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Three Essays on International Economics and Finance

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THREE ESSAYS ON INTERNATIONAL MACROECONOMICS AND FINANCE

A Dissertation Presented

by

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DEDICATION

For my parents, my brother, and my dear, without whom I would be lost.

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ABSTRACT

THREE ESSAYS ON INTERNATIONAL MACROECONOMICS AND FINANCE

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This dissertation studies the macroeconomic and social impacts of two increasingly common macroeconomic policies: restrictions on international capital mobility – capital controls – and so-called unconventional monetary policy – often referred to as "quantitative easing." The consensus view is that capital controls can effectively lengthen the maturity composition of capital inflows and increase the independence of monetary policy but are not generally effective at reducing net inflows and influencing the real exchange rate. The first essay presents empirical evidence that although capital controls may not directly affect the long-run equilibrium level of

the real exchange rate, they may enable disequilibria to persist for an extended period of time relative to the absence of controls. Allowing the speed of adjustment to vary according to the intensity of restrictions on capital flows, it is shown that the real exchange rate converges to its long-run level at significantly slower rates in countries with capital controls. This result holds whether permanent or episodic controls are considered and is robust to controlling for differences in exchange rate regimes, domestic monetary conditions, and other country characteristics. The benchmark estimated half-lives for the speed of adjustment are around 3.5 years for countries with strict capital controls but as fast as 2 years in countries with no restrictions on international capital flows.

The second essay studies the social welfare implications of capital controls when controls are imperfectly binding and financial markets actively aim to bypass regulation. I consider a series of models of a small open economy featuring a "Dutch disease" externality arising from excessive capital inflows, as well as strategic interactions between a regulatory authority attempting to enforce capital controls and a financial sector attempting to evade them. In contrast to most existing theoretical models, which assume perfectly enforceable capital controls, the effective tax on capital inflows in this essay is endogenously determined by the interplay of the administrative capacity of domestic regulators, the complexity or sophistication of the financial sector, and the existence of regulatory loopholes. The models suggest that capital controls, by internalizing externalities associated with capital inflows, can improve welfare relative to a "laissez-faire" benchmark even when these are imperfectly binding. Moreover, when evasion is costly and the probability of avoiding detection by the regulator is affected by the evasion choices of financial actors, capital controls will have more traction and can drive a greater wedge between domestic and international financial markets. However, this implies that the economy?s ?first-best? outcome can no longer be achieved as a decentralized equilibrium using capital controls. This is because bank evasion activity represents a pure waste from a societal perspective and can be thought of as a type of deadweight loss.

The impact of the post-crisis Federal Reserve policy of near-zero interest rates and Quantitative Easing (QE) on income and wealth inequality has become an important policy and political issue. Critics have argued that by raising asset prices, near-zero interest rates and QE have significantly contributed to increases in inequality, while practitioners of central banking, counter that the distributional impact have probably been either neutral or even egalitarian in nature due to its employment impacts. Yet there has been little academic research that addresses empirically this important question. The third and final essay uses data from the Federal Reserve's Tri-Annual Survey of Consumer Finances (SCF) to look at the evolution of income by quantile between the "Pre-QE period" and the "QE period" analyzing three key impact channels of QE policy on income distribution: 1) the employment channel 2) the asset appreciation and return channel, and 3) the mortgage refinancing channel. Using recentered influence function (RIF) regressions pioneered by Firpo et. al (2007) in conjunction with the well-known Oaxaca-Blinder decomposition technique, I find that while employment changes and mortgage refinancing were equalizing, these impacts were nonetheless swamped by the large dis-equalizing effects of asset appreciations. In order to identify causality, I propose a simple counterfactual exercise

building on the extensive literature on macroecomic impacts of QE in order to place well defined upper and lower bounds on possible net causal magnitudes. I conclude that QE led to modest increases in inequality despite having some positive impacts on employment and mortgage refinancing.

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CHAPTER 1

CAPITAL CONTROLS AND THE REAL EXCHANGE RATE: DO CONTROLS PROMOTE DISEQUILIBRIA?

1.1 Introduction

Once considered heretical to the tenets of prudent macroeconomic policy, in recent years capital controls have regained respectability in official policy circles and received fresh attention among academics as potential macro-prudential tools.[1] In the wake of the global financial crisis and mounting evidence of the destabilizing effects of unregulated international capital flows, the International Monetary Fund (IMF), previously the champion of capital account liberalization, reversed decades of official policy recommendations and declared that capital controls should once again be included in a country's "policy toolkit."[2] At the same time, as expansionary mon-

[1] A growing theoretical literature has shown that capital controls improve welfare in models featuring financial amplification dynamics arising from collateral constraints (Lorenzoli [84], Jeanne and Korinek [65], Korinek [72], Korinek [74], Davis and Presno [28], Liu and Spiegel [83], Heathcote [59]). In these types of models, capital flows impose externalities because private agents fail to internalize the contribution of their borrowing decisions to systemic risk. As a result, the decentralized equilibrium is characterized by "over borrowing" and is inefficient. Capital controls in this context can be seen as a Pigouvian tax to force agents to internalize the externality. Capital controls have also been shown to improve welfare in small open economies with fixed exchange rates and rigid nominal wages (Farhi and Werning [40], Schmitt-Grohé and Uribe [114]).

[2] Examples of work by IMF staff articulating this change in opinion are Ostry et al. [96], Ostry et al. [95], and Ostry et al. [94]. These new perspectives on the role of capital controls became part of the IMF's "institutional view" late in 2012 (IMF [62]).

etary policy in industrial nations has flooded emerging markets with foreign funds, a number of countries have imposed restrictions on capital inflows, specifically citing a concern with excessive exchange rate appreciation and a desire to preserve export sector competitiveness. This shift in opinion regarding the use of capital controls has taken place along with a growing recognition that some rapidly industrializing nations, in particular China, have benefitted from so-called "neo-mercantilist" policies and have used capital controls to deliberately maintain an undervalued real exchange rate.

These calls for the greater use of capital controls to manage the real exchange rate stand at odds with the empirical literature on the effectiveness of controls, which has not found clear evidence that controls can influence this variable (for detailed reviews of this literature see Engel [36] and Magud et al. [87]). Several empirical studies have focused on Chile's experience with capital controls during the 1990s, which sought to limit short-term capital flows in order to stabilize the economy and prevent unwanted exchange rate appreciation (Valdés-Prieto and Soto [116], Edwards [32], De Gregorio et al.[29], Gallego et al. [50], Forbes [46]). While most of these studies conclude that Chile's capital controls had a meaningful impact on the maturity composition of net inflows, the results suggest either a very small and short-term effect on the real exchange rate (e.g. De Gregorio et al. [29]), or no significant effect at all (Gallego et al. [50]).[3]

[3] It is worth noting that there exists some evidence that Chile's capital controls may have had a significant effect on the *nominal* exchange rate. Edwards and Rigobon [33] show that capital controls slowed the appreciation of the Chilean Peso and decreased its volatility.

Cross-country and case studies of other capital control episodes have reached similar conclusions (Levy-Yeyati et al. [80], Baba and Kokenyne [4], Klein [71], Jinjarak et al. [66], Alfaro et al. [1], Forbes et al. [45]. For example, Baba and Kokenye [4] look at the effects of capital controls in emerging markets during three different episodes in the 2000s – the foreign exchange tax in Brazil (2008), and the URRs in Colombia (2007-08) and Thailand (2006-08) – and one episode of capital outflow liberalization – South Korea (2005-08). Their results show that controls during the 2000s appear to have successfully altered the maturity composition and lowered the overall volume of flows in Colombia and Thailand. Controls also appear to have successfully preserved monetary policy independence in Brazil and Colombia, albeit temporarily. However, their results provide no evidence that controls in any country were able to successfully influence the real exchange rate.

This paper presents new empirical evidence on the adjustment dynamics of the real exchange rate towards its long-run equilibrium in the presence of capital controls. In contrast with previous approaches, I explicitly model the adjustment dynamics of the real exchange rate as a function of the intensity of capital controls. Using a large panel of developed and developing countries, I show that while capital controls may not affect the equilibrium level of the real exchange rate, controls can substantially slow its speed of adjustment towards this long-run level, causing disequilibria to persist for extended periods of time. Specifically, this paper uses panel dynamic ordinary least-squares (DOLS) to estimate the long-run cointegrating relationship between the real exchange rate and a set of fundamentals. This equilibrium relationship is used to calculate the extent of real under or overvaluations – that is, of disequilibria – which are then imposed on an error-correction model to study the short-run adjustment dynamics towards equilibrium.

The empirical results are consistent with the hypothesis that capital controls slow the speed of adjustment towards the long-run equilibrium and therefore allow real exchange rate disequilibria to persist for longer periods of time relative to the absence of controls. The point estimates from the baseline model imply half-lives for the adjustment of disequilibria of roughly 3.5 years in countries with stringent restrictions on international financial transactions but as short as 2 years in countries with completely open capital accounts. These results therefore imply considerable differences in real exchange rate adjustment dynamics between countries depending on the intensity of capital controls. Moreover, these findings are not sensitive to whether permanent or temporary capital controls are considered, nor are they driven by a country's nominal exchange rate regime.

This paper is related to the vast literature on the empirical determinants of exchange rates. While a detailed review of this literature is beyond the scope of this paper, textbook treatments are provided in Sarno and Taylor [112] and Macdonald [86]. A recent strand in this literature argues that in the long-run the real exchange rate is pinned down by real fundamentals, including the relative productivity of the tradable sector (the Balassa-Samuelson effect), the terms of trade, and the net foreign asset position (Chinn and Johnson[22], Chinn [23], Cashin et al. [21], Bayoumi et al. [8], Ricci et al.[102], Bordo et al. [17]). Although this literature is diverse, the unifying theme is to treat the real exchange rate as nonstationary and use cointegration techniques, emphasizing explicit equilibrium relationships.

My results also shed light on the policy issue of real exchange rate misalignment. It has long been recognized that real overvaluations can negatively impact growth and may precede currency crises. Moreover, a growing literature has shown that there exists a robust relationship between an undervalued real exchange rate and faster economic growth (see, for example, Rodrik [103] and Rapetti et al.[100]). These positive growth effects have been explained through a variety of channels: sectoral misallocation of capital due to government and market failures (Rodrik [103]); hidden unemployment in an underdeveloped dual economy (Razmi et al.[101]); or learning by doing externalities in the tradables sector (Korinek and Serven [75]). What all these models have in common, however, is the importance for long-run growth of the tradable sector and the potential to use undervaluation as a development tool. But how exactly should policymakers wield this new tool? It is poorly understood how a persistent undervaluation can actually be achieved and whether restrictions on capital mobility can play a role.[4] Another contribution of this paper is therefore to help fill this gap. The empirical results presented below suggest that capital controls are capable of promoting real exchange rate misalignment for extended periods of time, and may therefore serve as an effective instrument to manage the real exchange rate.

The remainder of the paper proceeds as follows. Section 1.2 provides a brief review of the standard empirical determinant of the real exchange rate and possible theoretical channels. Section 1.3 describes the dataset and econometric methodology

[4] A notable contribution is Jeanne [64].

used in the empirical analysis. Section 1.4 presents the benchmark results while section 1.5 discusses a series of robustness exercises accounting for the role of the nominal exchange rate regime, as well as additional forms of group heterogeneity. The final section provides concluding remarks.

1.2 The Equilibrium Real Exchange Rate and its Determinants

Purchasing power parity (PPP) is perhaps the oldest theory of exchange rate determination and states that after accounting for the domestic prices of goods and nominal exchange rates, all national currencies should have the same purchasing power.[5] This proposition is derived from the Law of One Price (LOP), which holds that in the absence of frictions such as transaction costs or other barriers to trade, international goods trade should cause all identical goods to trade for the same price across markets after converting into a common currency. Otherwise, it would be possible to profit through arbitrage and thus prices would eventually equalize across countries. Despite its appealing simplicity, empirical evidence suggests that PPP often fails to hold even as a long-run proposition (see, e.g., O'Connell [92], Engel [35], Pesaran [98]).

A classic explanation for the failure of PPP is the relative productivity channel, which can be traced to Balassa [6] and Samuelson [111]. This is the so-called Balassa-

[5]The modern formulation of PPP is due to the Swedish economist Gustav Cassel in the early 20th century but elements of the doctrine can be traced to as far back as the Salamanca school in 16th century Spain.

Samuelson effect, which in its simplest form predicts that countries with higher productivity in the tradable goods sector will tend to have more appreciated real exchange rates.[6] Intuitively, consider a small open economy with a tradable and non-tradable sector. Suppose further that PPP holds but only for tradable goods. Productivity growth in the tradable sector will tend to raise wages in both sectors and create upward pressure on prices. However, since the price of tradable goods is pinned down by the world market, this will lead to an increase in the relative price of non-tradables, or in other words a real exchange rate appreciation.

The Balassa-Samuelson effect has proven remarkably robust since its first test by Balassa [6]. Two examples of recent empirical confirmation of the Balassa-Samuelson effect are Lothian and Taylor [85] and Chong et al. [25]. Employing a new semi-parametric approach, Chong et al. estimate the cointegrating relationship between the real exchange rate and productivity in a panel of 21 OECD countries at a quarterly frequency. Their novel local projection approach makes it possible to purge the effects of short-run shocks and frictions and yields strong confirmation of the Balassa-Samuelson effect. Lothian and Taylor use nearly two hundred years of data for the US, UK, and France to test the presence of the Balassa-Samuelson effect in an explicitly nonlinear framework that allows volatility shifts in the nominal exchange rate across monetary regimes. Their results suggest that the Balassa-Samuelson effect explains nearly 40 percent of variations in the sterling-dollar real exchange rate over the whole sample. Additional recent confirmation of the Balassa-Samuelson

[6] Some authors prefer to refer to this as the “Harrod-Balassa-Samuelson” effect due to early insights from Harrod [58].

effect is provided by Bordo et al. [17], who use historical data for 14 countries covering four distinct monetary regimes: the classical gold standard, the war and interwar years, Bretton Woods, and the post-Bretton Woods managed floats. They show that the traditional Balassa-Samuelson model cannot explain the small empirical effect of productivity on the real exchange rate or the substantial heterogeneity in its magnitude across monetary regimes. Modern versions of the model, including those that allow a role for product differentiation and terms of trade channels, fit the data much better. In particular, plausible shifts in structural parameters due to changes in monetary regimes can explain the historical variations in the Balassa-Samuelson effect and help reconcile discrepancies in estimates across countries. Bordo et al. [17] conclude: "although the Balassa-Samuelson effect tends to vary across regimes, the evidence suggests that it is present, and in the long-run the real exchange rate is not constant but conditioned on relative income levels."

