pointed by Rossana and Hu, lags between money and output are typically longer than a quarter. Thus, the assumption of $\lambda_{ym} = 0$ seems empirically justifiable. For estimations using annual frequency, on the other hand, such an assumption can be misleading. Including intercepts, the VAR becomes:

$$\begin{bmatrix} \Delta y_t \\ \Delta m_t \end{bmatrix} = \begin{bmatrix} \mu_y \\ \mu_m \end{bmatrix} + \begin{bmatrix} \beta_{y\varphi}(L) & \beta_{ym}(L) \\ \beta_{m\varphi}(L) & \beta_{mm}(L) \end{bmatrix} \begin{bmatrix} \xi_t^{\varphi} \\ \xi_t^{m} \end{bmatrix} \tag{12}$$

which can be transformed into

$$\begin{bmatrix}\beta_{y\varphi}(L) & \beta_{ym}(L)\\ \beta_{m\varphi}(L) & \beta_{mm}(L)\end{bmatrix}^{-1}\left[\begin{bmatrix}\Delta y_t\\ \Delta m_t\end{bmatrix}-\begin{bmatrix}\mu_y\\ \mu_m\end{bmatrix}\right]=\begin{bmatrix}\xi_t^{\varphi}\\ \xi_t^{m}\end{bmatrix} \qquad (13)$$

Let the inverse matrix $\begin{bmatrix}\beta_{y\varphi}(L) & \beta_{ym}(L)\\ \beta_{m\varphi}(L) & \beta_{mm}(L)\end{bmatrix}^{-1}$ which will be estimated, be written as

$$\alpha(L)=\begin{bmatrix}\alpha_{11}(L) & \alpha_{12}(L)\\ \alpha_{21}(L) & \alpha_{22}(L)\end{bmatrix}=\begin{bmatrix}\beta_{y\varphi}(L) & \beta_{ym}(L)\\ \beta_{m\varphi}(L) & \beta_{mm}(L)\end{bmatrix}^{-1}=|\beta(L)|^{-1}\begin{bmatrix}\beta_{mm}(L) & -\beta_{ym}(L)\\ -\beta_{m\varphi}(L) & \beta_{y\varphi}(L)\end{bmatrix} (9)$$

and finally, the VAR to be estimated becomes

$$\begin{bmatrix}\alpha_{11}(L) & \alpha_{12}(L)\\ \alpha_{21}(L) & \alpha_{22}(L)\end{bmatrix}\left[\begin{bmatrix}\Delta y_t\\ \Delta m_t\end{bmatrix}-\begin{bmatrix}\mu_y\\ \mu_m\end{bmatrix}\right]=\begin{bmatrix}\xi_t^{\varphi}\\ \xi_t^{m}\end{bmatrix} \qquad (14)$$

and the estimate for money neutrality is

$$\gamma_{ym}=-\frac{\alpha_{12}(1)}{\alpha_{11}(1)} \qquad (15)$$

For money to be neutral, γ_{ym} must equal zero and $\alpha_{11}(1)\neq 0$, otherwise tests for neutrality cannot be done. In estimating γ_{ym}, the estimation of the standard errors become crucial, since the significance of the γ_{ym} parameter will depend on it. As in Rossana & Hu, I use the delta method to construct the standard errors. The polynomials in the matrix $\beta_{ij}(L)$ are in the bivariate vector moving average process where neutrality measure is defined and $\alpha_{ij}(L)$ are the parameters to be estimated. The standard errors are constructed by computing the matrix multiplication

$V'\Sigma\, V$ where Σ is the parameter covariance matrix and V is the vector

$$V=-\begin{bmatrix}\dfrac{\partial\gamma_{ym}}{\partial\alpha_{11}}\\[2mm] \dfrac{\partial\gamma_{ym}}{\partial\alpha_{12}}\end{bmatrix} \qquad (16)$$

4.3 Empirical Results

This section presents the empirical evidence of temporal aggregation of data on neutrality tests. All results were obtained using MATLAB and STATA software. My contribution to this literature is to investigate whether temporal aggregation biases results from the single equation Bartlett or the bivariate VAR estimators.

I calculate this estimate to test LMN for all G-7 countries. The data is obtained from the OECD, IMF, St. Louis Federal Reserve and Bank of England databases. A detail description of the years and frequency of data used is presented in Appendix D. For U.S, U.K and Japan all units across all variables are in local country currency. For the other European countries, all output and consumption measures are in local currency and money is in domestic country Euros. In other words, it represents the Euros issued for each of those countries individually and not for the Euro area as a whole. Augmented Dickey Fuller (ADF) tests are performed on the data to test for unit root and variables are found to be I(1) (Dickey & Fuller, 1981). All the figures estimating the Bartlett kernel, b_k as k becomes large are in Appendix E. Long run neutrality would exist if this parameter goes to zero over time.

One commonly documented problem when testing neutrality tests is the effects of aggregated data. (Rossana & Seater, 1995) As pointed out in their paper, there is substantial loss of information in moving from high frequency monthly data to quarterly data and coefficients results from regression are dramatically affected. (Rossana & Seater, 1995) They point out that using high frequency data is preferred. I test for temporal aggregation biases using methods in Rossana & Hu (2017). For the U.S. and U.K, I use real consumption and M2 (M3 for U.K) to derive aggregated monthly, quarterly and annual data and compare it quarterly and yearly real GDP and M2 (M3 for

U.K). For the other five countries, I do the same using quarterly real GDP and M2 to derive lower frequency data.

4.31 Fisher and Seater Single Equation Evidence

Appendix E has all the figures containing the Bartlett estimator b_k. Figures 11-15 show neutrality tests for the U.S. Figures 11-13 represent monthly, quarterly and annual real consumption and M2 using temporally aggregated monthly data and figures 14 and 15 are using quarterly and yearly Real GDP and M2 data respectively. The results are very similar across data frequencies and consistently find money to be not neutral. Non-neutrality disappears as lag length increases. For lag lengths between ten to twelve years, the consumption effects are close to zero, but not quite within the standard error at monthly and quarterly frequencies. However, at annual frequency, consumption effects, within the standard error, reach zero around the nine-year mark. So, money is neutral at the annual level using temporally aggregated monthly data. At very long lags for all estimates, beyond around the fourteen-year mark, the parameters at all frequency increase sharply. However, one must be cautious in reading too much into the results at very long lags due to decreasing sample size. One surprising result from all these tests is that money is not neutral at very short lag lengths. Economists widely agree that there is a lag on the effect of money on real variables and so we should see money to be neutral at very short lag lengths. Overall, for the U.S. temporal aggregation has minimal effect on Bartlett parameter estimates. And money is not neutral where non-neutrality dissipates around year ten.

In figure 14, using quarterly real GDP and M2, at very short lag length money has no effect on output. This is perhaps the most appealing result in the case for U.S, since this is what economic wisdom would suggest we should observe. Beyond lag of three, money effects real macro activity which dissipates over time. Neutrality is reached around lag length of thirty using quarterly data. Using annual data, in figure 15, neutrality is reached around the ten-year mark, but then non-neutrality arises at longer lag lengths.

Figures 16-18 represent test results for Canada. Like what I observed for the U.S., data aggregation does not matter for Canada either when going from quarterly to annual frequency. Figure 16 uses quarterly Real GDP and M3 and finds that money is neutral at very short lag length of one, which dissipates quickly. Neutrality reaching at lag length forty-five or about fifteen years within one standard error. When aggregating quarterly data into annual in figure 17, there is strong evidence for money neutrality within the standard error and money has no effect on real output until year ten. Again, as mentioned before at higher frequencies, due to smaller sample one must be cautious. At annual frequency money is neutral at very small lag lengths, which is what one would expect, but neutrality dissipates quickly. As is evident from figures 17 and 18, temporal aggregation is not important. Results from Canada at all frequency are appealing since we can confidently say that money has no effect on real variables in the very short run.

France: Figures 19-21 represent test results for France. Data aggregation does not matter for France when going from quarterly to annual frequency. Figure 19 uses quarterly Real GDP and M2 and finds that money is neutral, and neutrality does not dissipate until after 7 years. When aggregating quarterly data into annual in figure 20, there is strong evidence for money neutrality within the standard error and money has no effect on real output. At annual frequency, the results are very similar to those reached under temporal aggregation. As is evident from figures 19 and 20, temporal aggregation is not important. Results from France at all frequency strongly support monetary neutrality. One does have to be a little careful in the validity of tests for all European countries due to such small sample sizes.

Figures 22-24 represent test results for Germany where data aggregation does not matter when going from quarterly to annual frequency. Figure 22 finds that money is not neutral, and non-neutrality does not dissipate at any frequency. When aggregating quarterly data into annual in figure 23, money is not neutral, where non-neutrality dissipates at lag lengths of ten. At annual frequency (figure 24), the results are identical to those reached with temporal aggregation. As is evident from figures 23 and 24, temporal aggregation is not important. For the case of Germany, temporal aggregation matters a little and LRN is weakly supported.

Figures 25-27 represent test results for Italy where data aggregation matters. Figure 25 finds that money is not neutral, and non-neutrality does not dissipate at any frequency. When aggregating quarterly data into annual in figure 26, money is not neutral. At annual frequency (figure 27), the results look very different to those obtained with temporal aggregation. As is evident from figures 26 and 27, temporal aggregation is important, but neither support long run neutrality. For the case of Italy, temporal aggregation matters and money effects real variables across all lags and temporal aggregation.

Figures 28-30 represent test results for Japan. Figure 28 finds that money is not neutral when using quarterly data, and non-neutrality does not dissipate at any frequency. When aggregating quarterly data into annual in figure 29, money is neutral at very short lags of two after which it is not neutral. At annual frequency in figure 30, the neutrality that is observed with temporal aggregation disappears. As is evident from figures 29 and 30, temporal aggregation is important.

Lastly figures 31-35 represent monthly, quarterly and annual real consumption and M3 using temporally aggregated monthly data and quarterly and yearly Real GDP and M3 respectively for United Kingdom. The results are very similar across quarterly and annual frequencies, with and without temporal aggregation. All frequency and aggregation techniques consistently find money to be neutral. Money has no real effects on macro variables in the very short run in all cases, which is very promising. For consumption data neutrality lasts for four to six years after which money is non-neutral. So, money is neutral at the quarterly and annual levels using temporally aggregated monthly data. Overall, for the U.K. temporal aggregation has minimal effect on Bartlett parameter estimates, as was seen for U.S. Using quarterly and yearly real GDP and M3, neutrality is reached very quickly and dissipates around year eight to ten.

4.32 Bivariate VAR evidence

Table 6 reports the estimated neutrality measures and the corresponding standard errors from the VAR framework for U.S and U.K. For the remaining five countries, these results are presented in Appendix E. Lag lengths for the tests were chosen using Hannan and Quinn (1979) method as they are known to be consistent. A parameter with *** signifies that for that time frequency, we can reject the fact that gamma is statistically different from zero with ninety-nine percent confidence. ** and * represent the level of certainty at the ninety-five and ninety percent levels.

Table 6: VAR results for United States

Date frequency	Measure	Lag length	γ_m	Standard Error
Monthly	Real C and M2	3	0.155***	0.059
Quarterly	Real C and M2	3	0.264**	0.129
Quarterly	Real GDP and M2	2	0.339	0.57
Annual	Real C and M2	1	0.185	0.135
Annual	Real GDP and M2	1	0.247	0.139

Table 7: VAR results for United Kingdom

Date frequency	Measure	Lag length	γ_m	Standard error
Monthly	Real C and M3	3	0.167***	0.066
Quarterly	Real C and M3	3	0.314**	0.139
Quarterly	Real GDP and M3	3	0.219	0.457
Annual	Real C and M3	2	0.585	0.561
Annual	Real GDP and M3	1	0.654	0.537

VAR tests clearly signify that temporal aggregation can distort neutrality tests. For the U.S, results at monthly frequency strongly reject monetary neutrality since the coefficient is significantly different from zero at the one percent level. But, as data gets temporally aggregated, non-neutrality results become less compelling with neutrality emerging when using annual data. Thus, confidence in non-neutrality declines as data gets temporally aggregated. The optimal lag lengths decrease as data gets aggregated from quarterly to annual, but not when going from monthly to quarterly.