Another standard long-run determinant of the real exchange rate is the net foreign asset position. Interest in the impact of net foreign asset holdings on international relative prices dates back at least to the time of Keynes during the 1920's debate on the so-called *transfer problem*. Contemporary textbook models of an open economy predict a positive relationship between stocks of foreign assets and the relative price of non-tradable goods (e.g. Vegh [117]). Since foreign assets represent a claim on tradable goods, an exogenous increase in foreign assets raises the supply of tradables and should lead to an increase in the relative price of non-tradables. Early empirical evidence of a positive association between net foreign asset stocks and the real exchange rate is provided by Gagnon [49] and Lane and Milesi-Ferretti [77]. More recent studies that find a positive and significant effect include Ricci et al. [102] and IMF [63].

Changes in the terms of trade can also affect the real exchange rate and may help explain the long-run failure of PPP. In his 1930 *A Treatise on Money*, Keynes noted that a major problem with the theory of purchasing power parity is its neglect of the influence of the terms of trade on the real exchange rate, which "not only upsets the validity of [its] conclusions over the long period, but renders them even more deceptive over the short period..."[7] It is well understood in standard open economy macroeconomic models that improvements in the terms of trade can lead to a real appreciation of the exchange rate.[8]

Other potentially important determinants of the real exchange rate include government expenditure and demographic factors, most notably population growth. Government expenditure is expected to influence the real exchange rate through its effect on aggregate demand and the price level. It may also produce a real appreciation since public spending tends to be more concentrated on non-tradable goods and services (see, for example, De Gregorio and Wolf [30], Arellano and Larrain [3], Chinn [23]). Although demographic factors have not received much attention in the equilibrium real exchange rate literature, higher fertility may appreciate the real exchange rate by raising consumption associated with child-rearing, which mainly

[7]Originally cited by Cashin et al. [21].

[8]One such textbook treatment is Chapter 4 of Vegh [117], which presents a simple intertemporal model of a small open endowment economy with three sectors: exportables, importables, and non-tradables. In this simple setup, wealth and intertemporal substitution effects both lead to a real appreciation following an improvement in the terms of trade and all that is required is for all goods to be normal.

Table 1.1: Sample description

Number of countries by World Bank group classifications			
Income Classification		Geographic Classification	
East Asia & Pacific	8	High Income: OECD	26
Europe & Central Asia	13	High Income: nonOECD	10
Industrial	25	Upper Middle Income	23
Latin America & Caribbean	19	Lower Middle Income	21
Middle East & North Africa	7	Low Income	8
South Asia	1		
Sub-Saharan Africa	15		

consists of non-tradables. Rose et al. [108] present a formal model and empirical evidence of this channel.

1.3 Data and Empirical Framework

In order to estimate the effect of capital controls on the persistence of real exchange rate disequilibria, I construct a dataset consisting of an unbalanced panel of 88 countries observed at a yearly frequency over the period 1980-2011. The sample is largely dictated by data availability and contains a mix of high, middle, and low income countries. Table 1.1 provides a breakdown of the sample composition by geographic regions and country income groups.[9]

Most of the variables come from the IMF's *International Financial Statistics* (IFS) and the World Bank's *World Development Indicators* (WDI).[10] The dependent variable of interest is the natural logarithm of the real effective exchange rate ($REER$), which is an index constructed on the basis of a weighted average of each

[9] The full set of countries included in the sample are listed in Appendix A.2.

[10] See the note for Table 1.2 for further details.

Table 1.2: Summary statistics

	Mean	Std. Dev.	Min	Max
Long run variables				
Log Real Effective Exchange Rate ($REER$)	4.626	0.371	2.278	7.685
Log PPP GDP per capita (LNY)	8.588	1.270	4.621	11.723
Net Foreign Assets / Imports (NFA)	-1.082	3.121	-41.475	30.253
Short run variables				
Log Commodity Terms of Trade (TOT)	4.732	0.374	2.675	6.421
Government Expenditure / GDP (GOV)	0.163	0.065	0.020	0.762
Population Growth (POP)	0.017	0.016	-0.181	0.175
Currency Crisis Dummy ($CRISIS$)	0.034	0.182	0.000	1.000
Capital control indices				
Schindler Index – Overall (SCH)	0.315	0.350	0.000	1.000
Schindler Index – Inflow (SCH_{IN})	0.285	0.331	0.000	1.000
Schindler Index – Outflow (SCH_{OUT})	0.345	0.397	0.000	1.000
Schindler Index – Equity (SCH_{EQ})	0.313	0.365	0.000	1.000
Schindler Index – Collective Investment (SCH_{CI})	0.300	0.372	0.000	1.000
Klein Episodic Controls ($KLEIN$)	0.011	0.075	0.000	1.000
Chinn-Ito Financial Openness Index ($CHITO$)	0.098	1.549	-1.864	2.439

Note: Each variable was obtained from the following sources. $REER$: IMF International Financial Statistics. LNY: World Development Indicators. NFA: External Wealth of Nations Database (Lane and Milesi-Ferretti [78]). TOT: IMF World Economic Outlook Database. GOV: World Development Indicators. POP: World Development Indicators. $CRISIS$: Broner et al. [18]. SCH_j: Fernandez et al. [41]. $KLEIN$: Klein [71]. $CHITO$: Chinn and Ito [24].

country's bilateral exchange rates vis-á-vis its trading partners deflated by its relative price level, where the weights reflect the importance of trade with each partner. The long-run variables included in the cointegrating relationship are the following: log PPP GDP per capita (LNY) , and net foreign assets divided by total imports (NFA). The short-run determinants of the real exchange rate are: log commodity terms of trade (TOT), government expenditure to GDP (GOV), annual population growth (POP), and a dummy variable for the advent of currency crises ($CRISIS$). Summary statistics are presented in Table 1.2.

Naturally, a key consideration is the appropriate measurement of capital controls. In the broadest sense, capital controls refer to any administrative or market-based restriction on cross-border financial flows. These can range from outright prohibitions on the ownership of domestic assets by foreigners, to simple taxes on foreign exchange transactions or international borrowing. Capital controls may also be imposed either on a small subset of specific assets categories, or across the board, restricting or otherwise regulating international transactions in all types of financial instruments. A further distinction can be made between controls on capital inflows – that is, when foreigners acquire domestic assets – and controls on capital outflows – when domestic residents increase their holdings of foreign assets.[11]

Measures of capital controls fall into two broad categories: so-called de jure and de facto indexes. De jure indexes attempt to measure legal or regulatory barriers to international financial transactions while de facto measures, on the other hand, capture the actually existing level of financial integration in a given country, often by observing macroeconomic outcomes. The vast majority of de jure-type indexes are based on information contained in the IMF's Annual Report on Exchange Arrangements and Restrictions (AREAR), a yearly publication documenting changes in IMF member country laws and regulations governing international financial trans-

[11]In addition to these distinctions, capital controls can also cover a wider and more subtle range of regulations governing capital inflows. For example, domestic monetary authorities may require firms to deposit a fraction of funds borrowed abroad in non-interest bearing accounts for a specified period of time. These "unremunerated reserve requirements" or URR, as they have come to be known, have been used most famously in Chile during the 1990s and in Colombia during the 2000s. Countries may also enforce so-called "minimum stay" requirements on foreign direct investment, barring the entry of short-term and potentially speculative investments.

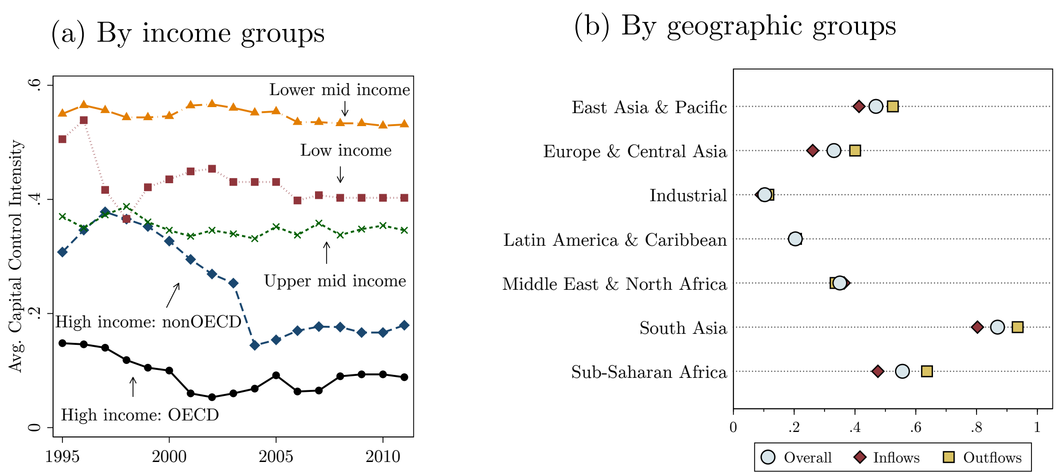
actions. A major problem with de facto measures of capital controls is that they are potentially as much an endogenous outcome variable as they are an indicator of restrictions on capital flows. As such, de facto indexes are poorly suited for empirical studies where the aim is to ascertain the effect of a policy change since they do not actually measure changes in a government's *intention* to restrict flows.

For this reason, I will primarily use the de jure index developed by Schindler [113], the so-called "Schindler index", which is based on detailed textual analysis of the AREAR and has also recently been updated to cover a larger number of countries and years by Fernandez et al. [41]. The Schindler index is an average of the number of international transaction categories with any restrictions for a given year and country. Thus, the index ranges from zero – indicating that the country has no capital controls on any category – to one – when a country has controls on every transaction category. For example, between 1995 and 2011 Mexico's Schindler index averaged 0.5, suggesting that half of all transaction categories had some form of restriction during that time period. As noted by Quinn et al.[99] in a thorough assessment of the most common measures of capital controls, the Schindler index is by far the most granular, covering a large range of disaggregated financial instruments and distinguishing between controls on inflows and outflows. There is, however, one major drawback of using the Schindler index that is worth noting. The AREAR only started publishing the detailed country reports on which the Schindler index is based starting in 1995 and as a result the index is only available in subsequent years. Moreover, because the index is based on textual analysis, its construction is labor intensive and does not include all IMF member countries. Thus, the sample used when investigating the short-run adjustment dynamics with capital controls is shorter, spanning 1995 to 2011, and includes less countries (43 compared to the 88 for the long-run analysis).

Figure 1.1 provides a broad overview of the relative prevalence of capital controls across regions and levels of development. As can be seen in Panel (a), large differences in the extent of capital account liberalization persist, on average, across country income groups. Perhaps not surprisingly, low income and lower middle income countries had tighter capital controls on the books throughout the 1995-2011 period, with restrictions on roughly 40 percent and 60 percent of transaction categories, respectively. Large variation in the prevalence of capital controls is also evident across regions. South Asian economies had the tightest capital controls on average, with restrictions on roughly 85 percent of transaction categories. Latin American and Caribbean countries, in contrast, had nearly the loosest capital controls, second only to industrialized economies.

Seven different measures of capital controls are considered in the benchmark regressions. The first five are the Schindler index for overall restrictions on international capital flows (SCH) and several subindexes for restrictions on inflows (SCH_{IN}), outflows (SCH_{OUT}), equity transactions (SCH_{EQ}), and collective investments (SCH_{CI}). In addition, I consider episodic capital controls ($KLEIN$) as defined by Klein [71]. As discussed in greater detail below, the Klein index extends the Schindler index to distinguish between permanent and episodic restrictions on capital mobility. As such, the two intensity measures have roughly the same interpretation as the aver-

Figure 1.1: Average intensity of capital controls by income group and region



Note: This figure reports the average value of the Schindler index for overall capital controls (SCH) broken up into the World Bank's country income (panel a) and geographic group (panel b) classifications. In panel (b), "Overall" refers to the Schindler index for both controls on capital inflows and outflows while "inflows" and "outflows", respectively, refer to the disaggregated indexes for restrictions on capital inflows and outflows.

age number of transactions with controls. As a robustness exercise, I also use the well-known Chinn-Ito index of financial liberalization from Chinn and Ito [24].

The order of integration of each variable was determined using the panel unit root tests proposed by Pesaran [98], Im et al. [61], and Levin et al. [79]. In all three tests the null hypothesis is that the series have a unit root. The results for all three tests on all the main variables are reported in Table 1.3. All three tests fail to reject the null hypothesis that the level of the real exchange rate is non-stationary but easily reject the null for its first difference. This indicates, consistent with the literature discussed above, that the real exchange rate is likely $I(1)$ and therefore it

Table 1.3: Panel unit root tests.

	CADF		IPS		Levin-Lin-Chu	
	Z_{t-bar}	p-value	$W_{\tilde{t}-bar}$	p-value	Adj. t^*	p-value
$REER$	-1.192	0.117	-1.250	0.106	0.511	0.695
$\Delta REER$	-8.299	0.000	-24.711	0.000	-16.236	0.000
LNY	3.477	1.000	5.023	1.000	1.960	0.975
ΔLNY	29.403	0.000	-23.104	0.000	-15.529	0.000
NFA	5.141	1.000	-0.782	0.217	0.115	0.546
ΔNFA	-8.211	0.000	-26.294	0.000	-18.860	0.000
TOT	-1.129	0.130	-0.279	0.390	-0.432	0.333
ΔTOT	-11.098	0.000	-34.173	0.000	-24.462	0.000
POP	4.488	1.000	-35.720	0.000	-27.552	0.000
ΔPOP	-6.420	0.000	-33.785	0.000	-28.940	0.000
GOV	0.904	0.817	-2.065	0.020	-0.700	0.242
ΔGOV	-10.406	0.000	-34.596	0.000	-24.774	0.000
SCH	3.379	1.000	0.868	0.807	-0.353	0.362
ΔSCH	-0.413	0.340	-24.390	0.000	-15.331	0.000
$CHITO$	0.885	0.812	-0.833	0.202	1.704	0.956
$\Delta CHITO$	-3.413	0.000	-37.726	0.000	-28.469	0.000

Note: Pesaran's CADF test is implemented in Stata by Lewandowski [82]. The CADF test considers the case with 2 lags, a constant, and cross-sectional demeaning. Both the Im-Pesaran-Shin and Levin-Lin-Chu tests include a time trend and common AR coefficient. The panel-specific lag-orders were chosen using the BIC.

will be treated as such in the empirical analysis that follows. The three tests also suggest that LNY, NFA and TOT are first-difference stationary. As such, these are also treated as $I(1)$. The results are somewhat ambiguous for population growth and government expenditure. Although Pesaran's CADF test fails to reject the null for POP, the IPS and LLC tests do reject the unit root null hypothesis. The results for GOV are similarly ambiguous: the unit root null is rejected by the IPS test but not by the CADF or the LLC tests. In addition, the panel unit root tests suggest that both the SCH and $CHITO$ measures of capital controls can be treated as $I(1)$.