Results from the U.K shows that money is not neutral at the one percent and ten percent levels using monthly and temporally aggregated quarterly data. However monetary neutrality exists when data gets aggregated at the annual frequency.

For the remaining countries, the results are presented in Appendix E, tables 11 through 15. Using quarterly data money is significantly different from zero for Canada, France and Italy, but non-neutrality cannot be rejected for Japan and Germany. When aggregating quarterly data to get annual frequency, money is neutral for Canada, Japan and Germany, but neutrality is strongly rejected for Italy and France. Annual level data rejects non-neutrality for all countries. Hence, the results for all seven countries suggest that VAR results are very sensitive to temporal aggregation.

Sensitivity of results to lag length chosen is well known in VAR literature. King and Watson use lag lengths of six in their studies. To compare the dynamic adjustment period from Bartlett estimates (Fisher and Seater), I calculated impulse responses for all countries to orthogonalized innovations in the estimated VAR's and found the results to be consistent. These impulse responses are not reported in this paper.

To summarize, the Bartlett estimator is unaffected by temporal aggregation for five of seven countries but the results from the VAR approach is extremely sensitive for six of seven countries. Japan being an interesting case where F&S tests consistently rejects neutrality, but the VAR's do not for all frequency and aggregations.

CHAPTER 5: CONCLUSION

Chapter 1 uses an already developed testable theoretical model to test the effects of international linkages in financial markets and their impact on macro variables. I use the model developed by Devereux and Yetman to build a two-country model with financial linkages through investors borrowing from savers in both home and foreign. The ability of investors to lend to final goods producing firms creates the channels through which borrowing and these international effects take place. I further the literature on international macroeconomics by testing whether these financial linkages have a more profound effect during recessions than expansions.

Results suggest that contractions in both consumption by savers and lenders and investment in both home and foreign are stronger during recessions than in expansions. I measure this effect by looking at leverage constraints faced by investors; Tier 1 assets to capital by major banks amongst fourteen countries. I assume that investors face tighter leverage constraints during recessions than expansions. This happens because savers require investors to hold more capital to asset ratio during economic downturn. Other authors calibrate this parameter and assume it to be constant. This paper employs a Markov regime switching model to estimate this parameter using maximum log likelihood method. Using output data for the U.S, I find the parameter for leverage constraints to be more than three times higher during expansions than recessions, implying that investors face a severe tightening of funds.

This results board well for public policymaking where most central banks lower interest rates and easy lending during recessions. This was especially true during the recession of 2007. An important result for countries that are financially integrated with the rest of the world is that when a negative shock is experienced in another country, the home country can act preemptively.

A second contribution of chapter 1 is to include shocks directly in the financial markets. I then look at both a negative productivity and financial sector shock. A surprising result of the financial shock is that there is perfect correlation in asset prices in home and foreign. Lastly, chapter 2 looks at neutrality tests using Fisher and Seater method across G-7 countries and finds mixed results in support of long run neutrality of money. The long debated, theoretically sound and yet empirically inconclusive LMN does not get any clearer after my tests.

There are a few extensions to my first chapter that are worth mentioning. Building capital adjustments across international portfolios, estimating the other parameters and including a central banking mechanism into the model would make this economy more realistic. Including monetary policy by central banks might help capture some of the missing dynamics of financial linkages.

The chapter on neutrality tests provides a much less convincing support of its hypothesis. Using the Fisher and Seater Bartlett estimators, money is neutral for France, Germany and U.K. VAR results suggest the same for Japan, Germany and U.K. for all frequencies. Even though proving monetary neutrality is a mixed bag, a convincing aspect of the Fisher and Seater tests is that the results are unaffected by temporal aggregation. This is an appealing feature of the F&S tests. VAR results on the other hand are extremely sensitive to temporal aggregation and must be considered with caution. Money plays a very important role in an economy and it would be worth including monetary variables in the two-country model from chapter 1.

One aspect of neutrality tests I did not consider are biases from structural change. The data set used by Fisher and Seater in their original work was using data from Friedman and Schwartz (1982), which covers U.S. data from 1867 to 1975. We know that data in that time-period had several structural breaks from the Industrial

Revolution to monetary policy. It would be worthwhile to run the tests I do here across the different regimes for these countries to get a more robust understanding.

APPENDIX A

Investors maximize equation (1) subject to equations (2) and (3). Bellman equation is:

$V\left(k_{1t-1,}\, k_{2t-1,}\, B_{t-1}\right) = U(C_t^I) + E_t\beta^I(C_t^I)\, V(k_{1t}^I, k_{2t}^I, B_{1t}) + \lambda_t[W_t^I + (q_{1t} + R_{1Kt})k_{1t-1}^I + (q_{2t} + R_{2Kt})k_{2t-1}^I + B_t^I - R_{t-1}^I\, B_{t-1}^I - C_t^I - q_{1t}k_{1t}^I - q_{2t}k_{2t}^I] + \mu_t[\kappa(q_{1t}k_{1t}^I + q_{2t}k_{2t}^I) - B_t^I]$ (*I*-1)

where k_{1t}^I, k_{2t}^I and B_t^I are the state variables and C_t^I the control variable. λ_t is the multiplier on the budget constraint and μ_t the multiplier on the leverage constraint, μ_t being positive means that the investor would like to borrow more.

FOC:

$C_t: U'(C_t^I) = \lambda_t$ (*I*-2)

$B_t: E_t\beta^I(C_t^I)\frac{dv(\bullet)}{dbt} = -\lambda_t + \mu_t$

Envelope Theorem states that

$$\frac{\mathrm{dv}(\bullet)}{\mathrm{db}_{t-1}} = \frac{\partial v(\bullet)}{\partial b_{t-1}} = -\lambda_t R_{t-1}\ and\ so\ \frac{dv(\bullet)}{dbt} = -\lambda_{t+1}R_t$$

$therefore\ E_t\beta^I(C_t^I)\lambda_{t+1}R_t + \mu_t = \lambda_t$ (*I*-3)

$k_{1t} : E_t\beta^I(C_t^I)\lambda_{t+1}(q_{1t+1} + R_{1Kt+1)}) = \lambda_t q_{1t} - \mu_t\, \kappa\, q_{1t}$ (*I*-4)

$k_{2t} : E_t\beta^I(C_t^I)\lambda_{t+1}\big(q_{2t+1} + R_{2Kt+1)}\big) = \lambda_t q_{2t} - \mu_t\, \kappa\, q_{2t}$ (*I*-5)

combining the FOC's we get the Euler equations

$C_t\ \&\ k_{1t} \Rightarrow U'(C_t^I) = E_t\beta^I(C_t^I)U'(C_{t+1}^I)\left(\frac{q_{1t+1} + R_{1kt+1}}{q_{1t}}\right) + \mu_t\,\kappa$ (*I*-6)

$C_t\ \&\ k_{2t} \Rightarrow U'(C_t^I) = E_t\,\beta^I(C_t^I)U'(C_{t+1}^I)\left(\frac{q_{2t+1} + R_{2K,t+1}}{q_{2t}}\right) + \mu_t\,\kappa$ (*I*-7)

$C_t \& B_t \Rightarrow U'(C_t^I) = E_t\,\beta^I(C_t^I)U'(C_{t+1}^I)\,R_t + \mu_t$ (*I*-8)

Facing leverage constraints does not impose any restrictions on diversifying the portfolio of equity holdings. (3) restriction applies equally to borrowing domestic or foreign equity. Hence (*I*-6) and (*I*-7) gives us the portfolio selection condition:

$E_tU'(C_{t+1}^I)\left(\frac{q_{1t+1} + R_{1k,t+1}}{q_{1t}} - \frac{q_{2t+1} + R_{2K,t+1}}{q_{2t}}\right) = 0$ (*I*-9)

Like Devereux and Yetman, I define $r_{1,t+1} = \frac{q_{1t+1} + R_{1k,t+1}}{q_{1t}}$ and the previous equation can be written as

$$E_t U'(C^I_{t+1})\left[r_{1,t+1} - r_{2,t+1}\right] = 0 \qquad (I\text{-}10)$$

combining equations (I-6), (I-7) and (I-8) we can solve for μ_t

$$\mu_t \; = E_t\beta^I(C^I_t)U'(C^I_{t+1})\left[\frac{\left(\frac{q_{1t}k_{1t}}{q_{1t}k_{1t}+q_{2t}k_{2t}}\right)\left(\frac{q_{1t+1}+R_{1kt+1}}{q_{1t}}\right)+\left(1-\frac{q_{1t}k_{1t}}{q_{1t}k_{1t}+q_{2t}k_{2t}}\right)\left(\frac{q_{2t+1}+R_{2kt+1}}{q_{2t}}\right)-R_t}{1-\kappa}\right] \qquad (I\text{-}10)$$

This shows that when $\mu_t \; > 0$, the expected return on the portfolio exceeds the cost of borrowing. Using (I-10) one can derive the optimal equity portfolio for investors.

Savers maximize equation (5) subject to equations (7). Bellman equation is:

$$V\left(k_{1t-1,}B_{t-1}\right) = U(C_t) + E_t\beta(C_t)V\left(k_{1t,}B_t\right) + \lambda_t[C^S_t + q_{1t}\,k^S_{1t} - W^S_t - q_{1t}k^S_{1t-1} - G(k^S_{1t-1}) - B^S_t + B^S_{t-1}R_{t-1}] \qquad (S\text{-}1)$$

FOC:

$$C_t: U'C_t) = -\lambda_t \qquad (S\text{-}2)$$
$$k_{1t}: E_t\beta^S(C^S_t)(-\lambda_{t-1}\{q_{1t+1} + G'(k^S_{1t})\}) = -\lambda_t q_{1t} \qquad (S\text{-}3)$$
$$B_t: E_t\beta(C_t)(-R_t\lambda_{t+1}) = \lambda_t \qquad (S\text{-}4)$$

combining the FOC's

$$C_t \;\&\; k_{1t} \Rightarrow U'(C^S_t) = E_t\beta^S(C^S_t)U'(C^S_{t+1})\left(\frac{q_{1t+1}+G\,'(k^S_{1t})}{q_{1t}}\right) \qquad (S\text{-}5)$$

$$C_t \;\&\; B_t \Rightarrow U'(C^S_t) = E_t\beta^S(C^S_t)U'(C^S_{t+1})R_t \qquad (S\text{-}6)$$

Production Firms maximize (8) subject to equation (10)

FOC:

$$L_t \Rightarrow W_t = A_tF_1(L_t\,, K_{t-1}) \qquad (F\text{-}1)$$

$$K_{t-1} \Rightarrow R_{1K,t} = A_tF_2(L_t\,, K_{t-1}) \qquad (F\text{-}2)$$

$$logA_t = \rho log(A_{t-1}) + \upsilon_t$$

System of Equations:

As mentioned in section 3 of the paper the equilibrium is described by equations 2, 3, 7,12, I-6, I-7, I-8, S-5, S-6, F-1, F-2 for home and foreign along with a single global equation 11 and 13.