Table 1.4: Panel cointegration tests

	Panel-Specific		Pooled	
	G_t	G_α	P_t	P_α
$REER$, LNY, NFA	-1.533*	-4.954	-12.914***	-3.448**
$REER$, LNY, NFA, TOT	-1.650	-5.412	-14.482**	-4.638
$REER$, LNY, NFA, SCH	-1.853	-2.050	-6.452	-1.522
$REER$, LNY, NFA, $CHITO$	-1.831	-5.777	-12.221	-3.710

Note: This table reports the Z-values from the Westerlund [118] panel cointegration tests. The null hypothesis is no cointegration. All tests consider the case with one lag and panel specific intercepts. These tests were implemented in Stata by Westerlund and Edgerton [119]. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The variables were tested for cointegration using the panel error-correction tests proposed by Westerlund [118] and implemented by Westerlund and Edgerton [119]. These tests are derived from a panel error-correction model that allows for heterogeneity in the error-correction dynamics, including panel-specific intercepts, trends, and slopes. The test statistics are based on the idea that if the series are cointegrated, the coefficient on the error-correction term should be significantly negative. Westerlund develops four alternative statics, two of which are constructed by averaging the estimated coefficients (G_α) and t-statistics (G_t) from each panel-specific error-correction term. The latter two are calculated by pooling observations across panels and estimating the error-correction term (P_α) and t-statistic (P_t).

Test results are shown in Table 1.4. Three of the four test statistics reject the null hypothesis of no cointegration for the model including $REER$, LNY, and NFA. Results for the model including the log terms of trade are inconclusive: only one of the three test statistics rejects the null of no cointegration. This is consistent with results presented by Cashin et al. [21], who showed that the real exchange rate may only be cointegrated with the terms of trade in so-called commodity currency countries.[12] Given the inconclusive evidence of a cointegrating relationship, TOT is treated as a short-run determinant of the real exchange rate and omitted from the baseline specification of the long-run level. Finally, Table 1.4 also reports results for tests of a long-run relationship between $REER$, NFA, and two complementary measures of capital controls: SCH and $CHITO$. All four test statistics fail to reject the no cointegration null. This suggests that capital controls do not have a long-run effect on the equilibrium real exchange rate. However, as we shall see below, this does not rule out significant effects on the short-run disequilibrium dynamics of the real exchange rate.

The cointegrating relationship is estimated using the method of dynamic ordinary least-squares (DOLS) proposed by Saikkonen [110]. As Saikkonen shows, the cointegrating relationship can be consistently and efficiently estimated by OLS adding leads and lags of the first differenced cointegrated variables with Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors. Because $REER_{i,t}$ is an index and does not contain information about the relative level of the real exchange rate, the model includes country fixed effects. The inclusion of country fixed effects also addresses potential omitted variable bias. Year dummies are also

[12] Cashin et al. [21] uncover evidence of significant cross-country heterogeneity in the relationship between the real exchange rate and the terms of trade. They find significant cointegrating relationships between the real exchange rate and the terms of trade but only in around one third of the countries in the sample. This suggests that the long-run equilibrium exchange rate is only driven by the terms of trade in so-called "commodity currency" countries. However, for these commodity currencies, movements in the terms of trade explain a remarkably large amount of the variation in the real exchange rate. Their estimates imply that nearly 85% of real exchange rate variations are due to the terms of trade.

included to control for common time factors. The estimated long-run equilibrium equation is given by

$$REER_{i,t} = \gamma_i + \alpha_t + \beta x_{i,t} + \sum_{j=-\rho}^{\rho} \eta \Delta x_{i,t-j} + e_{i,t} \tag{1.1}$$

where γ_i and α_t are vectors of country and year fixed effects, respectively, $x_{i,t}$ is a vector of $I(1)$ variables cointegrated with $REER_{i,t}$, and the fourth term on the right hand side is the set of leads and lags of $\Delta x_{i,t}$. The error term $e_{i,t}$ captures short-run deviations from the long-run relationship and can be interpreted as the extent of real exchange rate disequilibria. A positive $e_{i,t}$ implies the real exchange rate is overvalued while a negative value implies an undervaluation. To estimate how fast deviations from the long-run equilibrium are eliminated, the estimated residuals, $\hat{e}_{i,t}$, are imposed on the error-correction model (ECM) in equation (1.2):

$$\Delta REER_{i,t} = \Theta_{i,t} \hat{e}_{i,t-1} + \alpha \Delta x_{i,t} + \beta z_{i,t} + u_{i,t} \tag{1.2}$$

where

$$\Theta_{i,t} = \theta_1 + \theta_2 SCH_{i,t} \tag{1.3}$$

The ECM is augmented with a vector of short-run stationary variables $z_{i,t}$. These include the annual change in the government expenditure to GDP ratio (ΔGOV), population growth (POP), the log growth of the commodity terms of trade (ΔTOT), and a dummy for currency crises ($CRISIS$). The coefficient $\Theta_{i,t}$ measures the speed of adjustment towards the long-run equilibrium and varies across both countries and years. Consistency between equations (1.1) and (1.2) requires $\Theta_{i,t} < 0$. Otherwise, $e_{i,t}$ would be non-stationary and therefore $REER_{i,t}$ and $x_{i,t}$ cannot be cointegrated. Rather than allowing unlimited heterogeneity, the speed of adjustment is modeled as a function of a constant base-rate θ_1 and an additional term that depends on the intensity of capital controls. Hence, the speed of adjustment is captured by the marginal effect of $\hat{e}_{i,t}$ on $\Delta REER_{i,t}$:

$$\frac{\partial \Delta REER_{i,t}}{\partial \hat{e}_{i,t-1}} = \begin{cases} \theta_1 & \text{if } SCH_{i,t} = 0 \text{ (no capital controls)} \\ \theta_1 + \theta_2 & \text{if } SCH_{i,t} = 1 \text{ (full capital controls)} \end{cases} \tag{1.4}$$

If capital controls slow the speed of adjustment and cause disequilibria to persist for longer periods of time, then $\Theta_{i,t}$ should be smaller in absolute value when controls are present. This requires $\theta_1 < 0$, $\theta_2 > 0$, and $|\theta_2| \leq |\theta_1|$. The latter restriction ensures that the system is stable and that disequilibria are not explosive.

Putting the pieces together, the empirical strategy is to estimate the long-run equilibrium relationship (1.1) and use the residuals to estimate the ECM in (1.2). To estimate the effect of differences in capital controls on the speed of adjustment, the different measures of capital control intensity are interacted with the lagged residuals. Therefore, a positive and statistically significant coefficient on the interaction term would confirm the hypothesis. The ECM is augmented with a lagged dependent variable to account for potential persistence in short-run real exchange rate movements and a full set of country and time dummies to deal with unobservable short-run time-invariant and country-invariant factors. Since the introduction of a lagged dependent variable in a fixed-effects framework introduces dynamic panel bias (Nickell bias), the ECM is estimated using two-step GMM.

1.4 Benchmark Results

The results for the benchmark equilibrium real exchange rate level regressions are presented in Table 1.5. I consider a variety of specifications for the long-run relationship, including a simple model where the long-run real exchange rate only depends on log GDP per capita. These results appear in column (1). The coefficient is positive, indicating that an increase in productivity leads to a real appreciation, and statistically significant at the one percent level. Its magnitude is also economically significant and consistent with the existing literature: a one percent in increase in GDP per capita leads to roughly a quarter of a percent increase in the real exchange rate. Column (2) considers another stripped down model where the equilibrium $REER$ depends solely on NFA. Consistent with the literature, a higher net foreign assets position has a statistically significant positive effect on the real exchange rate. In particular, a one standard deviation increase of NFA leads to a six percent real appreciation. Next, column (3) considers the log commodity terms of trade which, as expected, has a positive coefficient. However, the estimate is not statistically significant. The specification in column (4), which will serve as the baseline for the error-correction models estimated below, includes both LNY and NFA simultaneously. Both coefficients have the expected signs and are significant at standard significance levels.

Table 1.5: Long-run cointegrating relationship

Dependent Variable: *REER*	(1)	(2)	(3)	(4)	(5)
Log PPP GDP Per Capita (LNY)	0.254***			0.226***	0.266***
	(0.051)			(0.048)	(0.066)
Net Foreign Assets / Imports (NFA)		0.019*		0.023**	0.022**
		(0.010)		(0.010)	(0.010)
Log Terms of Trade (TOT)			0.091		0.070
			(0.057)		(0.054)
Error-Correction Term					
$\hat{e}_{t-1}$	-0.210***	-0.186***	-0.204***	-0.192***	-0.186***
	(0.034)	(0.033)	(0.033)	(0.034)	(0.033)
Observations	2,191	2,191	2,173	2,191	2,173
Countries	88	88	88	88	88
R-squared	0.585	0.572	0.556	0.598	0.601
RMSE	0.193	0.196	0.199	0.190	0.189
Country FE?	Yes	Yes	Yes	Yes	Yes
Year FE?	Yes	Yes	Yes	Yes	Yes

Note: The benchmark DOLS specification includes one lead and two lags of the differenced long-run explanatory variables. Results are robust to different lag lengths. The coefficient and standard error estimates for the leads and lags are not reported. Full results are available upon request. Robust HAC standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

To compare with the results below, in each level specification I report the error-correction term for a simple ECM with homogenous adjustment dynamics. The speed of adjustment ranges from a low of 0.19 to a high of 0.21, indicating that roughly a fifth of the disequilibria are eliminated each year. These estimates are consistent with previous studies and, in particular, are very close to those reported by Ricci et al. [102], who report an adjustment speed of 0.2. As a reference, these estimated adjustment speeds imply half-lives on average of roughly 3 years.[13]

The results for the ECM with heterogenous adjustment dynamics in (1.2) are shown in Table 1.6. The lagged residual $\hat{e}_{i,t-1}$ corresponds to the baseline level specification in column (4) of Table 1.5. As described above, the ECM is augmented with a lagged dependent variable and a full set of country and time dummies. Because the combination of a lagged dependent variable and fixed country effects introduces Nickell bias, the model is estimated using two-step GMM. The baseline ECM specification is reported in column (1), which includes an interaction term between $\hat{e}_{i,t-1}$ and the Schindler index of capital control intensity (SCH). The first thing to note is that the results appear to support the hypothesis that capital controls slow the speed of adjustment towards long-run equilibrium. Specifically, the interaction term has a positive and significant coefficient that is smaller in absolute value than the coefficient on $\hat{e}_{i,t-1}$. The Hansen J statistic test for the over identifying restrictions fails to reject the null hypothesis while the Kleibergen-Paap statistic for testing for weak instruments does reject the null. This indicates that the model is well specified and that the lagged levels of the real exchange rate are good instruments for $\Delta REER_{i,t-1}$.

As discussed above, the speed of adjustment is measured by the marginal effect of $\hat{e}_{i,t-1}$ on $\Delta REER_{i,t}$. The baseline results are consistent with the hypothesis that the

---

[13] The adjustment speed half-life can be calculated as follows. Setting all short-term covariates equal to zero, the half-life is given by: $HL = \ln(1/2)/\ln(1+\hat{\theta})$, where $\hat{\theta}$ is the estimated error-correction term.

marginal effect increases with the intensity of capital controls – that is, the speed of adjustment is slower the higher the intensity of controls. This is depicted graphically in Figure 1.2, along with the 95 percent confidence interval. The different adjustment dynamics based on the intensity of capital controls can also be depicted graphically as a phase-diagram in $(e_{i,t-1}, \Delta REER_{i,t})$-space. A dynamically stable equilibrium relationship requires a downward sloping curve, where steeper slopes correspond to faster adjustment dynamics. This is shown in Figure 1.3 for two cases: no capital controls ($SCH = 0$) and full capital controls ($SCH = 1$). The "phase arrows" portray the dynamic directions of motion. Specifically, whenever $e_{i,t-1} < 0$ and the real exchange rate is undervalued, $\Delta REER_{i,t} > 0$ and thus the undervaluation is gradually eliminated. As can be seen in Panel (a), when controls are absent the real exchange rate rapidly adjusts to eliminate disequilibria (a steeper adjustment curve). However, when controls are set at their full intensity in Panel (b), the adjustment curve is flatter and disequilibria are corrected more sluggishly.

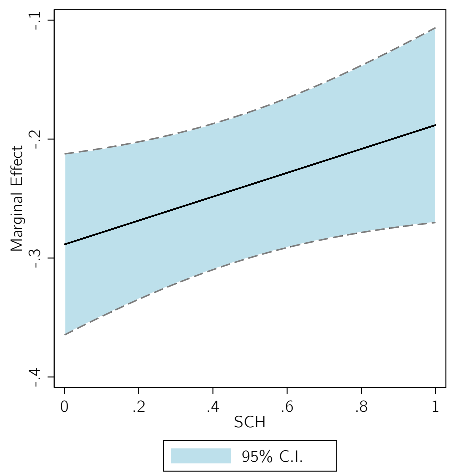
The remaining columns in Table 1.6 report results from using alternative measures of capital controls. The specifications in columns (2) and (3) consider the effects of controls exclusively on capital inflows and on capital outflows, respectively. These results are not very different from the baseline specification, although the point estimates for the interaction term with SCH_{IN} and SCH_{OUT} are slightly smaller. Taking full advantage of the granularity of the Schindler index, I also examine if controls on some types of financial instruments are more effective than others. Columns (4) and (5) report results using the SCH subindexes for equities and collective investments, respectively. These results are very similar to the baseline estimates in column (1),

Table 1.6: Error-Correction Models

Dependent Variable: $\Delta REER$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\hat{e}_{t-1}$	-0.289***	-0.274***	-0.288***	-0.300***	-0.285***	-0.253***	-0.222***
	(0.039)	(0.037)	(0.038)	(0.037)	(0.036)	(0.031)	(0.034)
$\hat{e}_{t-1} \cdot SCH$	0.100**						
	(0.051)						
$\hat{e}_{t-1} \cdot SCH_{IN}$		0.091*					
		(0.051)					
$\hat{e}_{t-1} \cdot SCH_{OUT}$			0.079*				
			(0.042)				
$\hat{e}_{t-1} \cdot SCH_{EQ}$				0.122**			
				(0.049)			
$\hat{e}_{t-1} \cdot SCH_{CI}$					0.100**		
					(0.043)		
$\hat{e}_{t-1} \cdot KLEIN$						0.154**	
						(0.069)	
$\hat{e}_{t-1} \cdot CHITO$							-0.022**
							(0.010)
$\Delta REER_{t-1}$	0.150***	0.148***	0.153***	0.156***	0.149***	0.145***	0.176***
	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.063)
$CRISIS$	-0.220***	-0.221***	-0.220***	-0.221***	-0.221***	-0.221***	-0.148***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.025)
ΔGOV	0.707**	0.710**	0.706**	0.702**	0.733**	0.721**	0.880***
	(0.326)	(0.326)	(0.326)	(0.336)	(0.317)	(0.322)	(0.265)
POP	1.761**	1.806**	1.734**	1.781**	1.781**	1.951**	2.626**
	(0.786)	(0.792)	(0.789)	(0.787)	(0.781)	(0.823)	(1.114)
ΔTOT	-0.020	-0.020	-0.021	-0.021	-0.018	-0.024	-0.043
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.036)
Observations	707	707	707	707	707	707	1,380
Countries	48	48	48	48	48	48	59
R-squared	0.414	0.413	0.414	0.417	0.417	0.414	0.319
RMSE	0.056	0.056	0.056	0.055	0.055	0.056	0.086
Hansen J Stat (p)	0.755	0.726	0.786	0.744	0.740	0.691	0.267