$$C^I_t + q_{1t}k^I_{1t} + q_{2t}k^I_{2t} + R_{t-1}B^I_{t-1} = W^I_t + (q_{1t} + R_{1Kt})k^I_{1t-1} + (q_{2t} + R_{2Kt})k^I_{2t-1} + B^I_t \qquad (2)$$

$$B^I_t \leq \kappa(q_{1t}k^I_{1t} + q_{2t}\,k^I_{2t}\,)\;where \qquad (3)$$

$$C_t^S + q_{1t}\mathrm{k}_{1t}^S = W_t^S + q_{1t}\, k_{1t-1}^S + G(k_{1t-1}^S) + \mathrm{B}_t^S - B_{t-1}^S R_{t-1} \tag{7}$$

$$U'(C_t^I) = E_t\beta^I(C_t^I)U'(C_{t+1}^I)\left(\frac{q_{1t+1} + R_{1kt+1}}{q_{1t}}\right) + \mu_t\,\kappa \tag{I-6}$$

$$U'(C_t^I) = E_t\,\beta^I(C_t^I)U'(C_{t+1}^I)\left(\frac{q_{2t+1} + R_{2K,t+1}}{q_{2t}}\right) + \mu_t\,\kappa \tag{I-7}$$

$$U'(C_t^I) = E_t\,\beta^I(C_t^I)U'(C_{t+1}^I)\,R_t + \mu_t \tag{I-8}$$

$$U'(C_t^S) = E_t\beta^S(C_t^S)U'(C_{t+1}^S)\,\left(\frac{q_{1t+1}+G\,'(k_{1t}^S)}{q_{1t}}\right) \tag{S-5}$$

$$U'(C_t^S) = E_t\beta^S(C_t^S)U'(C_{t+1}^S)R_t \tag{S-6}$$

$$W_t = A_tF_1(L_t\,,K_{t-1}) \tag{F-1}$$

$$R_{1K,t} = A_tF_2(L_t\,,K_{t-1}) \tag{F-2}$$

$$nk_{1,t}^I + nk_{1,t}^{I^*} + (1-n)k_{1,t}^S = 1 \tag{12}$$

$$n\left(B_t^I + B_t^{I^*}\right) + (1-n)\left(B_t^S + B_t^{S^*}\right) = 0 \tag{11}$$

$$n\left(C_t^I + C_t^{I^*}\right) + (1-n)\left(C_t^S + C_t^{S^*}\right) = A_t\,F(1, n(k_{1,t-1}^I + k_{1,t-1}^{I^*})) + A_t^*\,F\left(1, n\left(k_{2,t-1}^I + k_{2,t-1}^{I^*}\right)\right) + (1-n)\left(G\left(k_{1,t-1}^S\right) + G(k_{2,t-1}^{S^*})\right) \tag{13}$$

(I-6) and (I-7) are combined into (I-9) or equation (4), (4’) in the paper.

Solution as developed in (Devereux & Sutherland, Country portfolios in open economy macro models, 2011)

The system of equations is solved by log-linearizing around a non-stochastic steady state by computing the second order approximation of the portfolio equation 4 along with a first order approximation of the rest of the model. In a two-country model with portfolio choices we have:

$$E_tU'(C_{t+1}^I)\left(\frac{q_{1t+1} + R_{1k,t+1}}{q_{1t}} - \frac{q_{2t+1} + R_{2K,t+1}}{q_{2t}}\right) = 0 \tag{I-9}$$

$$E_tU'(C_{t+1}^I)\left[r_{1,t+1} - r_{2,t+1}\right] = 0 \tag{I-10}$$

where $r_{1,t+1} = \frac{q_{1t+1} + R_{1k,t+1}}{q_{1t}}$ and $r_{x,t+1} = \left[r_{1,t+1} - r_{2,t+1}\right]$

Equation (I-9) exists for home and foreign:

$$E_tU'(C_{t+1}^I)r_{x,t+1} = 0 \text{ and } E_tU'\left(C_{t+1}^{I^*}\right)r_{x,t+1} = 0 \tag{I-11}$$

APPENDIX B

Appendix B contains the data source used in section 5 to estimate the Markov estimate: Annual frequency data for leverage ratio is from a commercial database maintained by the International Bank Credit Analysis (IBCA). U.S real GDP measure is from OECD database. The data for both real GDP and leverage ratio is from 1995-2012 amongst 14 OECD countries. This range of years includes multiple business cycles.

Table 8: Summary of country and bank asset database

Countries	*ASSETS (2012, USD bn)*	*Location of the ultimate borrower*		*No. of banks*
		Domestic	*Other*	
Austria	610	70.2	29.8	5
Australia	3073	74.2	25.8	7
Belgium	1169	57.9	42.1	3
Canada	3402	68.6	31.4	6
Switzerland	2753	37.0	63.0	6
Germany	5297	77.5	22.5	14
Spain	3542	67.4	32.6	14
France	8731	72.3	27.7	6
Italy	3177	80.8	19.2	12
Japan	3555	82.8	17.2	5
Netherlands	2711	60.4	39.6	3
Sweden	1921	58.3	41.7	4
United Kingdom	10730	62.7	37.3	7
United States	10273	73.8	26.2	17
Sum/average*	60944*	67.4	32.6	109*

Table 9: Summary statistics for Tier 1 capital to total assets and output

Variable name	*Variable description*	*Number of observations*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Tier 1 / Total assets $_t$	Tier 1 over total assets	1592	5.12	2.11	-0.50	14.61
$\Delta NGDP_t$	Growth rate of nominal GDP adjusted	2646	4.52	2.80	-5.43	16.01
$\Delta RGDP_t$	Growth rate of real GDP adjusted	2646	2.08	1.86	-5.28	5.92

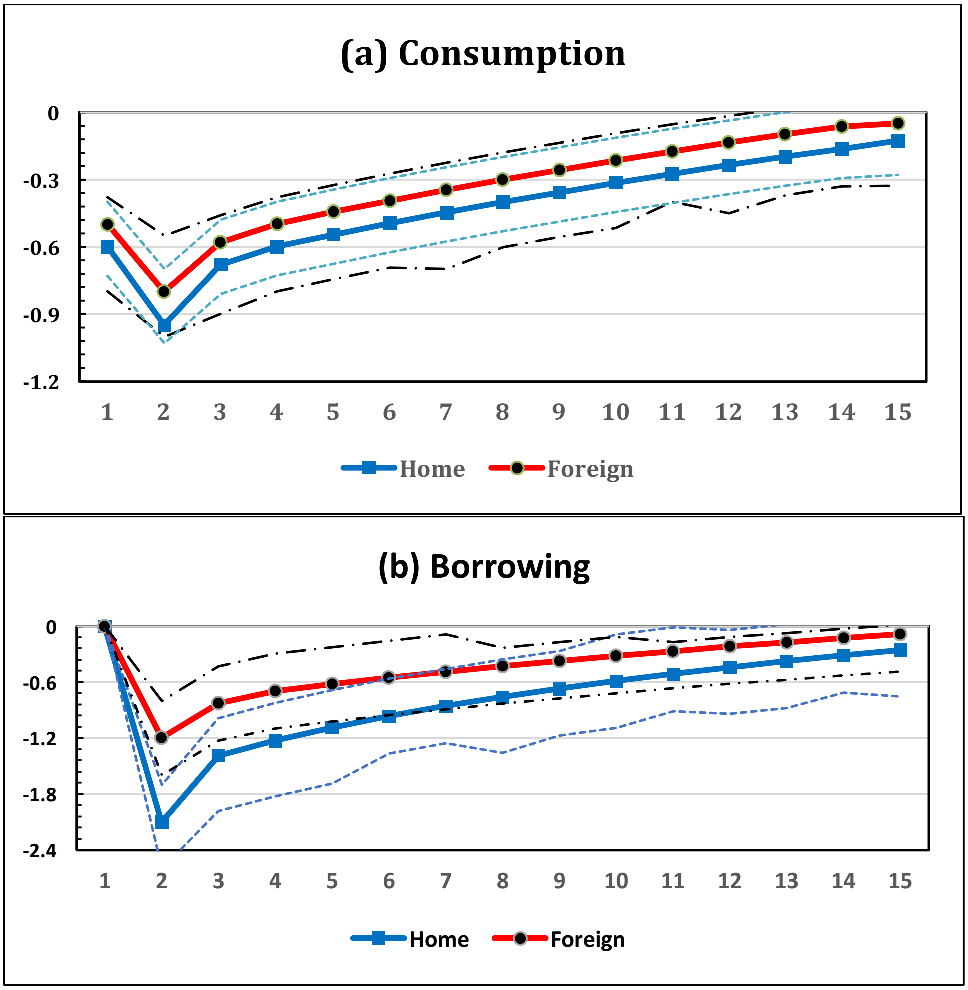
Table 10: Unit root tests for Tier 1 capital to total assets and output

Variable	**ADF I(1)**	**PP I(1)**
Log Real GDP	-6.8** (1)	-7.03** (1)
Log tier 1 capital to assets	-13.6** (1)	-11.6* (1)
5% significance level is denoted by ** Lag length is chosen using SIC criteria and is represented in parenthesis		

APPENDIX C

The impulse responses from the two-country DSGE model with Monto Carlo error bands are presented here for select variables. The dashed blue lines are the bands around the home curves and the black dashed lines for foreign.

Figure 8: Productivity shock with high leverage constraint, no transactions costs (corresponds to Figure 2)



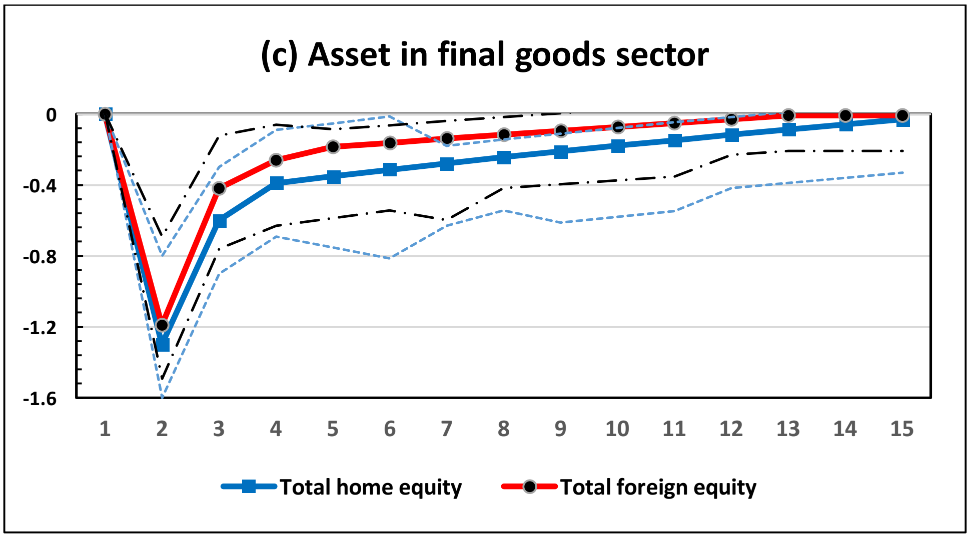
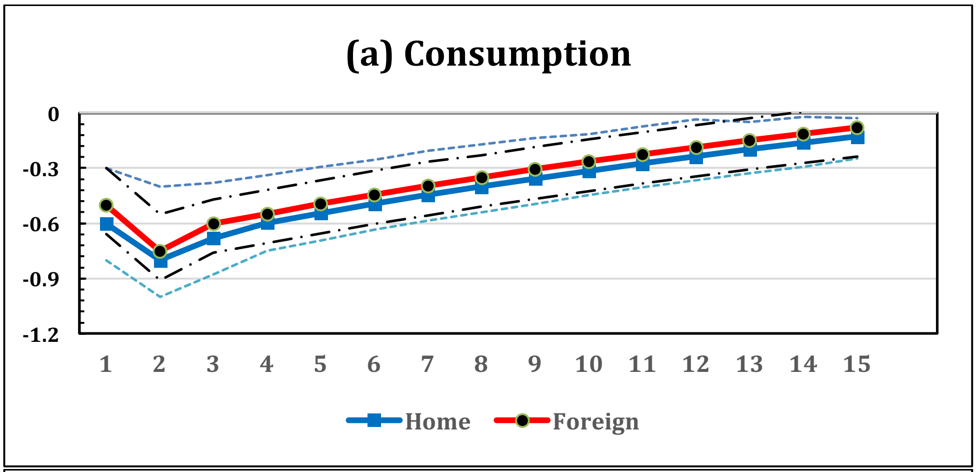
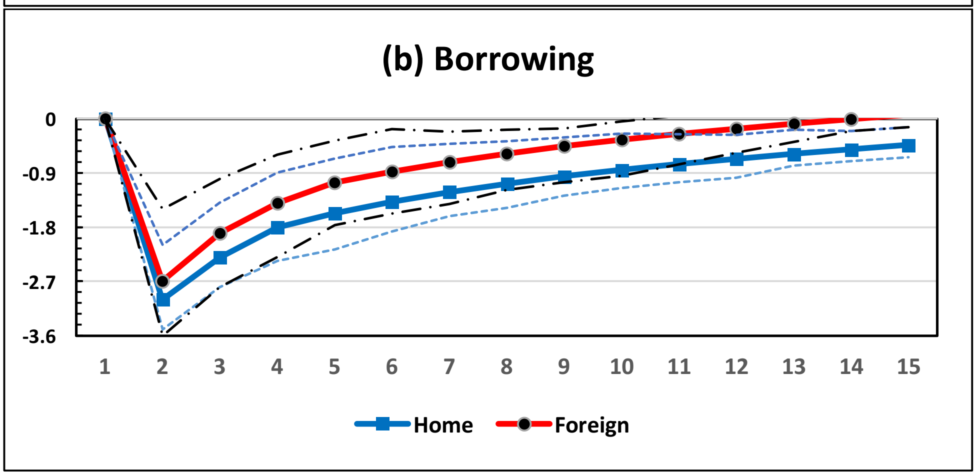


Figure 9: Productivity shock with low leverage constraint, with transactions costs (corresponds to Figure 5)





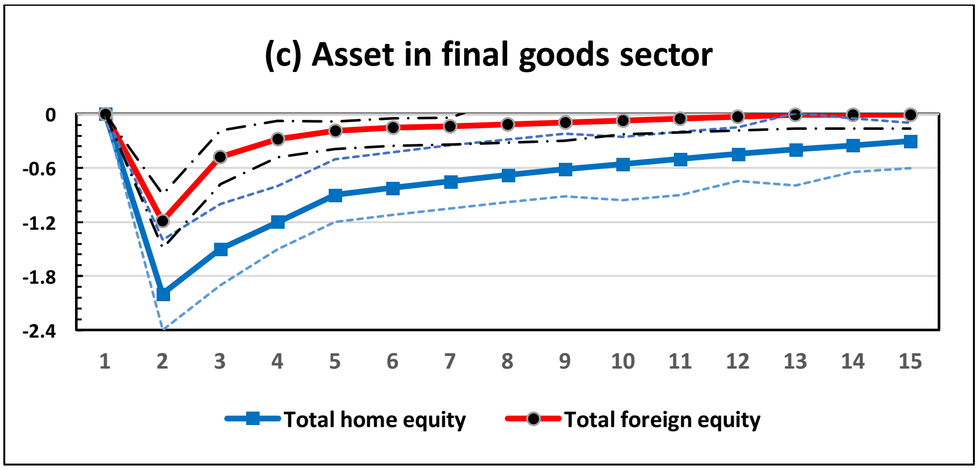
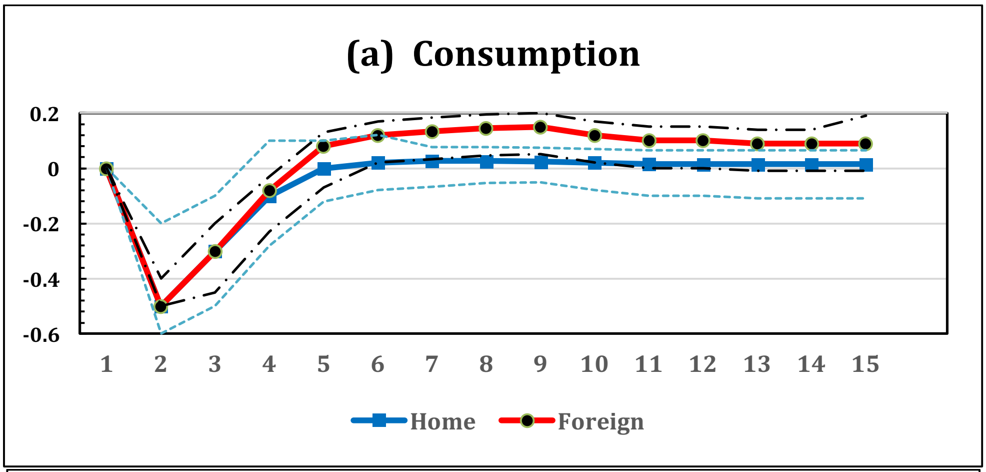
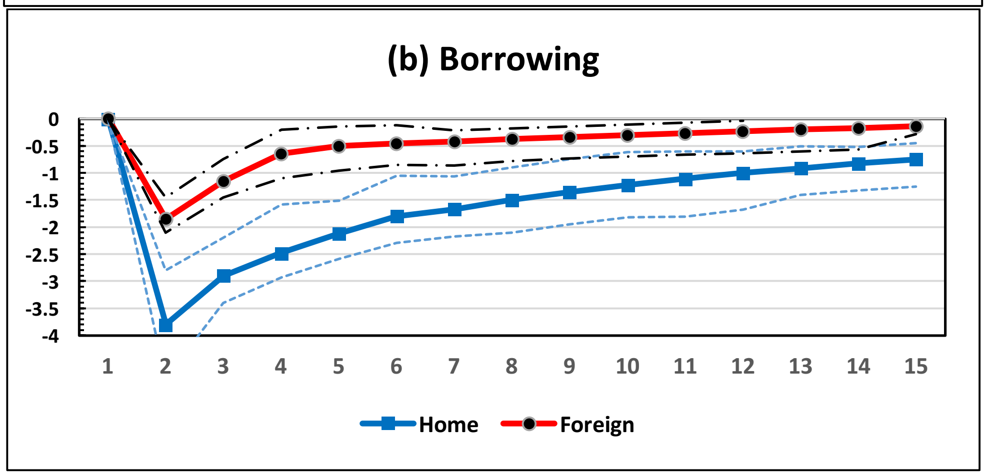


Figure 10: Financial sector shock, without transactions costs (corresponds to Figure 7)





APPENDIX D

Appendix D describes the data used for money neutrality tests. Data sources include the International Monetary Fund (IMF), Organization for Economic Co-Operation and Development (OECD), St. Louis Federal Reserve and the Bank of England. In converting money variables from higher to lower frequencies, the standard stock conversion method of using the last monthly or quarterly measurement in the year is used to generate lower frequency data. For output and consumption, the method of summing monthly to get quarterly and quarterly to get annual data is used.

Table 11: Data description for Money Neutrality F&S and VAR tests

	Variable	Frequency	Time	Source
Canada	M3	Quarterly	1970Q1-2017Q1	IMF
	M3	Annually	1970-2016	IMF
	GDP	Quarterly	1970Q1-2017Q1	OECD
	GDP	Annually	1970-2016	OECD
France	M2	Quarterly	1980Q4-1998Q4	IMF
	M2	Annually	1977-1998	IMF
	GDP	Quarterly	1980Q4-1998Q4	OECD
	GDP	Annually	1960-2016	OECD
Germany	M2	Quarterly	1970Q1-1998Q4	IMF
	M2	Annually	1970-1998	IMF
	GDP	Quarterly	1970Q1-1998Q4	OECD
	GDP	Annually	1970-1998	OECD
Italy	M2	Quarterly	1974Q1-1998Q2	OECD, IMF
	M2	Annually	1974-1998	OECD, IMF
	GDP	Quarterly	1974Q1-1998Q2	OECD
	GDP	Annually	1974-1998	OECD, IMF
Japan	M2	Quarterly	1970Q1-2016Q4	IMF
	M2	Annually	1970-2016	IMF
	GDP	Quarterly	1970Q1-2016Q4	OECD
	GDP	Annually	1970-2016	OECD
United Kingdom	M3, Index	Monthly	M121986-M82016	OECD
	M3, Index	Quarterly	1987Q1-2016Q4	IMF
	M3, Index	Annually	1983-2016	OECD
	C	Monthly	M121986-M82016	BOE
	GDP	Quarterly	1987Q1-2016Q4	OECD
	GDP	Annually	1983-2016	OECD
United States	M2	Monthly	1960-2016	IMF
	M2	Quarterly	1960Q1-2017Q1	IMF
	M2	Annually	1960-2016	IMF
	C	Monthly	1960M1-2016M12	St. Louis Fed
	GDP	Quarterly	1960Q1-2017Q1	OECD
	GDP	Annually	1960-2016	OECD

APPENDIX E

Money neutrality results using Fisher & Seater methodology using different temporal aggregation schemes for G-7 countries. The graphs below represent the Bartlett Parameter Estimates with confidence interval bands around the parameter.