Note: Each ECM is estimated with two-step GMM using the residuals from the DOLS regression in Table 1.5. All specifications include lagged differences of the long-run variables LNY and NFA. The single lag-order was chosen using the AIC and BIC. SCH refers to the overall Schindler index. SCH_j refers to the Schindler sub indexes j, where IN, OUT, EQ, and CI denote, respectively, average restrictions on capital inflows, outflows, equities, and collective investments. $KLEIN$ is an index for the intensity of Klein [71]'s episodic capital controls. $CHITO$ refers to the Chinn-Ito index of financial liberalization [24]. Robust HAC standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1.2: Error correction speed as a function of capital controls intensity



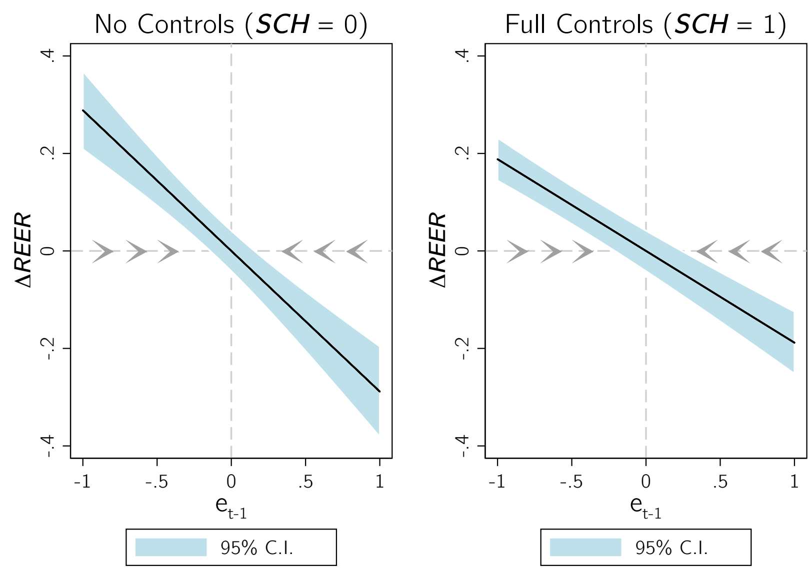
Note: This figure shows the speed of adjustment as a function of the level of capital controls $(\theta_1 + \theta_2 SCH_{it})$. The estimated coefficients and standard errors correspond to specification (1) from Table 1.6.

although the point estimate for controls on equity transactions is somewhat larger than for the average index and for collective investments.

Zooming into further detail, Tables A.1 and A.2 report ECM estimates using even finer instrument subcategories for capital inflows and outflows, respectively. In general terms, the results imply substantially different adjustment speeds depending on the type of restriction imposed. For instance, there is no evidence that restricting cross-border bond transactions has a statistically significant impact on the speed of adjustment.[14] The results are further nuanced within instrument categories: restric-

[14]Estimates considering controls on inward and outward direct investment, as well as for financial credits (not reported) are similarly insignificant. Full results are available upon request.

Figure 1.3: Adjustment Dynamics



Note: The adjustment dynamics correspond to specification (1) from Table 1.6. The arrows show the direction of motion. The left panel was calculated setting capital control intensity to zero ($SCH = 0$). The right panel considers the case with capital controls set to the highest intensity ($SCH = 1$).

tions on selling or issuing equities abroad appear effective (Table A.1, column (3)) but restrictions on the local purchase of equities by non-residents do not (Table A.1, column (2)). Inflow restrictions on collective investments, on the other hand, appear to be unambiguously effective, as are outflow restrictions on equity transactions.

As Klein [71] argues, it is potentially important to distinguish between permanent and episodic capital controls. This is because domestic financial institutions with experience in international financial markets may find it easier to evade short-term restrictions and taxes on capital flows, rendering episodic capital controls less effective than long-term ones. Thus, as an additional robustness exercise, I consider the impact of episodic capital controls as defined by Klein.[15] Specifically, I use an index of the average intensity of episodic controls, $KLEIN$. This index is simply an episodic counterpart of SCH that, in line with Klein's work, excludes permanent restrictions on capital flows. The key takeaway from this robustness exercise is that episodic capital controls also appear to slow the speed of adjustment, as indicated by the positive and significant coefficients on the interaction term. Moreover, the point estimate for the $KLEIN$ interaction term is substantially larger than for any other measure of capital controls. This suggests that temporary capital controls are not only an effective means of slowing $REER$ adjustment, but may also be more effective than their permanent counterparts.

This result, however, should be interpreted with care. First, the large adjustment slowdown observed with episodic controls may arise because these are often imposed in conjunction with other policy measures designed to lean against the wind. In other words, the estimated impact of temporary controls may be picking up the effects of other complementary policy interventions. Second, as discussed above, it is highly likely that controls may lose their efficacy over time as financial markets learn how to evade them and exploit legal loopholes. Therefore, the larger point estimate for the $KLEIN$ interaction term may reflect the possibility that the controls in question have not remained in place long enough to lose their efficacy.

As a final robustness exercise, column (7) of Table 1.6 reports results using Chinn and Ito [24]'s index of international financial liberalization. Unlike SCH

[15] The episode dates and instruments covered were taken from Table A.1 in Klein [71].

Table 1.7: Estimated Half-Lives (years) from Error-Correction Model

	SCH (1)	SCH_{IN} (2)	SCH_{OUT} (3)	SCH_{EQ} (4)	SCH_{CI} (5)	$KLEIN$ (6)	$CHITO$ (7)
No Controls	2.036	2.163	2.037	1.943	2.065	2.378	2.144
Average Controls	2.318	2.443	2.254	2.267	2.354	2.992	2.728
Full Controls	3.323	3.418	2.946	3.536	3.392	6.629	3.475

Note: This table reports the number of years it takes the real exchange rate to eliminate half of its disequilibrium from its long-run equilibrium level. The half-lives correspond to the specifications in columns (1) through (7) in Table 1.6. In the case of the Schindler indexes and Klein's episodic index, the half-lives are calculated evaluating the capital controls at zero (no capital controls), the sample average for each control measure (average controls), and at one (full controls). For the Chinn-Ito index of capital account liberalization, the half-lives are calculated setting $CHITO$=2.4 (complete liberalization), $CHITO$=0.1 (sample average), and $CHITO$=-1.9 (completely closed).

and $KLEIN$, $CHITO$ ranges from -1.86 (most closed) to 2.44 (most liberalized). As such, a *negative* coefficient on the interaction term would now constitute evidence in favor of the hypothesis that less open capital accounts slow the adjustment speed of the real exchange rate.[16] As expected, the coefficient on the interaction term is negative and statistically significant. Moreover, these estimates are remarkably similar to the benchmark results: the error-correction speed when $CHITO$ is set to its minimum is roughly -0.18. Similarly, the estimates imply a speed of adjustment of -0.28 in a fully liberalized country.

These estimates imply significant heterogeneity in the speed of adjustment across both countries and time. To illustrate these differences in speed, Table 1.7 reports the estimated half-lives for the persistence of disequilibria. The real exchange rate converges to its equilibrium level at a very high speed in countries with relatively

[16] $CHITO$ has the advantage that it covers more countries and years than the SCH data.

Table 1.8: Correlation between capital controls and floating exchange rate regimes

Capital Control Measure j:	Overall	Inflows	Outflows	Equity	Bonds	Collective Inv.
	(1)	(2)	(3)	(4)	(5)	(6)
FLOAT	-0.070	-0.070	-0.066	-0.058	-0.104	-0.124

Note: Reports the correlation coefficient between various measures of capital controls and a dummy variable for the presence of a floating exchange rate regime. See Appendix A.3 for details on the construction of the exchange rate regime variables.

low control intensities. For instance, in the baseline estimate it only takes 2 years for half of a deviation to be eliminated in countries with no controls. On the other hand, the half-life is as high as 3.3 years with a full set of controls and 3.5 years in countries with strict controls on equity transactions. The differences are even starker when episodic controls are imposed: the half-life for countries with strict episodic controls is nearly 7 years.

1.5 Robustness Checks

This section reports the results from a series of robustness exercises. First, I consider the impact of a potentially important omitted variable that may also influence the speed of adjustment of the real exchange rate and that is correlated with capital account policies: the exchange rate regime. Second, I examine if the benchmark results are robust to the inclusion of additional forms of heterogeneity in the error-correction mechanism. In particular, I consider an extended specification that allows the error-correction speed to vary according to various country grouping schemes.

There are two main reasons why the exchange rate regime may matter when identifying the effect of capital controls on real exchange rate adjustment dynamics. First, managed regimes by definition are intended to dampen exchange rate fluctuations or to target specific levels of the exchange rate. For example, under a pegged regime all adjustment towards the long-run equilibrium must take place through changes in relative price-levels, which may be sluggish due to nominal rigidities. Second, managed regimes are often implemented in conjunction with capital controls (see Table 1.8). If having a managed exchange rate slows the speed of adjustment, then a naive model that fails to take into account the exchange rate regime will tend to overstate the true effect of capital controls.

To examine this potential channel, I rely on *de facto* exchange rate regime data constructed by Ilzetzki et al. [60]. This index classifies exchange rate regimes by increasing degrees of flexibility, ranging from hard pegs and the absence of a national currency on one end of the spectrum, to freely floating on the other end. I use this data to construct a dummy variable $FLOAT_{i,t}$ that takes on a value of one if country i has a floating regime during year t and zero otherwise. Details on the classification scheme and construction of this variable are provided in Appendix A.3.

The extended ECM incorporating the exchange rate regime is given by:

$$\Delta REER_{i,t} = \Theta_{i,t}\hat{e}_{i,t-1} + \rho_1 SCH_{i,t-1} + \rho_2 SCH_{i,t-1} \cdot FLOAT_{i,t} + \alpha \Delta x_{i,t} + \beta z_{i,t} + u_{i,t} \tag{1.5}$$

where

$$\Theta_{i,t} = \theta_0 + \theta_1 SCH_{i,t-1} + \theta_2 FLOAT_{i,t} + \theta_3 SCH_{i,t-1} \cdot FLOAT_{i,t} \tag{1.6}$$

Table 1.9: Extended Error Correction Models – Exchange Rate Regime Heterogeneity

Dependent Variable: $\Delta REER$						
Control Measure j:	Overall	Inflows	Outflows	Equity	Bonds	Col. Inv.
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{e}_{i,t-1}$	-0.232***	-0.218***	-0.234***	-0.213***	-0.279***	-0.242***
	(0.036)	(0.038)	(0.035)	(0.036)	(0.036)	(0.034)
$\hat{e}_{i,t-1} \cdot SCH_j$	0.153**	0.136*	0.138**	0.119*	0.174**	0.166***
	(0.066)	(0.071)	(0.059)	(0.065)	(0.070)	(0.061)
SCH_j	0.033	0.040	0.027	0.040	0.046	0.038
	(0.034)	(0.036)	(0.030)	(0.032)	(0.037)	(0.028)
$\hat{e}_{i,t-1} \cdot FLOAT$	-0.041	-0.035	-0.049**	-0.049**	-0.037	-0.032
	(0.025)	(0.025)	(0.024)	(0.024)	(0.026)	(0.023)
$\hat{e}_{i,t-1} \cdot FLOAT \cdot SCH_j$	-0.052	-0.069	-0.036	-0.069	-0.103	-0.045
	(0.084)	(0.094)	(0.074)	(0.088)	(0.078)	(0.082)
$FLOAT \cdot SCH_j$	-0.061	-0.066	-0.056	-0.084*	-0.077*	-0.053
	(0.046)	(0.052)	(0.038)	(0.045)	(0.045)	(0.043)
Observations	519	519	519	519	453	519
R-squared	0.334	0.325	0.340	0.333	0.387	0.333
RMSE	0.0417	0.0420	0.0415	0.0417	0.0404	0.0417
Hansen J Stat (p)	0.818	0.898	0.767	0.887	0.135	0.838

Note: Each ECM is estimated with two-step GMM using the residuals from the DOLS regression in Table 1.5. All specifications include contemporaneous and lagged differences of the long-run variables LNY and NFA. The single lag-order was chosen using the AIC and BIC. $FLOAT$ refers to a dummy variable for floating exchange rate regimes based on data from Ilzetzki et al. [60]. Robust HAC standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The main difference between this specification and the benchmark specification (1.2) is the inclusion of extra interaction terms between the exchange rate regime dummy and the lagged residuals $\hat{e}_{i,t-1}$, as well as the intensity of capital controls $SCH_{i,t}$. The coefficient θ_2 in (1.6) measures the difference in adjustment speeds between fixed and floating exchange rate regimes. Thus, a negative and significant θ_2 would indicate that real exchange rate disequilibria are corrected more quickly under floating regimes. Note that this specification also tests for the presence of short-run effects of capital controls on the real exchange rate and for whether these short-run effects differ across exchange rate regimes. These are captured, respectively, by coefficients ρ_1 and ρ_2.

Results for the extended ECM model are reported in Table 1.9 for the overall Schindler index, as well as for various subindexes: controls on inflows, outflows, equities, bonds, and collective investments. The first thing to note is that these results are qualitatively and quantitatively quite similar to the benchmark results reported above. As above, the interaction term between SCH_j and $\hat{e}_{i,t-1}$ is positive and remains statistically significant after controlling for the exchange rate regime. This suggests that the slower adjustment speed associated with higher capital controls is not driven by the exchange rate regime. Second, these results do not provide clear evidence that the exchange rate regime affects real exchange rate adjustment dynamics. While the point estimates for θ_2 are consistently negative, these are not significant at standard confidence levels in all but two specifications.