United States

Figure 11: Monthly Real Consumption and M2

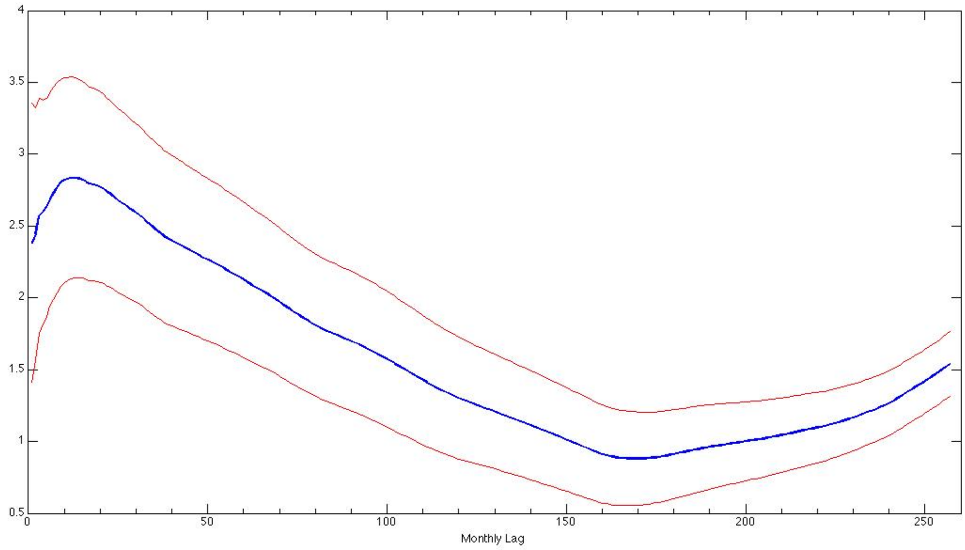


Figure 12: Aggregated quarterly Real Consumption and M2

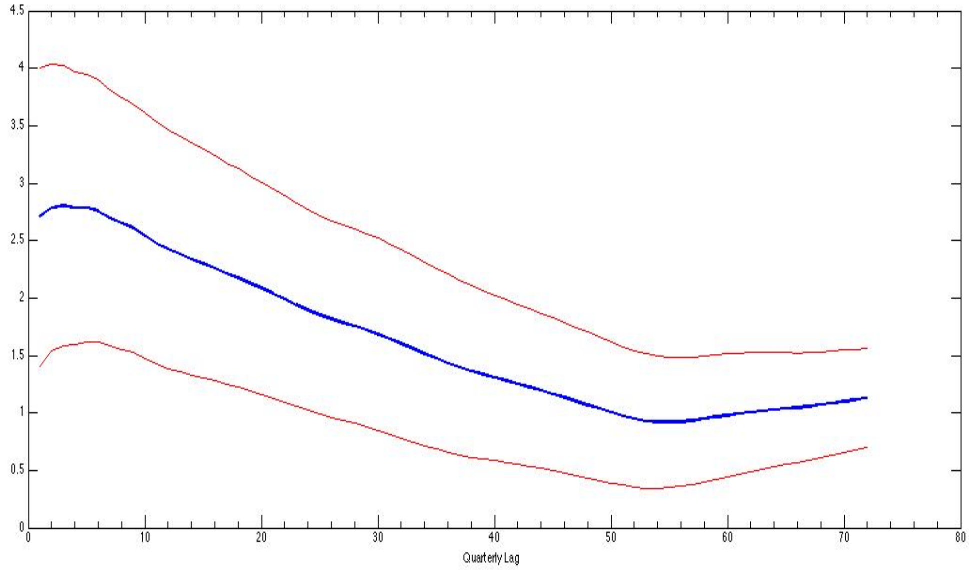


Figure 13: Aggregated annual Real Consumption and M2

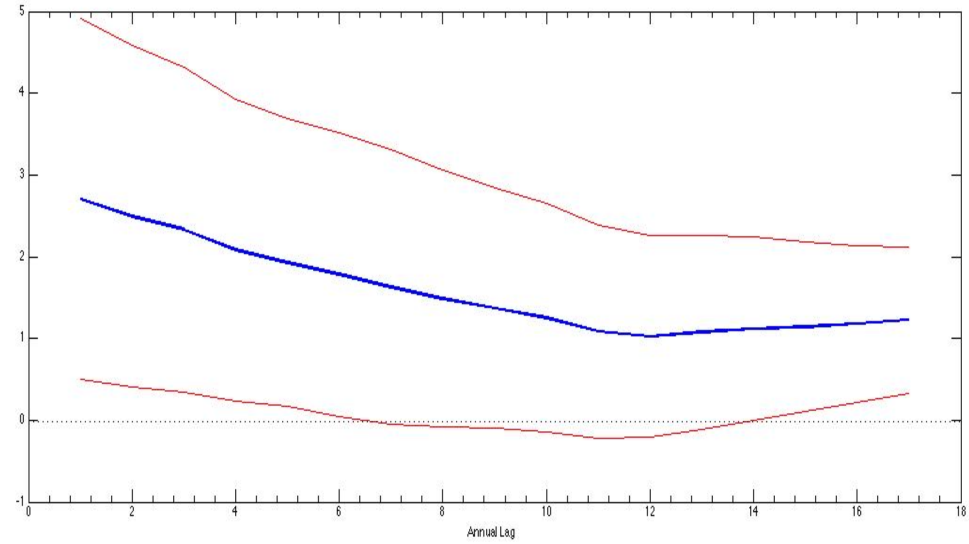


Figure 14: Quarterly Real GDP and M2

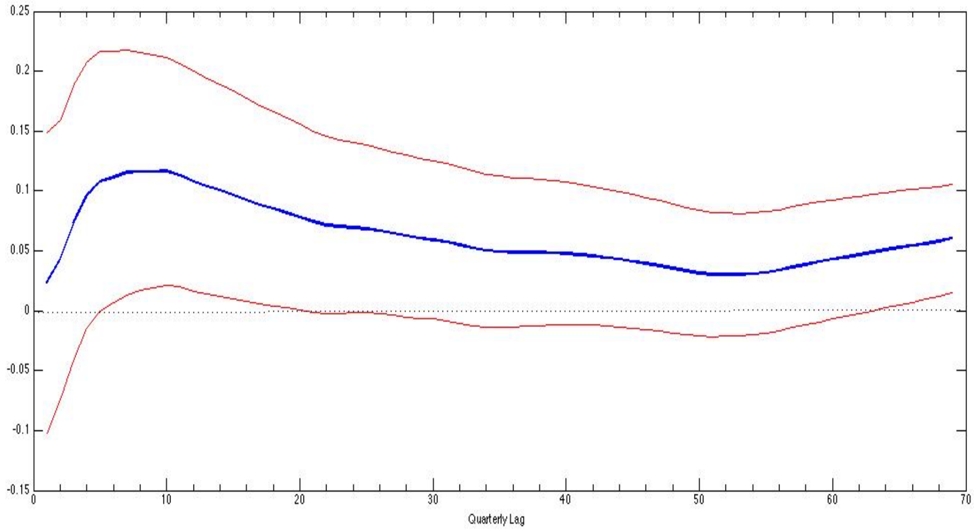
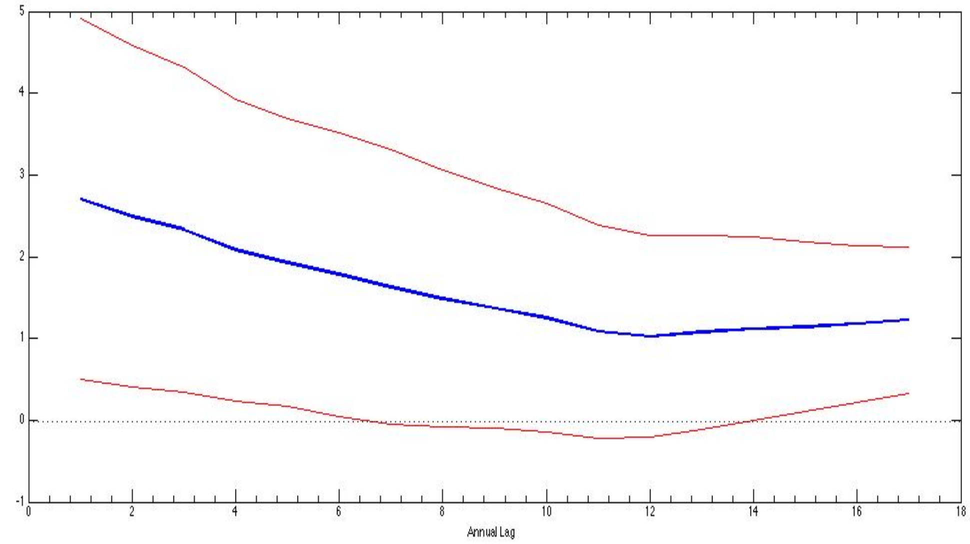


Figure 15: Annual Real GDP and M2



Canada

Figure 16: Quarterly Real GDP and M3

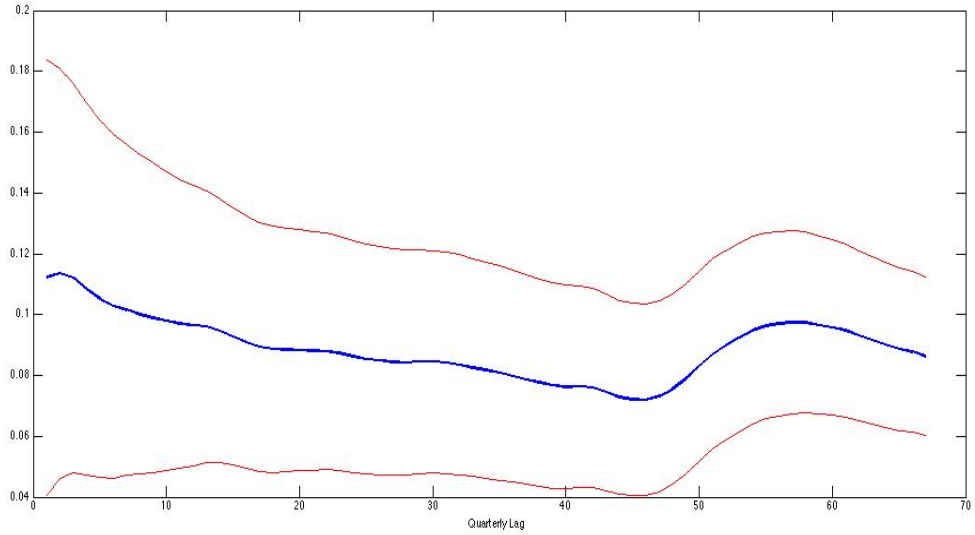


Figure 17: Aggregated annual Real GDP and M3

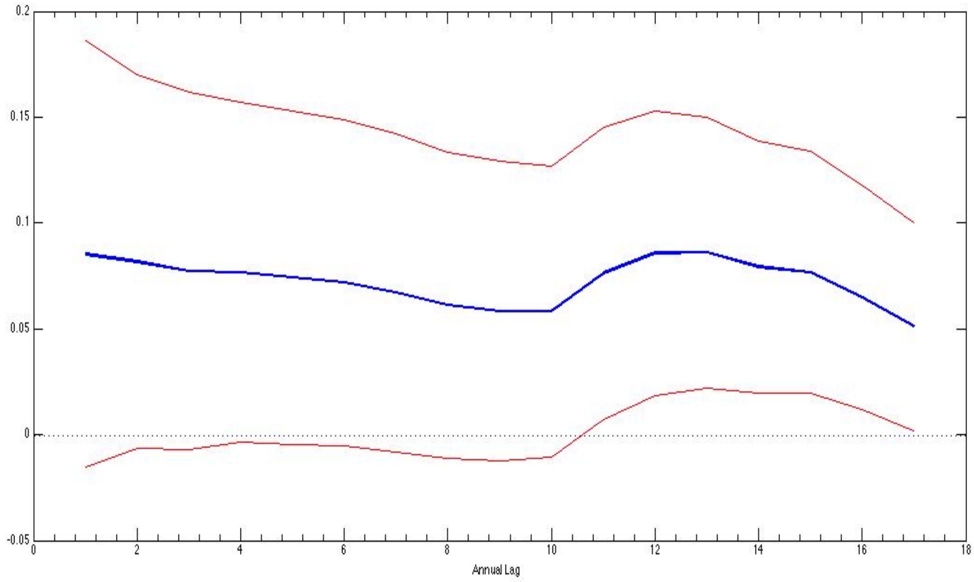
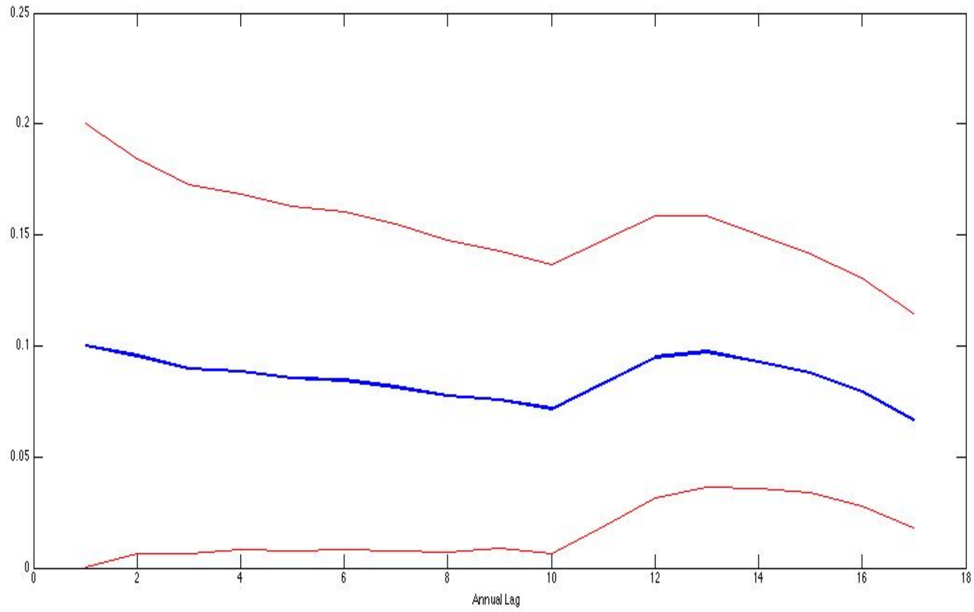