As a final robustness exercise, I also examine the potential impact of various forms of country-group heterogeneity in real exchange rate adjustment dynamics. Specifically, I allow the adjustment speed to vary according a country's monetary environment and regime, as well as a country's level of development. To this end, I estimate the following augmented error-correction model:

$$\Delta REER_{i,t} = \Theta_{i,t}\hat{e}_{i,t-1} + \rho_1 SCH_{i,t-1} + \rho_2 SCH_{i,t-1} \cdot G_i^j + \alpha\Delta x_{i,t} + \beta z_{i,t} + u_{i,t} \quad (1.7)$$

where

$$\Theta_{i,t} = \theta_0 + \theta_1 SCH_{i,t-1} + \theta_2 G_i^j + \theta_3 SCH_{i,t-1} \cdot G_i^j \tag{1.8}$$

The term G_i^j is a generic dummy variable indicating country membership in a group classification scheme j. To account for the potential influence of monetary factors, the set j includes dummies for countries with unusually high average inflation during the sample, defined as an average inflation rate exceeding the 95th percentile. It also includes an indicator for countries with inflation targeting regimes. Details on the list of countries with inflation targeting regimes are presented in Appendix A.4. To capture the level of development, I consider three alternative classifications: the World Bank's definition of "high income" and "industrial" countries, as well as OECD membership.

Table 1.10 reports the results of the group heterogeneity ECMs. As above, these results are qualitatively quite similar to the benchmark results in the previous section. The interaction term between the extent of disequilibria and the intensity of capital controls is positive and significant in all five specifications, indicating that the inclusion of additional forms of heterogeneity in the error-correction model does not cast doubt on the benchmark results.

These results also do not provide evidence that real exchange rate adjustment dynamics differ substantially across developed and developing countries or between inflation targeting and non-targeting countries, as evidenced by the insignificant coefficients on the interaction term $\hat{e}_{i,t-1} \cdot G^j$ in specifications (2) through (5). The only exception is the distinction between high and low inflation countries (column 1 of Table 1.10). Indeed, the results suggest that the error-correction term is statistically indistinguishable from zero in high inflation countries.

Table 1.10: Extended Error Correction Models – Country Group Heterogeneity

Dependent Variable: $\Delta REER$					
Country Group G_j:	High Inflation	Inflation Target	High Income	OECD	Industrial
	(1)	(2)	(3)	(4)	(5)
$\hat{e}_{i,t-1}$	-0.293***	-0.288***	-0.382***	-0.333***	-0.275***
	(0.040)	(0.043)	(0.075)	(0.063)	(0.052)
$\hat{e}_{i,t-1} \cdot SCH$	0.215***	0.213***	0.279***	0.236**	0.163**
	(0.068)	(0.070)	(0.107)	(0.093)	(0.083)
SCH	0.038	0.041	0.106*	0.075*	0.027
	(0.032)	(0.032)	(0.059)	(0.039)	(0.042)
$\hat{e}_{i,t-1} \cdot G_j$	0.245*	0.034	0.122	0.017	-0.020
	(0.147)	(0.038)	(0.078)	(0.075)	(0.065)
$\hat{e}_{i,t-1} \cdot G_j \cdot SCH$	-0.518	-0.424*	-0.053	-0.035	-0.314
	(0.357)	(0.250)	(0.171)	(0.204)	(0.201)
$G_j \cdot SCH$	-0.269*	-0.176*	-0.086	-0.142**	-0.123*
	(0.147)	(0.092)	(0.074)	(0.065)	(0.075)
Observations	694	694	694	694	694
R-squared	0.354	0.362	0.357	0.364	0.352
RMSE	0.054	0.053	0.054	0.053	0.054
Hansen J Stat (p)	0.967	0.950	0.823	0.889	0.998

Note: Each ECM is estimated with two-step GMM using the residuals from the DOLS regression in Table 1.5. All specifications include contemporaneous and lagged differences of the long-run variables LNY and NFA. The single lag-order was chosen using the AIC and BIC. Robust HAC standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

1.6 Concluding Remarks

This paper has examined the relationship between capital controls and the real exchange rate. The consensus among empirical studies on the effects of capital controls is that these enable domestic authorities to maintain an independent monetary policy and shield countries from short-term, speculative flows. The evidence is far less conclusive when it comes to limiting the overall volume of flows and influencing the real exchange rate. Previous studies, however, have largely overlooked the long-run determinants of the real exchange rate and are therefore misspecified. Taking the determinants of the real exchange rate seriously, it was shown that capital controls may have very dramatic effects on real exchange rate dynamics, especially if controls are sufficiently strict. Specifically, controls appear to enable real undervaluations or overvaluations to persist for significantly longer periods compared to countries without controls.

Future work should examine the role of error-correction non-linearities and in particular potential differences between the speed of adjustment of overvaluations and undervaluations. Moreover, these non-linearities may also be compounded by different types of capital controls. For instance, controls on inflows may slow the correction of undervaluations but *increase* the speed of adjustment when the real exchange rate is overvalued. Conversely, tighter controls on outflows may cause undervaluations to be eliminated more quickly while allowing overvaluations to persist for longer or become more severe.

The broader lesson to take from this study is that capital controls are an effective policy tool for managing the real exchange rate. In other words, controls can help achieve policy objectives in addition to the macro-prudential concerns stressed by the recent literature. In particular, capital controls can be of use to countries seeking to deliberatively maintain a real exchange rate undervaluation. Nevertheless, strictly speaking, the empirical results presented above to do not explain how an undervaluation is initially achieved but rather suggest that the real exchange rate, once already undervalued, will take longer to converge to its long-run level. How the undervaluation is originally achieved and how this affects the short-run dynamics of the real exchange rate requires further research.

CHAPTER 2

LEAKY CAPITAL CONTROLS IN THE PRESENCE OF SAVVY FINANCIAL MARKETS

2.1 Introduction

The last several years have witnessed a renewed use of capital controls in emerging markets in response to volatile capital flows and financial crises. For example, prudential restrictions on capital inflows were imposed in Brazil during the aftermath of the global financial crisis in order to stem excessive exchange rate appreciation and systemic risk.[1] Similarly, countries like Iceland, Greece, and Cyprus have imposed extensive controls on capital outflows to limit the fallout from domestic banking crises. This "hands on" approach to capital flow management has been accompanied by an active academic literature investigating the theoretical welfare rationale for imposing capital controls in a variety of circumstances, including the existence of borrowing constraints (e.g. Jeanne and Korinek [65], Bianchi [13]), learning-by-doing externalities (e.g. Korinek [73], Michaud and Rothert [89]), and nominal rigidities (e.g. Schmitt-Grohé and Uribe [114], Farhi and Werning [40]).[2]

[1]See, Ostry et al. [95] for an account of Brazil's experience.

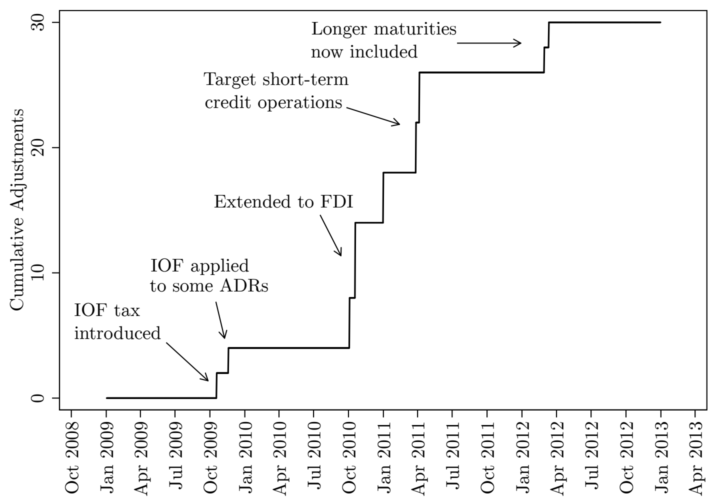
[2]A detailed review is provided by Engel [36].

Although this recent theoretical literature has improved our understanding of the welfare effects of capital controls, it has largely ignored issues related to their implementation and enforcement. Models typically assume that capital controls are perfectly enforceable and that the imagined social planners or financial regulators are able to effortlessly correct any existing externalities by setting a tax on capital flows at its optimal level. This idealized benchmark is helpful for clarifying theoretical mechanisms but could be misleading from a policymaking perspective where policies are, in general, imperfectly binding and political economy concerns are important; especially in emerging market settings where limited institutional capacities are the norm. Moreover, because capital control policies deliberately aim to segment international and domestic financial markets, these necessarily create an incentive for evasion by financial actors seeking to profit from arbitrage opportunities.

Indeed, it is widely understood that maintaining effective capital controls requires the ability to identify and close regulatory loopholes and to monitor illicit activity by investors attempting to bypass regulation (see, e.g. Ostry et al. [95]). The business and financial press is not lacking in accounts of investors creatively exploiting regulatory loopholes or devising other illicit means through which to bypass restrictions on capital mobility. As Figure 2.1 illustrates, this was a particular concern in Brazil between 2009-2012, for example, where authorities had to constantly tweak their "IOF" tax on capital inflows in order to close loopholes and make it harder for investors to get away with unauthorized flows.[3] Similarly, authorities in Iceland have

[3]Closing regulatory loopholes has also recently been a concern for the implementation of China's controls on capital outflows. For example, in November, 2016, a Bloomberg News article reported

Figure 2.1: Timeline of Brazil's IOF Tax – Daily cumulative policy adjustments



Note: This figure is based on data from the IMF Annual Report on Exchange Arrangements and Restrictions (AREAR) database. Cumulative adjustments refers to the total number of changes in capital controls policies since January 2009.

credited their success with capital controls during the aftermath of the 2009 collapse with reforms that eliminated loopholes.[4]

This paper explores the implication of imperfect enforcement of capital controls and regulatory evasion by the financial sector in the setting of a small open economy with a "Dutch disease" externality arising from excessive capital inflows. In the models presented below, the enforcement and implementation of capital controls arise endogenously as the outcome of non-cooperative strategic behavior of a domestic

that "China's policy makers are playing catch-up as investors get more creative in evading capital controls." [51]

[4]See, OECD [93].

regulatory authority and the financial sector. The regulatory authority is assumed to have a limited administrative capacity to implement capital controls in the face of a banking sector actively attempting to bypass their enforcement. This setup is used to study the welfare rationale for capital controls and how varying forms of imperfect enforcement impact a planner's ability to correct externalities associated with capital inflows.

The results are as follows. First, optimally chosen capital controls improve welfare relative to the "laissez-faire" benchmark with no capital controls, even with imperfect enforcement and active evasion by financial markets. Second, when evasion is costly and the probability of avoiding detection by the regulator is affected by the evasion choices of financial actors, capital controls will have more traction and can drive a greater wedge between domestic and international financial markets. However, this implies that the economy's "first-best" outcome can no longer be achieved as a decentralized equilibrium using capital controls. This is because bank evasion activity represents a pure waste from a societal perspective and can be thought of as a type of deadweight loss. Finally, we demonstrate the possibility of a "perverse" case where easier evasion could actually be beneficial from a social perspective if the distortions arising from illicitly avoiding the capital controls are large.

The problem of imperfect enforcement and regulatory evasion has long been recognized by the empirical literature and policy-oriented studies on the effectiveness of capital controls. Indeed, evasion is often cited as an explanation for why capital controls may be ineffective in practice despite theoretical arguments in their favor (see, e.g. Forbes et al. [45]). In a similar vein, Habermeier et al. [56] note that differences in policymakers' administrative capacities may be linked to the poor implementation of controls and could explain cross-country differences in their effectiveness. A constrained regulatory authority may also find it difficult to properly detect financial actors attempting to avoid the regulation. For example, in the Chilean context during the 1990s, Edwards [32] suggests that Chile's capital controls may have been ineffective because of the government's inability to adequately monitor evasion. Concerns about evasion in Chile were also raised by Forbes [47], who suggests that large firms may have been well poised to exploit legal loopholes and bypass the controls on capital inflows.

Differences in the characteristics and development of the domestic financial sector may also impact the ability of a regulatory authority to enforce capital controls. Intuitively, all else equal, complex financial sectors may be harder to adequately monitor than simpler ones. For example, Garber [52] argues that derivatives contracts could be devised to evade restrictions that target short-term inflows by effectively disguising short-term borrowing as long-term debt. Ostry et al. [95] point out that foreign investors can also use derivatives to avoid paying taxes on domestic assets. Similarly, Klein [71] argues that more developed financial systems with experience in financial markets may be better at finding loopholes or other ways around capital controls.

And yet, despite the clear potential for evasion or poor implementation of capital control policies, it is not obvious *a priori* that imperfectly enforced capital controls should prove ineffective. So long as evasion is costly or enforcement is at least partially binding, capital controls could still succeed in segmenting the domestic and international financial markets. This point is made by Levy-Yeyati et al. [81], who show using an event-study methodology that the "cross market premium" – the difference in price of identical stocks trading in two separate markets – increases when capital controls are imposed. This suggests that even if some investors succeed in avoiding the controls, on average controls can still be binding.

The closest to the current paper is Bianchi [10], who study a model of endogenous sudden stops with "leaky" capital controls. In their model, capital flows impose pecuniary externalities through their effect on the value of collateral and an occasionally binding borrowing constraint. Capital controls may improve welfare by encouraging precautionary savings but are assumed to be imperfectly enforceable, as in this paper. The key difference is that their model assumes that a fraction of agents in the economy are "unregulated" and can perfectly evade the capital controls. In contrast, in this paper evasion of the capital controls arises endogenously from the strategic interaction of banks and a domestic regulatory authority.

Another closely related work is Schulze [115], which provides two alternative models of capital control evasion through import and export misreporting. However, in contrast to the models presented below, Schulze's models focus exclusively on the mechanics of evasion and enforcement, foregoing an explicit welfare analysis of capital controls. Thus, Bianchi [10] and Schulze [115] can be seen as two modeling extremes: with exogenous enforcement and explicit welfare analysis at one extreme, and endogenous enforcement without welfare analysis at the other. The models presented below combine both aspects and is therefore the first paper in the literature to simultaneously study the welfare rationale for imposing capital controls with endogenously determined enforcement and evasion.

The rest of the paper will proceed as follows. Section 2.2 introduces the basic framework considered in all the models below by considering the standard case without regulatory evasion by the financial sector. Section 2.3 then considers a model where the domestic banking sector has access to a variety of loopholes through which to attempt to evade the capital controls. Section 2.4, in turn, presents a simple extension of the loophole model that results in the perfect evasion of capital controls by the financial sector. Next, Section 2.5 examines a more general model where banks can directly influence the probability of being caught evading the capital controls. Finally, Section 2.6 offers some concluding remarks.

2.2 Basic Framework

Consider a small open endowment economy with a single tradable good and a unit measure of identical households. For simplicity, the economy exists for only two periods. There exists a competitive domestic banking sector that acts as an intermediary between domestic households and the world financial market. Households borrow during the first period in order to finance consumption and repay their debt during the second period.

In order to motivate the use of capital controls, the economy features a stylized "Dutch disease" externality that reduces the size of the endowment during the second period proportionately to the level of aggregate capital inflows. This welfare rationale for imposing capital controls is similar in spirit to those considered in Korinek [73] and can be thought of as a type of "learning-by-exporting" externality.

Households make consumption and borrowing decisions over both periods in order to maximize the following utility function

$$u(c_1, c_2) = \ln(c_1) + c_2 \tag{2.1}$$

subject to the two period budget constraints,

$$c_1 = d \tag{2.2}$$

$$c_2 = y - (1+r)d + \pi + \ell \tag{2.3}$$

where d is the level of household debt, y is an endowment of tradable goods, π are profits from the financial sector, and ℓ denotes lump sum transfers. The government is assumed to run a balanced budget, which implies that in the aggregate the lump sum transfers will equal the revenues from the capital controls, $\ell = \tau d$. Although each individual household takes y as given, in the aggregate the endowment is a decreasing function of net imports or, equivalently, of capital inflows.[5] For simplicity, the second period endowment takes the following form:

$$y = \bar{y} - \varphi d \tag{2.4}$$

[5]Note that in this model capital inflows and the stock of foreign debt are equal. This is because of the two-period assumption and the implicit assumption that the initial stock of net foreign liabilities is zero.

Each household's optimal choice of c_1 is defined by the first order condition:

$$\frac{1}{c_1} = 1 + r \tag{2.5}$$

Banks borrow from the international financial market at the exogenous constant interest rate r^* and lend to households at the domestic rate r. In addition to their borrowing costs, banks also face a convex portfolio cost to capture administrative costs internal to the bank. For simplicity, we will assume the portfolio costs are quadratic. Banks must satisfy a balance sheet constraint requiring that its assets equal its liabilities: $d = d^*$, where d^* denotes foreign borrowing. Bank profits are thus given by:

$$\pi = (r - r^* - \tau)d - \frac{\theta}{2}d^2 \tag{2.6}$$

The term $\tau > 0$ denotes a tax on bank borrowing and therefore represent a positive tax on capital inflows. The first order condition for the bank's optimization problem yields the lending inverse supply schedule:

$$r = r^* + \tau + \theta d \tag{2.7}$$

Notice that there is a wedge between the domestic and international interest rates. This wedge is composed of two components, (1) the tax on capital inflows, τ, and (2) the marginal portfolio cost.

We can now proceed to characterizing the model's decentralized equilibrium.

Definition 1 (Decentralized equilibrium) *A decentralized equilibrium consists of a domestic interest rate, r, and allocations $\{c_1, c_2, d, d^*\}$ for $t = 1, 2$, such that:*

- *The equilibrium allocations solve the representative household's optimization problem taking the domestic interest rate as given.*
- *Banks maximize profits taking the domestic and international interest rates as given.*
- *The loan market clears.*

To solve for the equilibrium level of first period consumption (which is equal to net capital inflows), combine (2.5) and (2.7) to obtain:

$$\frac{1}{d} = 1 + r^* + \tau + \theta d \tag{2.8}$$

which implicitly defines the equilibrium capital inflows as a decreasing function of the inflow tax. That is, equilibrium capital inflows are given by $d = d(\tau)$ and satisfy $d'(\tau) < 0$.

The decentralized equilibrium is clearly not Pareto optimal since individual households do not take into account their contribution to the Dutch disease externality when making their first period borrowing decision. Because households take the second period endowment as given, aggregate capital inflows will be inefficiently large. Put differently, this economy suffers from "overborrowing" in equilibrium or "excessive" capital inflows. To find the efficient level of capital inflows, we can set up the following social planner problem:

$$\max_{d} \quad u = \ln(d) + \bar{y} - (1 + r^* + \varphi)d - \frac{\theta}{2}d^2 \tag{2.9}$$

The social planner's optimal choice of capital inflows, d_{sp}, is thus defined by:

$$\frac{1}{d_{sp}} = 1 + r^* + \varphi + \theta d_{sp} \tag{2.10}$$

Comparing conditions (2.8) and (2.10), it is evident that the social planner equilibrium can be achieved by setting the tax on capital inflows at $\tau = \varphi$ and rebating the revenue back to households in lump-sum fashion.

Definition 2 (First-best equilibrium) *The economy's first-best equilibrium is the outcome achieved by the unconstrained social planner, with equilibrium capital inflows satisfying (2.10).*

Definition 3 (Laissez-faire equilibrium) *The economy's Laissez-faire equilibrium is the decentralized equilibrium with no capital controls ($\tau = 0$).*

The model up to this point is standard and assumes that capital controls are perfectly enforceable. As such, the socially optimal equilibrium can be achieved simply by setting the inflow tax at its optimal level. In the next section we'll start to relax this assumption by considering an extension of the basic model with imperfect capital control enforcement due to regulatory loopholes.

2.3 A Model With Loopholes

To capture the idea that banks can exploit a variety of loopholes to avoid capital controls, suppose that banks have access to $J \in \mathbb{N}$ borrowing strategies. Another way to interpret this is that banks can borrow from international financial markets using J distinct classes of financial instruments. To focus exclusively on the issue of regulation, suppose that each instrument $j \in J$ charges the same constant interest rate r^*. Thus, the only reason banks may prefer one instrument j over another is in order to evade the capital controls. The domestic regulator in charge of enforcing the capital controls is institutionally constrained in the sense that it has a limited capacity to monitor bank borrowing behavior. In particular, the regulator is assumed to only be able to monitor one of the J instrument categories at a time. Banks are aware of this enforcement constraint and attempt to avoid the capital controls by choosing an instrument not being monitored by the regulator.

Formally, consider a simultaneous move game in which the bank (player B) chooses an instrument to borrow with and the regulator (player R) chooses which instrument to monitor. With J distinct instruments, the sets of actions available for players $i = \{B, R\}$ are $A_i = \{1, 2, \ldots, J\}$, where each individual action for player i is denoted by a_i. Let $v(a_B, a_R)$ denote the bank's payoffs given actions a_B and a_R. The regulator's payoffs, similarly, are given by $m(a_B, a_R)$. The bank attempts to avoid paying the tax on capital inflows and loses $-\tau$ per unit of borrowing if it is "caught" by the regulator. Conversely, if the regulator successfully catches the bank attempting to evade the capital controls it gains τ per unit of borrowing. Therefore, the bank's payoffs are $v(a_B, a_R) = -\tau$ if $a_B = a_R$ and $v(a_B, a_R) = 0$ if $a_B \neq a_R$. Similarly, the regulator's payoffs are $m(a_B, a_R) = \tau$ if $a_B = a_R$ and $m(a_B, a_R) = 0$ if $a_B \neq a_R$. This information is summarized below.

Loophole Game. *The capital control loophole game consists of:*

- ***Players:*** *the "bank" (B) and the "regulator" (R).*

Figure 2.2: Enforcement game with two instruments ($J = 2$)

		Regulator 1	Regulator 2
Bank	1	$-\tau$, τ	0 , 0
	2	0 , 0	$-\tau$, τ

- ***Actions:*** *instrument borrowing and monitoring choices* $A_i = \{1, 2, \ldots, J\}$ *for* $i = \{B, R\}$.

- ***Payoffs:*** *player* B*'s payoffs are*

$$v(a_B, a_R) = \begin{cases} -\tau & \forall\ a_B = a_R \\ 0 & \forall\ a_B \neq a_R \end{cases}$$

and player R*'s payoffs are*

$$m(a_B, a_R) = \begin{cases} \tau & \forall\ a_B = a_R \\ 0 & \forall\ a_B \neq a_R \end{cases}$$

This game has the structure of a classic matching pennies game and, as such, has no pure strategy Nash equilibrium. Instead, both players randomize and play mixed strategies in equilibrium, playing each action with an equal probability. Therefore, the probability that the bank will be "caught" evading the capital controls and will have to pay the inflow tax is:

$$p = \frac{1}{J} \tag{2.11}$$

Notice that the bank's lending and borrowing problem is no longer deterministic since the expected tax on capital inflows is now a random variable. Using (2.11), expected profits are given by:

$$\mathbb{E}\{\pi\} = \left(r - r^* - \frac{\tau}{J}\right) d - \frac{\theta}{2} d^2 \tag{2.12}$$

For simplicity, banks are assumed to bear all the risk associated with evading the capital controls. The bank's first order condition requires banks to equate marginal cost of foreign borrowing to the the domestic interest rate:

$$r = r^* + \frac{\tau}{J} + \theta d \tag{2.13}$$

Using the household's Euler equation and the result from (2.13), the equilibrium capital inflows when capital controls are imperfectly binding is defined by:

$$\frac{1}{d} = 1 + r^* + \frac{\tau}{J} + \theta d \tag{2.14}$$

Therefore, as before, capital inflows are decreasing in the tax rate and increasing in the available loopholes. In order to distinguish this equilibrium from the first one considered above without evasion, the evasion equilibrium will be denoted with a "tilde." That is, $\tilde{d} = \tilde{d}(\tau, J)$, with $\tilde{d}_\tau < 0$ and $\tilde{d}_J > 0$.

2.3.1 Regulatory Equilibria

We can consider two alternative solution concepts for the regulatory game. First, consider the case of a *naive planner* that sets the capital inflow tax without anticipating evasion by the financial sector. Intuitively, the planner in this setup does not realize it is playing a game in the first stage of the model and simply chooses the tax rate τ without taking the bank's strategic behavior into account. As a result, the *effective* inflow tax will generally differ from the optimal tax. Second, the naive planner can be contrasted with a *sophisticated planner* who anticipates the bank's evasion behavior. The sophisticated planner is the first mover in a sequential game and thus chooses the inflow tax taking into account that the capital controls are imperfectly binding. These two planner concepts are summarized below.

Definition 4 (Naive planner) *The naive planner does not take the bank's evasion into account and chooses an inflow tax τ_{np} in order to maximize perceived social welfare.*

Definition 5 (Sophisticated planner) *The sophisticated planner anticipates bank evasion and chooses an inflow tax τ_{sp} in order to maximize the true social welfare function subject to the bank's best response function.*

Let's start with the naive planner case. Since the naive planner does not anticipate the bank's evasion, it believes that equilibrium capital inflows are $d(\cdot)$ instead of $\tilde{d}(\cdot)$. The naive planner's problem consists of choosing τ in order to maximize the naive social welfare function:

$$\max_{\tau} \; u(\tau) = \ln(d(\tau)) + \bar{y} - (1 + r^* + \varphi)d(\tau) - \frac{\theta}{2}(d(\tau))^2 \tag{2.15}$$

As in the non-strategic case, the naive social welfare function is maximized at $\tau_{np} = \varphi$, where the subscript n indicates that this is the inflow tax chosen by the naive planner.

However, since the naive planner incorrectly believes that equilibrium capital inflows are given by $d(\cdot)$ instead of $\tilde{d}(\cdot)$, this is the wrong objective function and therefore τ_{np} will not maximize social welfare.

To see this, let's examine the sophisticated planner's problem. The sophisticated planner anticipates the bank's evasion and recognizes that equilibrium capital controls are given by $\tilde{d}(\tau, J)$ rather than $d(\tau)$. In other words, the sophisticated planner maximizes the "true" social welfare function:

$$\max_{\tau} \; \tilde{u}(\tau) = \ln(\tilde{d}(\tau, J)) + \bar{y} - (1 + r^* + \varphi)\tilde{d}(\tau, J) - \frac{\theta}{2}(\tilde{d}(\tau, J))^2 \tag{2.16}$$

The inflow tax that maximizes social welfare is given by $\tau_s = J\varphi$. This can be shown as follows. The sophisticated planner's first order condition for τ is

$$\tilde{d}_\tau \left[\frac{1}{\tilde{d}} - (1 + r^* + \varphi + \theta \tilde{d}) \right] = 0 \tag{2.17}$$

Recall that loan market equilibrium requires (2.14) to hold. We can rewrite the first order condition as:

$$\tilde{d}_\tau \left[\frac{\tau}{J} - \varphi \right] = 0 \tag{2.18}$$

which is clearly satisfied when $\tau = J\varphi$. Therefore, we can conclude that the sophisticated planner sets a larger *de jure* inflow tax than the naive planner.

A couple of observations are in order. First, the naive planner, by failing to anticipate the bank's evasion behavior, will set an inflow tax that is inefficiently low compared to the tax chosen by the sophisticated planner ($\tau_{np} < \tau_{sp}$). In general, the greater the number of loopholes (or alternatively, financial instrument categories), the larger this discrepancy becomes. Examining equation (2.11), it is evident that in the limit as the number of loopholes become arbitrarily large the naive planner's inflow tax becomes totally ineffective (since $\lim_{J\to\infty^+} p\tau = 0$). In other words, as evasion becomes arbitrarily easy, the capital controls are no longer binding and the equilibrium reduces to the laissez-faire case with no capital controls (i.e. $\tau = 0$).

A second and important point, however, is that for a finite J, the naive inflow tax nevertheless improves welfare relative to the laissez-faire case with no capital controls. Specifically, the following inequality holds:

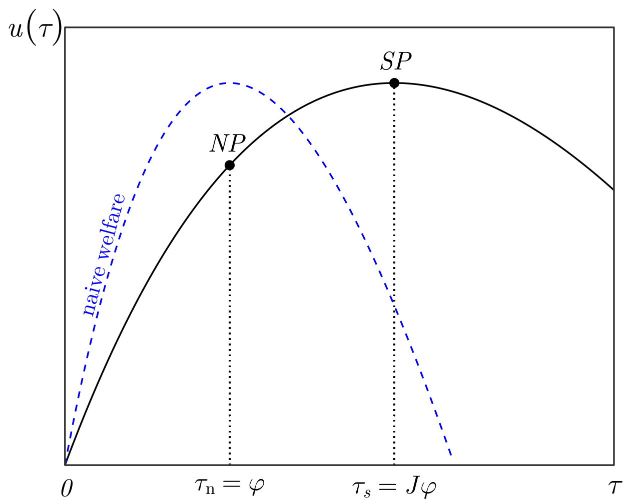
$$\tilde{u}(0) < \tilde{u}(\tau_{np}) < \tilde{u}(\tau_{sp}) \tag{2.19}$$

Intuitively, this means that even if capital controls are imperfectly binding, they nevertheless improve welfare relative to the laissez-faire equilibrium with no capital controls. This point is illustrated in Figure 2.3, which depicts the sophisticated planner's social welfare function in black and the naive planner's perceived welfare function in blue. Social welfare is maximized at point SP, which can be implemented by setting an inflow tax $\tau_{sp} = J\varphi$.