Figure 18: Annual Real GDP and M3



France

Figure 19: Quarterly Real GDP and M2

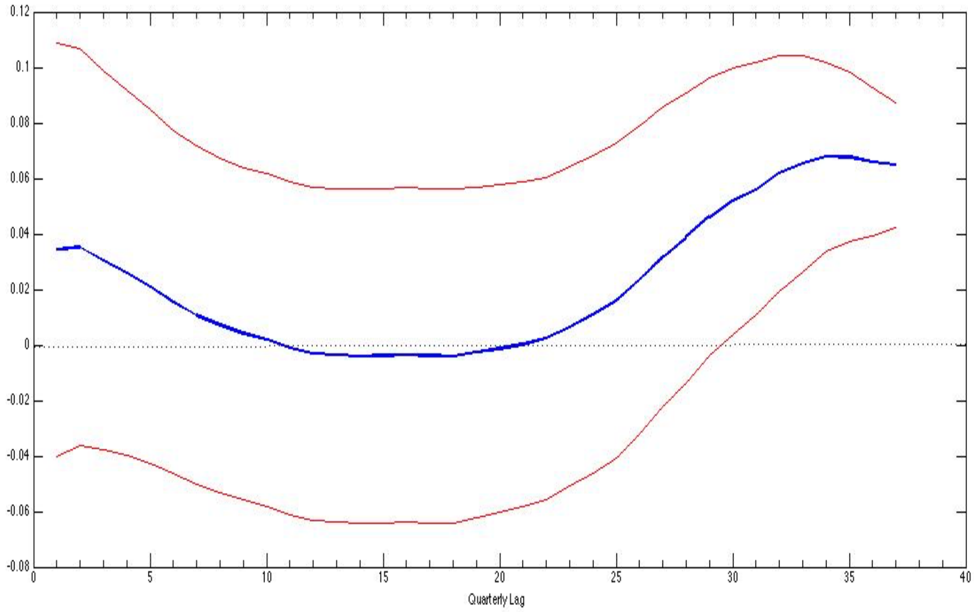


Figure 20: Aggregated annual Real GDP and M2

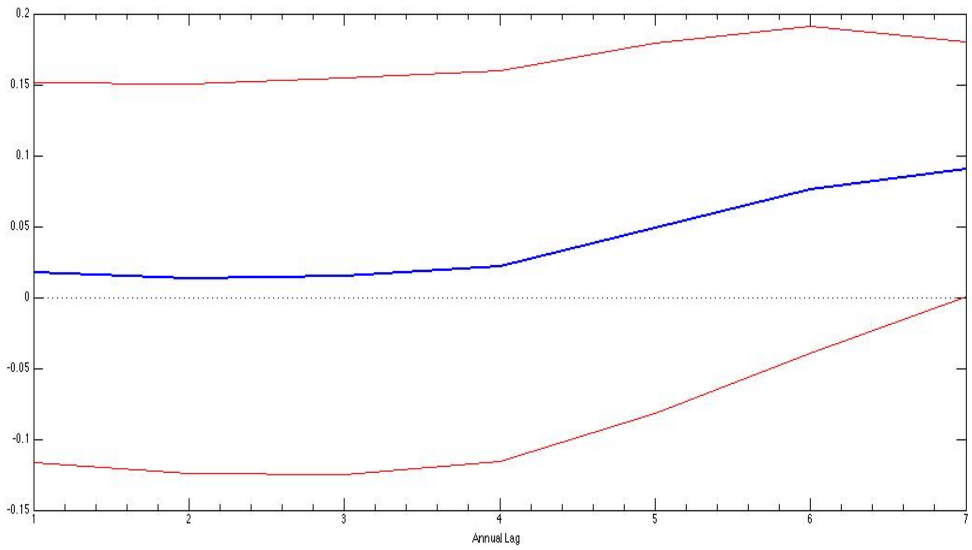
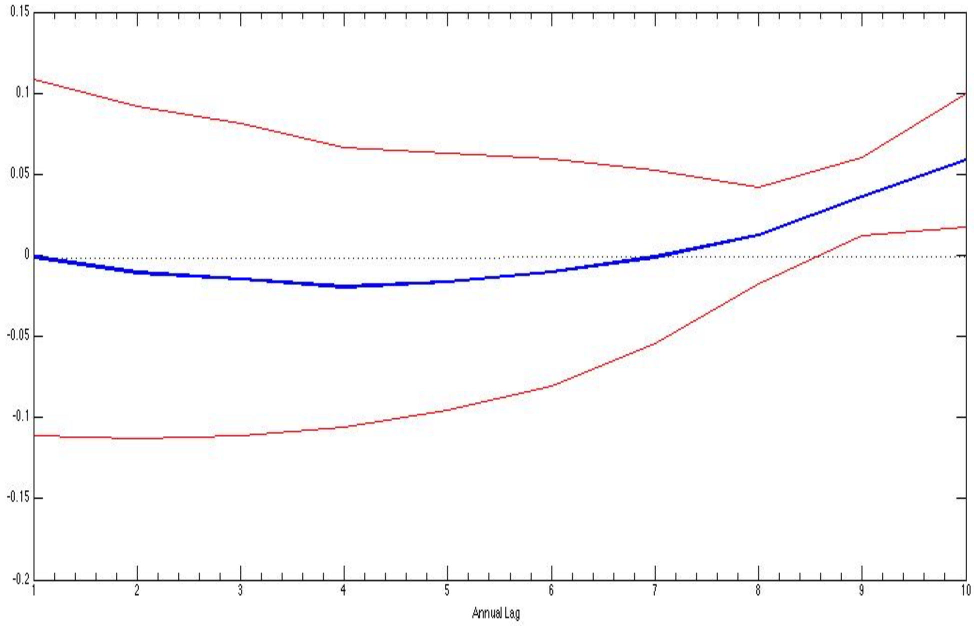


Figure 21: Annual Real GDP and M2



Germany

Figure 22: Quarterly Real GDP and M2

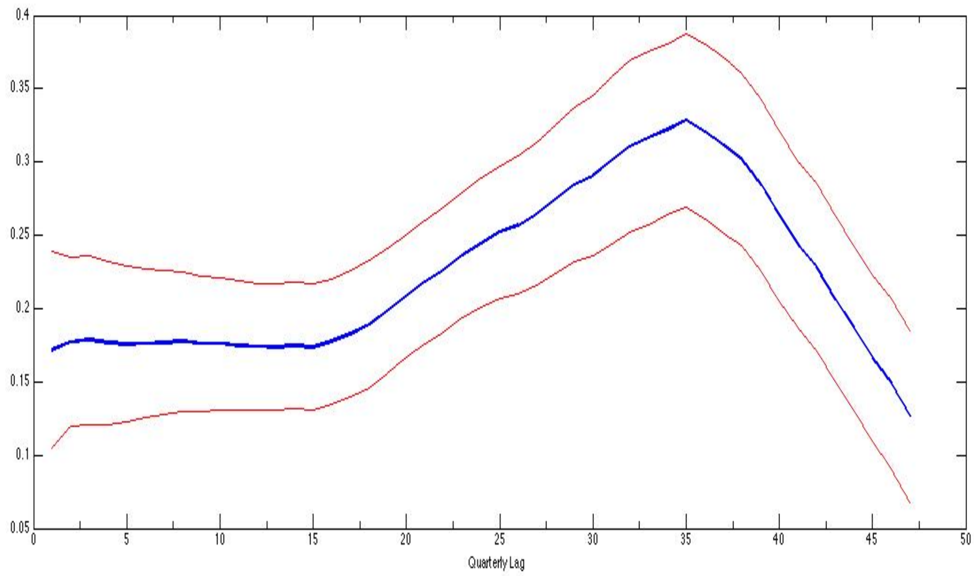


Figure 23: Aggregated annual Real GDP and M2

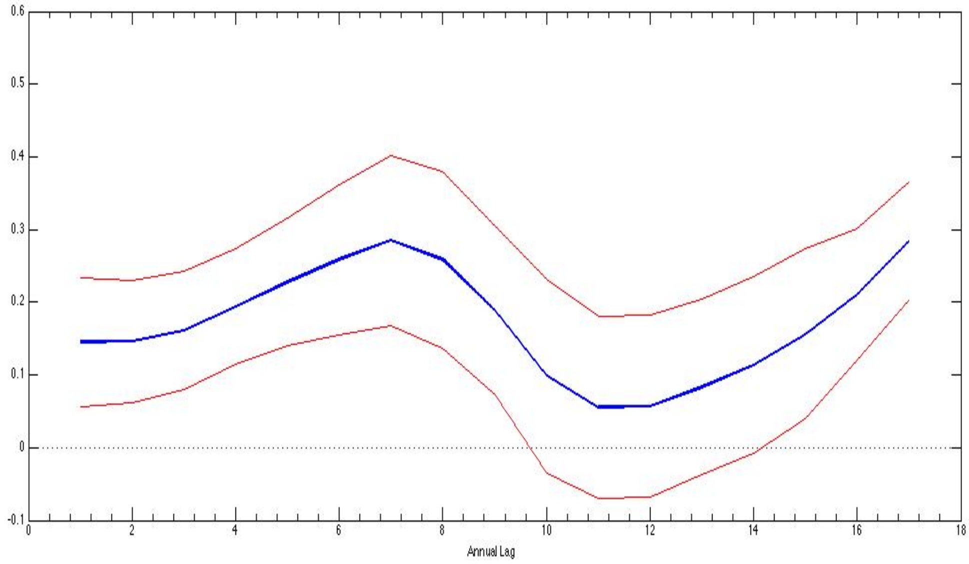
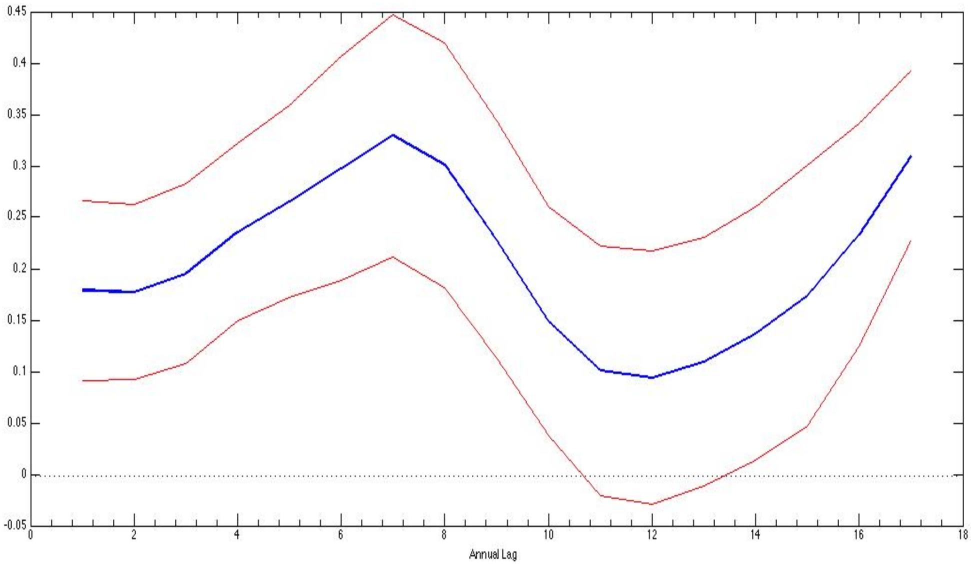