2.4 A Model With Perfect Evasion

A natural robustness exercise is to consider a modified loophole game where the regulator chooses which loophole to monitor before the bank makes its evasion decisions. In other words, let's consider a sequential move version of the loophole game from the previous section. The players in this game are still the regulator (R) and the bank (B). Unless noted otherwise, we will use the same notation as for the

Figure 2.3: Social welfare function under various equilibria ($\tilde{u}(\tau)$)

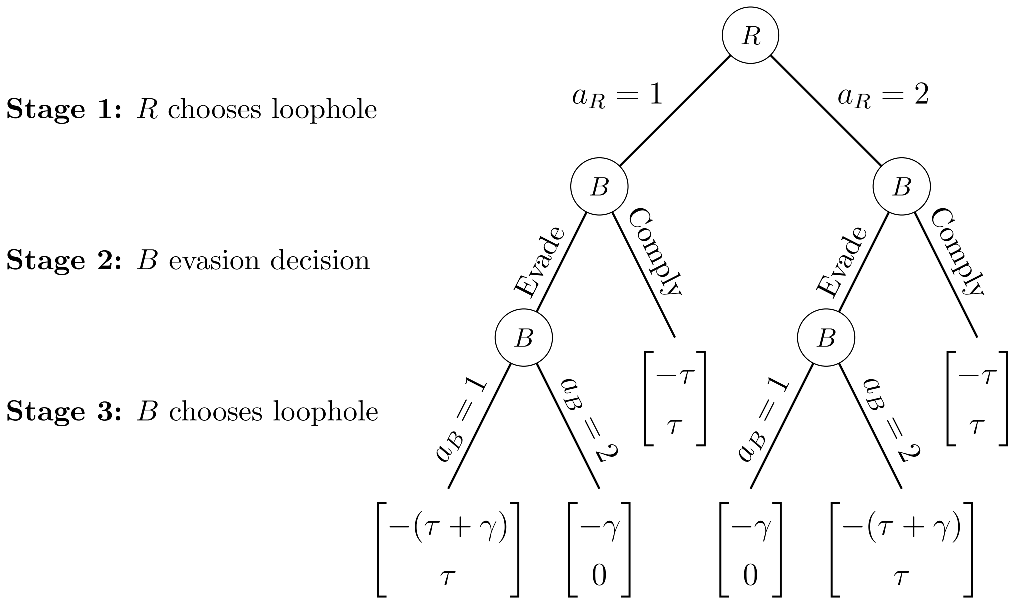


Note: This figure depicts the sophisticated planner's social welfare function (**in black**) and the naive planner's perceived welfare function (**in blue**). The points SP and NP refer, respectively, to the sophisticated planner and naive planner solutions.

simple loophole game. Player B still attempts to choose a different loophole from the one being monitored by player R and if both choose the same loophole, we say that the bank has been "caught" attempting to evade the capital controls.

Figure 2.4 illustrates the structure and timing of the sequential loophole game in the case with two available loopholes ($J = 2$). The timing of the game is as follows. During the first stage, the regulator chooses which loophole to monitor. During stage two, the bank observes which loophole is being monitored and then decides whether to attempt to "evade" the capital controls or to "comply" and pay the inflow tax. We will assume evasion is costly and that the bank must pay a unit cost of $\gamma > 0$ if

Figure 2.4: Sequential loophole game with two loopholes ($J = 2$)



Note: This figure shows the extensive form game tree for the sequential loophole game with two loopholes ($J = 2$). The bank and the regulator, respectively, are shown as players B and R. Player B's payoffs are shown on the top row of each payoff matrix. All payoffs are normalized for a unit of bank borrowing ($d^* = 1$).

it chooses to evade the capital controls. During the third and final stage, the bank chooses which loophole to use to borrow from the international financial market.

Proceeding by backwards induction, clearly the bank's best response during the third stage is to choose $a_B \neq a_R$ whenever $\tau > 0$. In the second stage, the bank compares the unit costs of evading or complying with the capital controls and chooses to evade whenever the inflow tax is greater than the unit cost of evasion ($\tau > \gamma$). Thus, the bank can perfectly evade the capital controls regardless of which loophole the regulator chooses to monitor. As a result, the regulator will be indifferent between monitoring strategies during the first stage.

We can now use the game's equilibrium to solve the bank's borrowing and lending optimization problem. The bank's objective function is the same as above with the exception that it's borrowing costs are $(r^* + \tau)$ whenever $\tau \leq \gamma$, and equal to $(r^* + \gamma)$ otherwise. As a result, the domestic interest rate will be given by:

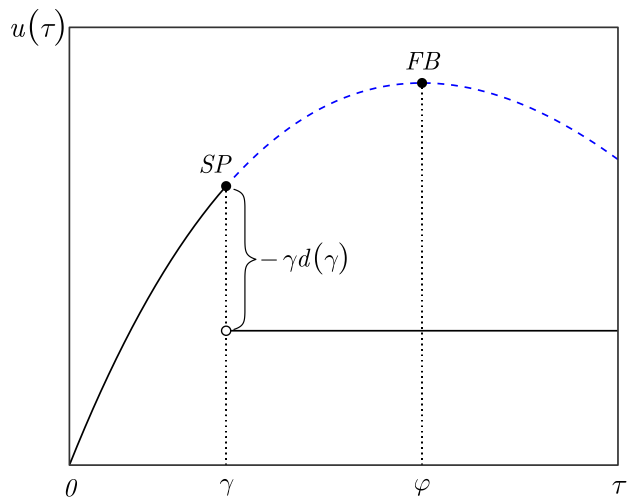
$$r = r^* + \theta d + \min\{\tau, \gamma\} \tag{2.20}$$

As is evident from equation (2.20), the domestic interest rate is increasing in the inflow tax but only until a certain level. Specifically, capital controls will lose their traction over the interest rate whenever the inflow tax exceeds the unit cost of evasion (i.e. $\tau > \gamma$). The intuition for this result is that, for a low inflow tax, financial markets do not have an incentive to evade the capital controls. A sufficiently high inflow tax, on the other hand, will trigger evasion by the financial sector. Since financial markets can perfectly evade the regulator's monitoring, capital controls will no longer influence the interest rate once evasion is triggered.

Once again, equilibrium in this model requires the loan market to clear and the sophisticated planner to choose an inflow tax, τ, to maximize social welfare. Denoting equilibrium capital inflows by $d(\tau)$, the planner's problem is:

$$\begin{aligned} \max_{\tau} \; u(\tau) = \ln(d) + \bar{y} - (1 + r^* + \varphi)d + \frac{\theta}{2}d^2 - \gamma d(\gamma) \cdot \mathbb{1}\{\tau > \gamma\} \\ \text{s.t} \quad d = \max\{d(\tau), d(\gamma)\} \end{aligned} \tag{2.21}$$

Figure 2.5: Social welfare with perfect evasion when $\varphi > \gamma$



Note: This figure compares social welfare as a function of the *de jure* capital inflow tax for both the unconstrained social planner (**in blue**) and the sophisticated planner (**in black**). The first-best equilibrium attained by the social planner is given by point FB. The sophisticated planner's solution is denoted by point SP.

where $\mathbb{1}\{\tau > \gamma\}$ is the indicator function, which is equal to one when $\tau > \gamma$ and zero otherwise. This optimization problem is almost identical to the one considered in the previous section with two exceptions. First, equilibrium capital flows as a function of τ are now bounded below by $d(\gamma)$, the level corresponding to an inflow tax of γ. Second, notice the additional term on the right hand side of (2.21). This term is the total cost from evading the capital controls when evasion is triggered. Unlike the bank's additional borrowing costs associated with the inflow tax, the evasion cost is not rebated back to consumers and as such represents a pure loss from a societal perspective.

There are two cases to consider. First, whenever the Dutch disease externality is small relative to the unit cost of evasion ($\varphi < \gamma$), a planner will be able to perfectly implement the economy's first-best equilibrium. This is because the inflow tax necessary to fully internalize the externality, $\tau = \varphi$, is below the level that trigger's financial market evasion. In other words, when the externality is small, the planner will be able to freely set the inflow tax at its optimal level without having to worry about financial sector evasion.

The second and more interesting case is when the externality is large relative to the unit cost of evasion ($\varphi > \gamma$). In this case, the planner would like to set $\tau = \varphi$ but knows that this will trigger evasion by financial markets and that any inflow tax above γ is totally ineffective at the margins. This case is illustrated in Figure 2.5, which depicts the planner's social welfare function in black. As a useful benchmark, the first-best welfare function without evasion is depicted in blue. Clearly, capital controls can no longer implement the first-best equilibrium and the planner will choose $\tau = \gamma$. This is because any inflow tax above γ will trigger evasion by the financial sector and lead to the incurrence of the evasion costs.

Nevertheless, capital controls will still improve welfare relative to the laissez-faire case (i.e. $u(0)$) even with perfect evasion. This is because any inflow tax, $0 < \tau \leq \gamma < \varphi$, delivers higher welfare than $u(0)$. Intuitively, even if financial markets are perfectly capable of evading the capital controls, these will still be partially binding as long as evasion is costly. Put differently, while perfect evasion may place a binding constraint on the planner's ability to correct large externalities, capital controls can still internalize a portion of the externality.

2.4.1 The Cost of Evasion

From a policymaking perspective, an obvious comparative static to consider is a fall in the unit cost of evasion. The unit cost of evasion may reflect a number of different factors in the underlying regulatory and financial structure of the economy. For example, it may be more expensive for banks to evade the capital controls in countries with extensive reporting requirements for foreign exchange transactions. Similarly, evasion may also be costlier in countries with well-trained and well-staffed regulators responsible for enforcing the capital controls.

While the link between the cost of evasion and the effectiveness of capital controls at segmenting the domestic and international financial markets is straightforward, the welfare effects are not obvious and depend crucially on whether we consider a sophisticated or a naive planner. Let's consider the sophisticated planner first. We know from the previous section that the optimal inflow tax is: $\tau_{sp} = \min\{\gamma, \varphi\}$. Whenever the cost of evasion is large relative to the externality ($\gamma > \varphi$), a small decrease in the unit cost of evasion will have no effect on social welfare. This is because γ is still high enough that evasion is not triggered and the economy remains at the first-best outcome. In contrast, if the unit cost of evasion is small or equal to the externality, a decrease in γ could trigger evasion and constrain the planner's ability to set the inflow tax at its optimal level. In this case, the effect of a fall in γ will unambiguously decrease social welfare.

Turning now to the naive planner, the welfare effects of a fall in the unit cost of evasion will again depend on whether or not evasion is triggered. Just like with the sophisticated planner, if γ is sufficiently large relative to the externality, a fall in γ

will have no effect on welfare. Similarly, if γ is small or equal to the externality and the fall in γ triggers evasion, social welfare will be reduced. However, unlike with the sophisticated planner, if the unit cost of evasion is sufficiently small relative to the externality, a further decrease could paradoxically improve welfare. This is because the naive planner sets $\tau_{np} = \varphi$, which implies an evasion cost of $\gamma d(\varphi)$. Since the equilibrium level of capital inflows is constant, a fall in γ simply has the effect of decreasing the total evasion losses incurred by triggering evasion.

2.5 A Model With Costly Evasion

The loophole game model in Section 2.4 provided an example of a setup where the equilibrium enforcement probability is a constant determined by the number of loopholes available to the banking sector. The key result from this framework is that a sophisticated planner could attain the first-best outcome by setting an inflow tax appropriately scaled to the number of loopholes. In this section we will consider a more general model where the bank can directly influence the probability of being caught by the regulator. In particular, the bank is assumed to be able to divert resources towards lowering the probability of being caught attempting to avoid the capital controls.

Formally, let $z \geq 0$ and $\gamma > 0$ denote the bank's evasion activity and the unit cost of evasion, respectively. Intuitively, when the bank borrows from abroad it can either lend all of the borrowed tradable goods or divert γz units to attempting to avoid paying the inflow tax. We will assume that larger "illicit" capital inflows are harder to hide than smaller inflows. Put differently, this means that the probability of being caught is increasing in the level of foreign borrowing but decreasing in evasion spending. Let's define the amount of effective evasion per unit of bank borrowing by $\kappa = z/d$ and denote the probability of being caught evading the capital controls by $p = p(\kappa)$, where $p(\kappa)$ satisfies $p' < 0$, $p'' > 0$, $p(0) = 1$, and $\lim_{\kappa \to \infty} p(\kappa) = 0$. The bank's problem is given by:

$$\max_{d,z} \ \mathbb{E}\{\pi\} = (r - r^*)d - \frac{\theta}{2}d^2 - p(\kappa)\tau d - \gamma z \tag{2.22}$$

The first order conditions for a maximum are given by:

$$r - r^* - \theta d - \tau\left(p(\kappa) - \kappa p'(\kappa)\right) = 0 \tag{2.23}$$

$$-p'(\kappa)\tau - \gamma = 0 \tag{2.24}$$

Equation (2.24) pins down the optimal choice of effective evasion for a given inflow tax: $\kappa^* = \kappa(\tau)$. By the implicit function theorem, we can see that effective evasion is increasing in the inflow tax:

$$\frac{\partial \kappa}{\partial \tau} = -\frac{p'(\kappa)}{p''(\kappa)\tau} > 0 \tag{2.25}$$

The intuition for this result is simple: a higher inflow tax increases the marginal cost of borrowing and thus creates a greater incentive for evasion. As a result, the equilibrium probability of being caught will be decreasing in the inflow tax: $p^* = p(\tau)$.

The household side of this model is the same as the benchmark framework described above. As such, equilibrium requires that the domestic loan market clears. In equilibrium, the domestic interest rate will be pinned down by the first order condition (2.23). Plugging in p^* and κ^*, the domestic interest rate is given by:

$$r = r^* + \theta d + \tau g(\tau) \tag{2.26}$$

where $g(\tau) = (p(\tau) - \kappa(\tau)p'(\tau))$. Note that the domestic interest rate is strictly increasing in τ. Differentiating (2.26) with respect to τ, we get:

$$\frac{\partial r}{\partial \tau} = p(\tau) - \kappa(\tau)p'(\tau) - \tau\kappa(\tau)\frac{\partial \kappa}{\partial \tau}p''(\tau) \tag{2.27}$$

Using the result from (2.25), this reduces simply to:

$$\frac{\partial r}{\partial \tau} = p(\tau) \tag{2.28}$$

The equilibrium level of capital inflows is, in turn, defined implicitly by the familiar condition:

$$\frac{1}{\tilde{d}} = 1 + r^* + \theta\tilde{d} + \tau g(\tau) \tag{2.29}$$

As before, it can be shown that equilibrium capital inflows are a decreasing function of the inflow tax, $\tilde{d}(\tau)$, with $\tilde{d}'(\tau) < 0$.