Figure 24: Annual Real GDP and M2



Italy

Figure 25: Quarterly Real GDP and M2

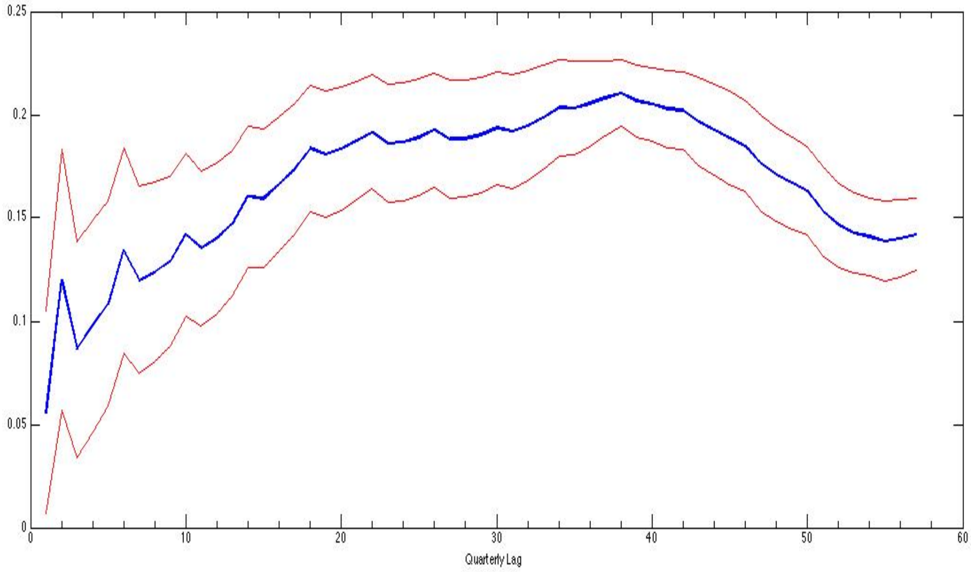


Figure 26: Aggregated annual Real GDP and M2

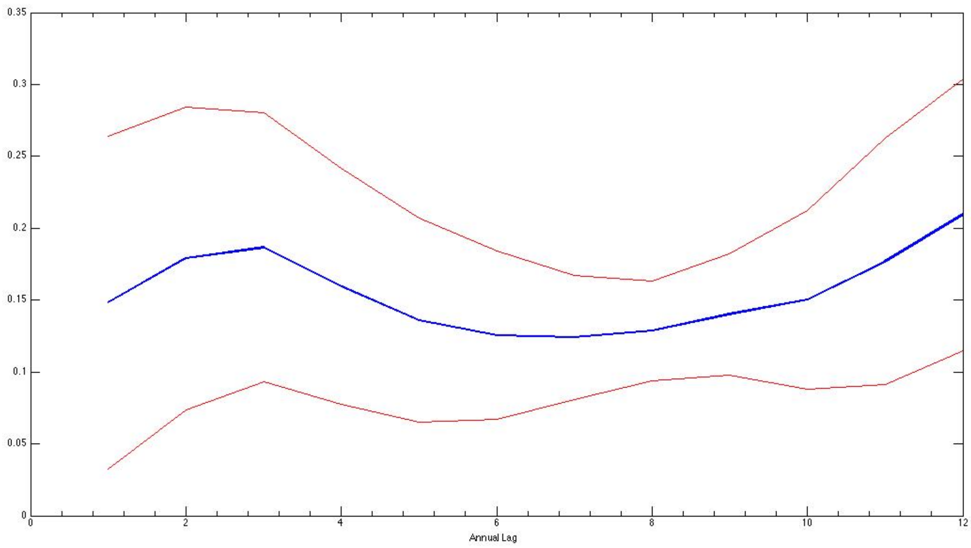
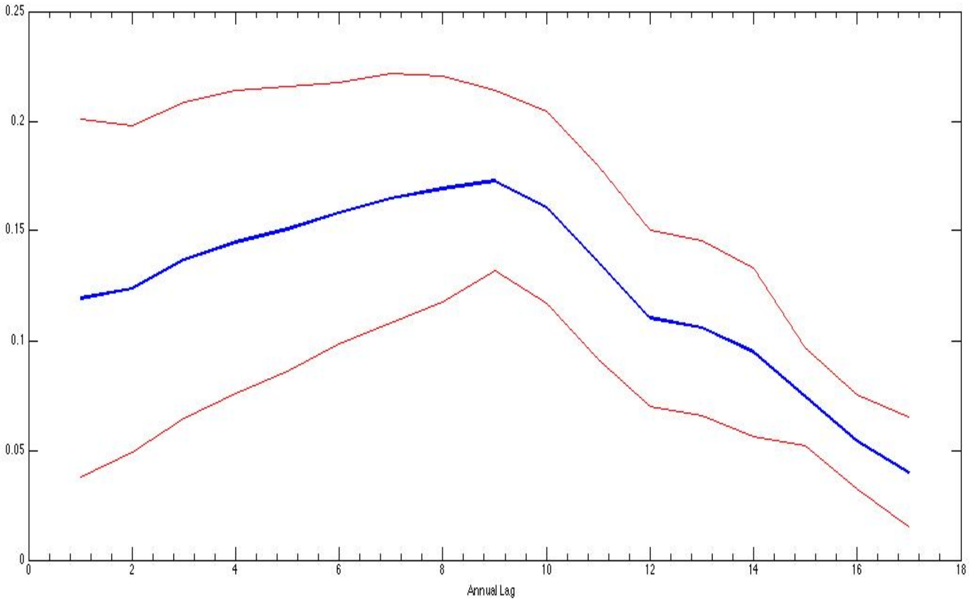


Figure 27: Annual Real GDP and M2



Japan

Figure 28: Quarterly Real GDP and M2

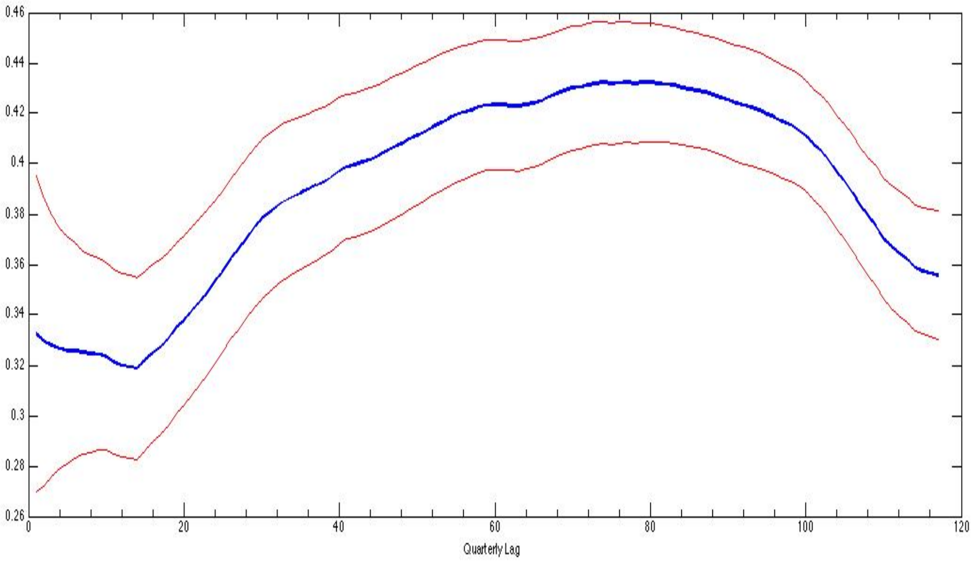


Figure 29: Aggregated annual Real GDP and M2

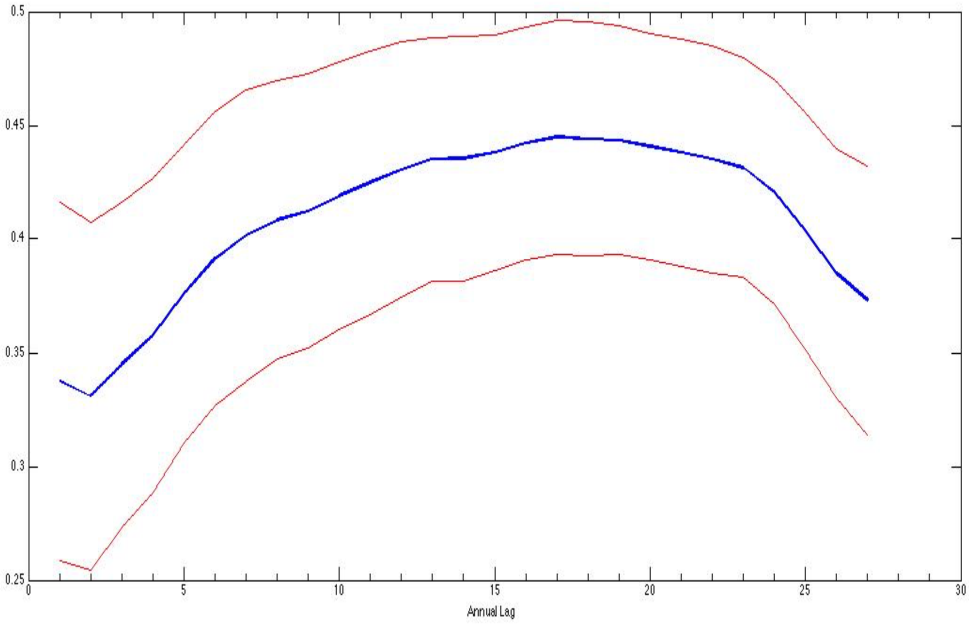
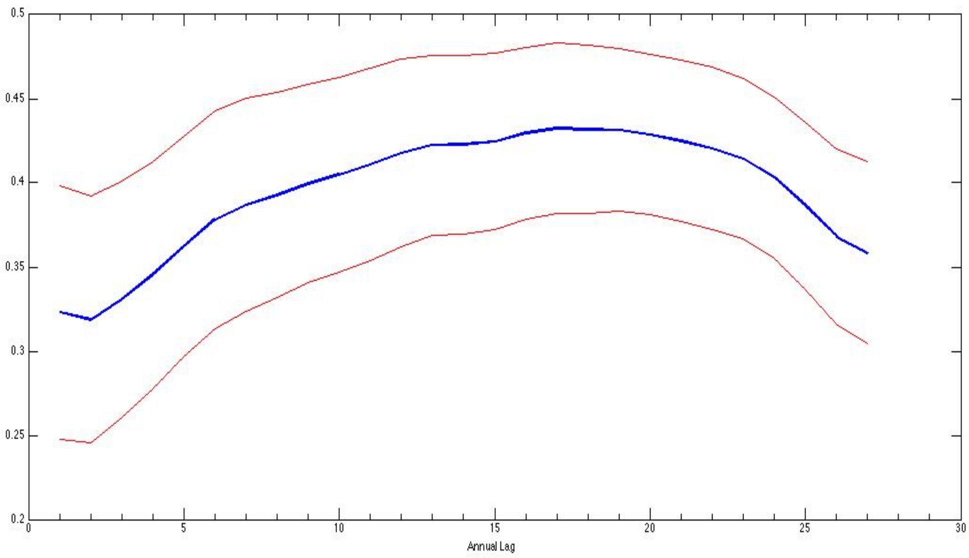


Figure 30: Annual Real GDP and M2



United Kingdom

Figure 31: Monthly Real C and M3

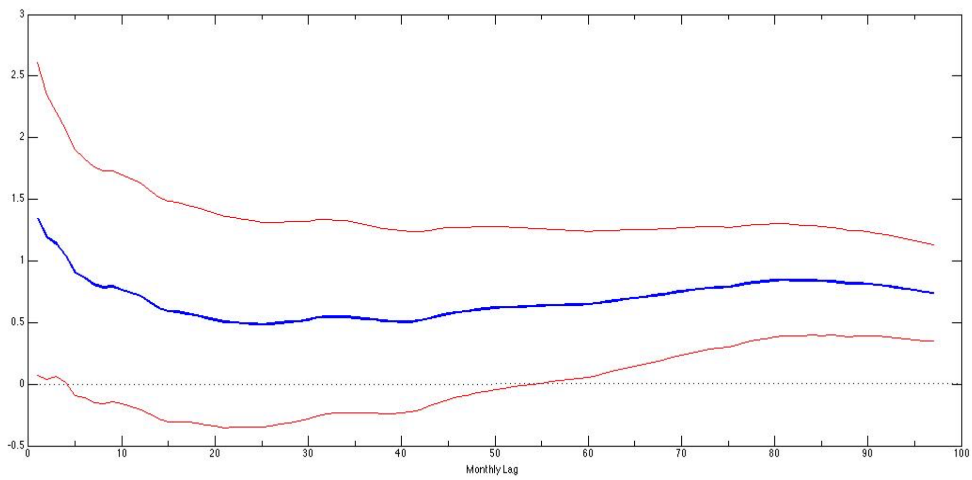


Figure 32: Aggregated quarterly Real C and M3

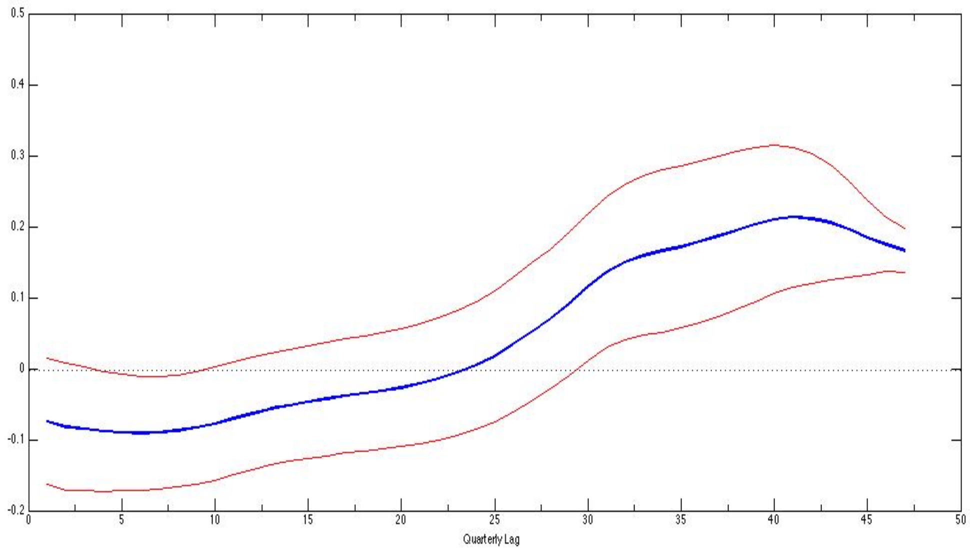


Figure 33: Aggregated annual Real C and M3

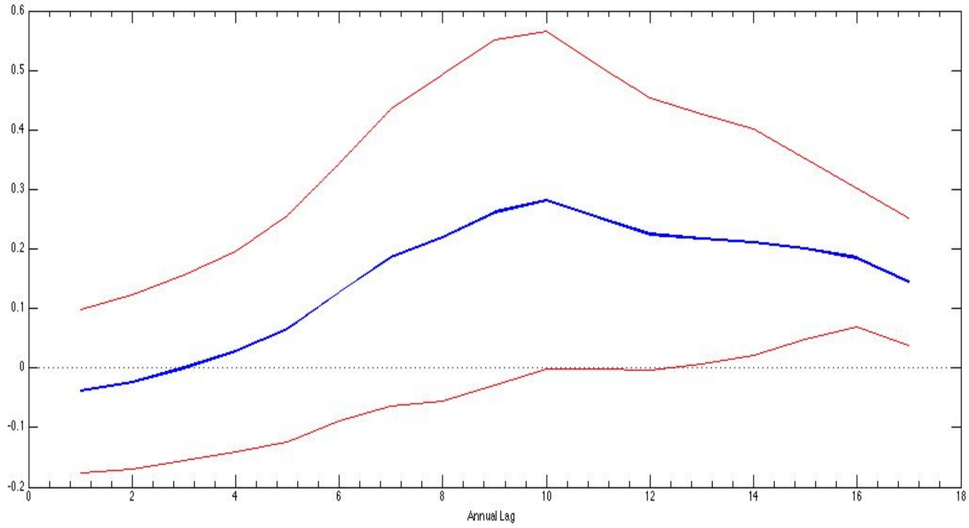


Figure 34: Quarterly Real GDP and M3

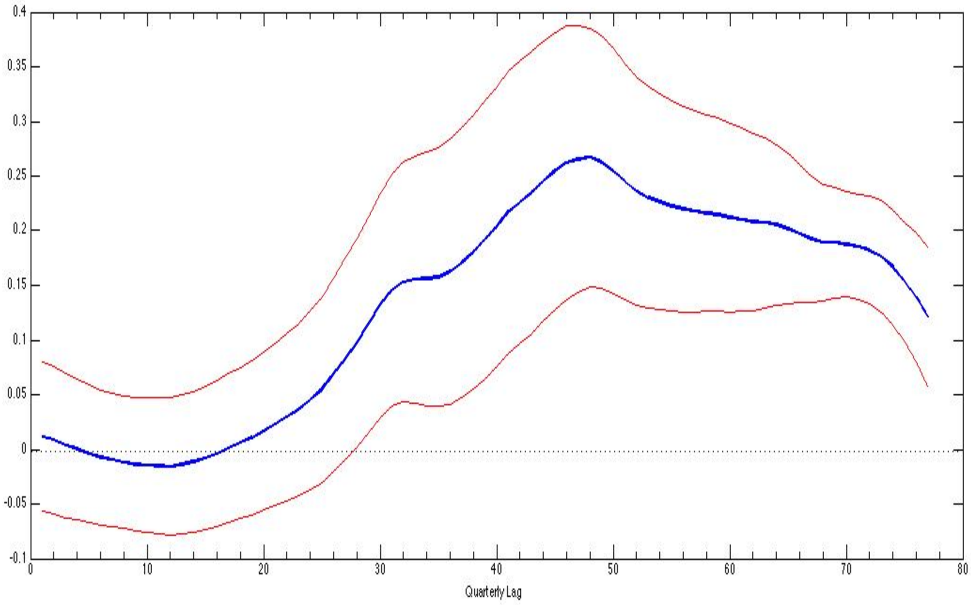
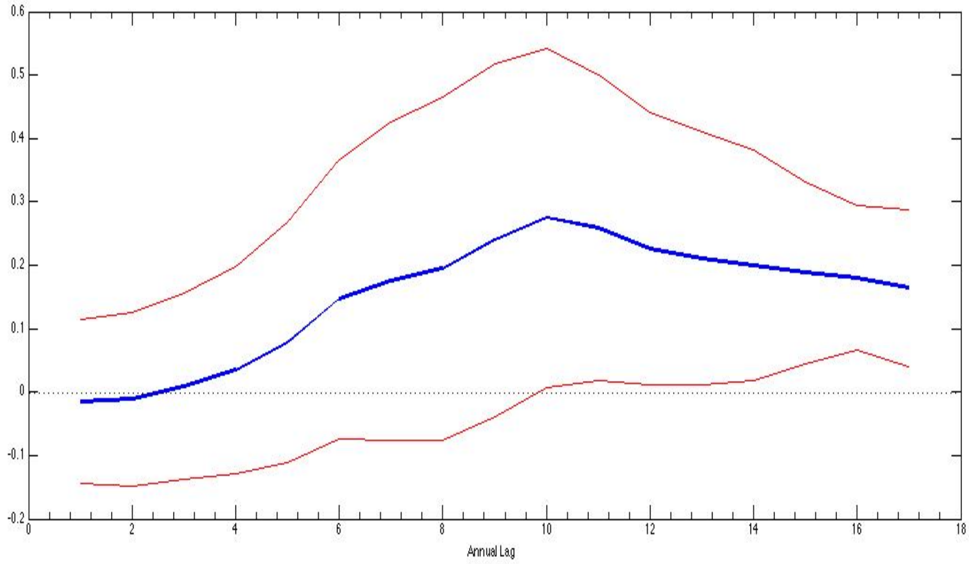


Figure 35: Annual Real GDP and M3



APPENDIX F

VAR based parameter estimates along with the standard error using the delta method for Canada, France, Germany, Italy and Japan are summarized in Appendix F. Results for U.S and U.K were reported within the paper for no other reason than the fact that I had data at all three frequency for U.S and U.K. The evidence is more compelling when I could aggregate data from monthly to quarterly and annual frequencies. *, ** and *** represents whether we are 90, 95 and 99 percent sure that the parameters are statistically significantly different from zero.

Table 12: VAR results for Canada

Date frequency	Measure	Lag length	γ_m	Standard Error
Quarterly	Real GDP and M3	3	0.264**	0.129
Aggregated Annual	Real GDP and M3	1	0.185	0.135
Annual	Real GDP and M3	1	0.254	0.165

Table 13: VAR results for France

Date frequency	Measure	Lag length	γ_m	Standard Error
Quarterly	Real GDP and M2	3	0.183*	0.099
Aggregated Annual	Real GDP and M2	2	0.285*	0.188
Annual	Real GDP and M2	1	0.354	0.211

Table 14: VAR results for Germany

Date frequency	Measure	Lag length	γ_m	Standard Error
Quarterly	Real GDP and M2	3	0.186	0.229
Aggregated Annual	Real GDP and M2	1	0.301	0.335
Annual	Real GDP and M2	1	0.29	0.165

Table 15: VAR results for Italy

Date frequency	Measure	Lag length	γ_m	Standard Error
Quarterly	Real GDP and M2	2	0.198***	0.061
Aggregated Annual	Real GDP and M2	1	0.343*	0.188
Annual	Real GDP and M2	1	0.609	0.411

Table 16: VAR results for Japan

Date frequency	Measure	Lag length	γ_m	Standard Error
Quarterly	Real GDP and M2	3	1.213	1.019
Aggregated Annual	Real GDP and M2	1	1.485	1.088
Annual	Real GDP and M2	1	0.964	0.811

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ABSTRACT

ESSAYS IN INTERNATIONAL MACROECONOMICS

by

ARJUN SONDHI

December 2017

Advisor: Dr. Robert J. Rossana

Major: Economics

Degree: Doctor of Philosophy

Financial crisis of 2007 provides a renewed interest in financial market linkages and their effect on macro variables. In an open-economy dynamic stochastic general equilibrium model setting, two things are investigated in this paper. First, what role do financial linkages play in propagating asymmetric cross-country dynamics. Specifically, the impact of a productivity shock in home country leads to a more synchronous behavior in consumption and investment in recessions than in expansions. Secondly, a new source of shock is included, one in the financial sector itself. Cross-country asset prices and fixed assets move identically in this scenario implying perfect risk-sharing. Lastly, testing for effects of temporal aggregation on neutrality based tests provide mixed results. F&S tests are immune to temporal aggregation amongst all but one G-7 countries while VAR results are very sensitive to temporal aggregation.

AUTOBIOGRAPHICAL STATEMENT

I have earned my B.A., M.A. and PhD in Economics from Wayne State University in 2001, 2005 and 2017 respectively. My fields are macroeconomics, international economics and health economics. I currently reside in a suburb of Metro Detroit and have been since I moved from India in 2001.