2.5.1 Evasion Equilibria

Once again, we can contrast the naive and sophisticated planner solutions. The naive planner does not anticipate the bank's strategic behavior and sets the inflow tax at $\tau_{np} = \varphi$. The sophisticated planner, on the other hand, is the first mover and chooses the optimal inflow tax subject to the bank's best response. The sophisticated planner's optimization problem is given by:

$$\max_{\tau} \; u(\tau) = \ln(\tilde{d}(\tau)) + \bar{y} - (1 + r^* + \varphi)\tilde{d}(\tau) - \frac{\theta}{2}\tilde{d}(\tau)^2 - \gamma\kappa(\tau)\tilde{d}(\tau) \tag{2.30}$$

The optimal inflow tax is therefore pinned down by the following first-order condition:

$$d_\tau \left[\frac{1}{d} - (1 + r^* + \theta + \varphi + \gamma\kappa) \right] - \gamma d \frac{\partial \kappa}{\partial \tau} = 0 \tag{2.31}$$

Using the loan market equilibrium condition (2.29), the first-order condition can be rewritten in a more intuitive form:

$$p^* \tau = \varphi - \zeta(\tau) \tag{2.32}$$

where $\zeta(\tau) \equiv \gamma\kappa[1 + \sigma_z/\sigma_d]$ and the terms σ_z and σ_d, respectively, denote the elasticities of z and d with respect to τ. Expressed in this form, the first-order condition equates the *effective* tax on capital inflows to the Dutch disease externality minus an additional term that represents the distortions introduced by the bank's evasion behavior. Condition (2.32) implies that the sophisticated planner will only be able to set an effective tax that perfectly internalizes the externality in the special case when there exists a $\tau > 0$ such that $\zeta(\tau) = 0$.

We can now state an important result from this model: with endogenous and costly evasion, *capital controls can no longer implement the economy's first-best equi-*

librium. To see this, let's start by setting up the social planner's unconstrained problem of directly choosing $\{d, z\}$.

$$\max_{d,z}\ u(d,z) = \ln(d) + \bar{y} - (1 + r^* + \varphi)d - \frac{\theta}{2}d^2 - \gamma z \tag{2.33}$$

The only difference between this problem and the no evasion benchmark case considered above is the last term $-\gamma z$ denoting the cost of evasion. Clearly, a social planner will choose $z = 0$ and an optimal d satisfying the first-order condition

$$\frac{1}{d} - (1 + r^* + \varphi + \theta d) = 0 \tag{2.34}$$

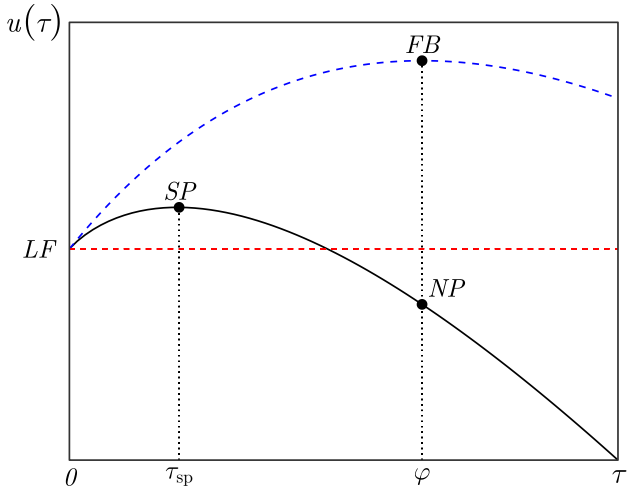
To show that this solution cannot be achieved through decentralization we will proceed by contradiction. Suppose there exists a $\tau^* > 0$ such that $\tilde{d}(\tau^*)$ satisfies (2.34). For τ^* to solve the unconstrained social planner's problem we must also have:

$$z = \kappa(\tau^*)\tilde{d}(\tau^*) = 0 \tag{2.35}$$

This condition is satisfied for either $\kappa(\tau^*) = 0$ or $\tilde{d}(\tau^*) = 0$. Clearly, $\tilde{d}(\tau^*) = 0$ cannot be optimal since it implies $c_1 = 0$ and negative infinity utility. Moreover, $\kappa(\tau^*) = 0$ holds when $\tau^* = 0$, but this contradicts our assumption of $\tau^* > 0$. Therefore, we can conclude that there does not exist a τ^* that implements the first-best equilibrium.

The intuition behind this result is simple: banks incur costs attempting to bypass the capital controls and as such decrease the economy's total supply of tradable goods. Put differently, active regulatory evasion is non-productive and as such an

Figure 2.6: Social welfare in the costly evasion model



Note: This figure compares social welfare as a function of the *de jure* capital inflow tax for both the unconstrained social planner (**in blue**) and the sophisticated planner (**in black**). The first-best equilibrium attained by the social planner is given by point FB, while the sophisticated planner's solution is at SP. The point NP shows the naive planner's solution. The laissez-faire benchmark (LF) with $\tau = 0$ is shown **in red.**

unconstrained social planner would set it equal to zero. Nevertheless, profit maximizing banks will always choose a positive amount of evasion expenditure whenever capital controls are present. A related implication is that the first-best outcome can de replicated by the sophisticated planner only in the trivial case with no externalities. Of course, this special case is not very interesting since there's no rationale to impose capital controls in the first place and the laissez-faire equilibrium is already equivalent to the social planner's.

Costly evasion also raises the possibility of a perverse case where capital controls set by the naive planner may actually decrease welfare relative to the laissez-faire outcome. In other words, a naive planner not taking the bank's strategic behavior into account could set capital controls that are inefficiently large. This is because, for large γ, the naive planner's solution may correspond to evasion losses that outweigh the gains from curbing capital inflows. This case is illustrated in Figure 2.6, which compares the sophisticated planner's welfare function against the unconstrained planner's function. The economy's first-best outcome is obtained at point FB, which is greater than the maximum welfare attainable by the sophisticated planner, at point SP. The naive planner incorrectly believes that his objective function is given by the unconstrained welfare function and therefore sets an inflow tax $\tau_{np} = \varphi$. This corresponds to point NP, which in this case lies below the laissez-faire welfare (shown in red).

2.5.2 The Cost of Evasion

Let's again consider what happens to social welfare when evasion becomes less costly for the financial sector. As in the model with perfect evasion from the previous section, the welfare effects of a change in the cost of evasion are not necessarily obvious. On the one hand, the capital controls are more binding when evasion is costlier and therefore the planner can set the effective inflow tax with greater ease. On the other hand, however, costlier evasion implies greater distortions arising from the evasion behavior of the financial sector.

Let $\tau(\gamma)$ denote the sophisticated planner's optimal inflow tax for a given value of γ and denote the value function for the maximized welfare function by $u(\tau(\gamma), \gamma)$. Differentiating with respect to γ, we get:

$$\frac{du}{d\gamma} = \frac{\partial u}{\partial \tau} \cdot \frac{\partial \tau}{\partial \gamma} + \frac{\partial u}{\partial \gamma} \tag{2.36}$$

Since $\tau(\gamma)$ is the inflow tax that maximizes welfare, we know by the Envelope Theorem that $\partial u/\partial \tau = 0$. We can therefore express the derivative of the value function as:

$$\frac{du}{d\gamma} = d_\gamma \left[\frac{1}{d} - (1 + r^* + \theta d + \varphi + \gamma\kappa)\right] - \gamma d \frac{\partial \kappa}{\partial \gamma} - z \tag{2.37}$$

where $d_\gamma < 0$ is the partial derivative of equilibrium capital inflows with respect to γ and $\partial\kappa/\partial\gamma < 0$ is the response of effective evasion, κ, to a marginal change in γ. Using the first-order condition (2.31), this can be rewritten as:

$$\frac{du}{d\gamma} = \gamma d \left(\frac{d_\gamma}{d_\tau}\frac{\partial \kappa}{\partial \tau} - \frac{\partial \kappa}{\partial \gamma}\right) - z \tag{2.38}$$

Let σ_p and σ_κ denote the elasticities, respectively, of p and of κ with respect to γ. With a bit more manipulation,[6] we can express the welfare impact of a change in the unit cost of evasion as:

$$\frac{du}{d\gamma} = (\sigma_p + \sigma_\kappa)z - z \tag{2.39}$$

This expression is ambiguous in sign and therefore implies that a decrease in the unit cost of evasion can either have positive or negative effect on welfare. Intuitively, the welfare effect can be decomposed into two terms. The first and positive term consists of the welfare gains from increasing the equilibrium enforcement probability

[6]Specifically, note that $d_\gamma/d_\tau = \kappa/p(\tau)$ and that $\frac{\partial\kappa}{\partial\tau} = p'(\tau)\frac{\partial\kappa}{\partial\gamma}$. Using these two results and rearraning, we get: $\frac{du}{d\gamma} = \gamma d\left(\frac{\kappa}{p(\cdot)}p'(\cdot)\frac{\partial\kappa}{\partial\gamma} - \frac{\partial\kappa}{\partial\gamma}\right)$. Noting that $\frac{\partial p}{\partial\gamma}\frac{\gamma}{p} = \left(p'(\cdot)\frac{\partial\kappa}{\partial\gamma}\right)\frac{\gamma}{p}$, and using the definitions $\sigma_p = \frac{\partial p}{\partial\gamma}\frac{\gamma}{p}$ and $\sigma_\kappa = -\frac{\partial\kappa}{\partial\gamma}\gamma/\kappa$, we get the result stated in (2.39).

of capital controls plus the reduction in the effective evasion expenditure due to the change in unit cost. The second and negative term reflects the welfare losses arising from a given level of evasion.

Clearly, an increase in the unit cost of evasion will only increase welfare if $\sigma_p + \sigma_\kappa > 1$ is satisfied. In this case, policies aimed at discouraging evasion – e.g. increasing administrative resources devoted to monitoring or closing regulatory loopholes – will result in a net welfare gain. However, in the perverse case where $\sigma_p + \sigma_\kappa < 1$ holds, regulatory changes that discourage evasion by increasing its cost could inadvertently lead to a net welfare loss. This is because while an increase in γ increases the equilibrium enforcement probability and reduces effective evasion, these gains are fully offset by the higher deadweight loss from the bank's evasion.

2.6 Concluding Remarks

The formal analysis presented in this paper supports the intuition that imperfectly binding capital controls can still effectively segment the international and domestic financial markets if evasion is costly. It also validates the idea that capital controls are relatively more or less binding depending on the number of regulatory loopholes and the sophistication of the financial sector. However, our welfare analysis suggests that when evasion is costly, capital controls can no longer perfectly internalize externalities arising from capital flows due to the inefficiencies associated with evasion. Moreover, if domestic authorities fail to properly anticipate financial sector efforts to avoid the capital controls, as was the case with the "naive planner" in the models above, they could inadvertently set an effective tax on capital flows that is either too high or too low from a societal perspective.

All of these caveats on the optimal use of capital controls, of course, depend critically on assumptions about what the relevant social welfare function should be. For example, if banks in our model were *foreign owned* and the domestic planner placed no weight on the welfare of foreigners, it is easy to see from the above analysis that capital controls could always implement the first-best outcome. This is because if banks were assumed to be foreign owned, the costs incurred by attempting to avoid the capital controls would no longer impact national income and the capital inflow tax could be set without having to consider the evasion costs.

We can conjecture that the key insights from the models presented above do not depend crucially on the stylized formulation of the Dutch disease externality. One could easily generalize the model to include a nontradable goods sector and a labor market, with learning-by-doing externalities in the tradable sector as in Michaud and Rothert [89]. While this would provide a more detailed rationale for imposing capital controls in order to promote a competitive real exchange rate undervaluation, it likely would not yield any major additional insights regarding the impact of regulatory evasion.

CHAPTER 3

DID QUANTITATIVE EASING INCREASE INCOME INEQUALITY?

3.1 Introduction

A controversy over the distributional impact of Federal Reserve monetary policy has erupted. Some politicians, pundits and even former central bankers have argued that, since the Great Financial Crisis struck in 2008, the Federal Reserve's near-zero interest rate policy and rounds of "unconventional" monetary policy have contributed to an increase in income and wealth inequality in the United States by promoting large increases in asset prices, and driving down returns to middle class savers with "money in the bank" (Brookings [19]). On the other side, former Federal Reserve Chair Ben Bernanke, current Chair Janet Yellen, and others have argued that Fed policy has been broadly supportive of those at the bottom and in the middle of the income distribution, largely because policy placed a floor under the economic collapse, and, since then, has promoted economic recovery, employment creation, and economic growth (Bernanke [12], Appelbaum [2]). This discussion is not just of historical interest: it interjects considerations of inequality into the very lively debate over whether the Federal Reserve should raise interest rates and if so, by how much.

Public debates over the distributional effects of monetary policy are certainly not unheard of but they tend to have a counter-cyclical profile. Politicians and mainstream economists tend to ignore the issue during periods of prosperity, preferring to focus on "aggregate" issues such as inflation and growth[1] In contrast, in times of financial crisis and resulting active intervention by the Federal Reserve, these distributional issues finally appear on the radar of politicians and make their way into economic discourse. A key example is the "Volcker" disinflation policy and deep recession of the late 1970's and early 1980's. At that time, the Federal Reserve was accused by some as raising interest rates excessively aggressively and keeping them too high for too long, leading to excessive levels of unemployment and job destruction, all in the interest of protecting the real wealth of bankers and other creditors from the scourge of inflation (Epstein [38], Greider [55]).

Indeed, the question of the distributional impact of monetary policy has a longer history, going back, for example, to the writings of Keynes who criticized high interest rates pursued by the Bank of England in the 1920's and 30's, and the related decision by Britain to return to the gold standard at pre-war parity after the First World War. Reminiscent of the discussion during the Volcker period, Keynes accused the Bank of England and the treasury of trying to protect creditors' wealth, while ignoring the impacts of tight money and an over-valued currency on the incomes and jobs of workers (Keynes [68, 69]. And, going further back, of course one should remember the fights over the gold standard and the populist movement in the late 19th early

[1]See Gornemann et al. [54] for a review of these models.

20th century US, where over-valued exchange rates and over-valued currencies were battled over on distributional, and highly rhetorical, terms (Goodwyn [53], Frieden [48]).

What is striking in the current debate is this: in all the historical cases mentioned earlier, it is high interest rates and restrictive monetary policy that are indicted as transferring income from the poor to the rich, whereas in the current period, the accusation is that it is low interest rates and expansionary monetary policy that is making inequality worse. Can both of these claims be true? Are there special factors that characterize the US economy now that generate results the opposite of those historically claimed?

While theory has an important role to play in understanding the relationship between monetary policy and income distribution in different periods and structural contexts, ultimately, adjudicating these claims becomes an empirical question.

There are two broad approaches to looking at the distributional impacts of monetary policy, or any policy for that matter. One looks at the functional distribution of income, and the second looks at the impact of policy on the personal distribution of income. In fact, the concerns expressed by Keynes and the populists, as mentioned above, largely relate to the functional distribution. Keynes and the populists were concerned about the impact of high interest rates on the incomes of the "financiers" or "rentiers" versus the workers and or the farmers. Concerns with the impact of monetary policy on financiers or bank profits, versus farmers and/or workers thus has a long history, though empirical work on this topic is thin (but see, for example, Epstein and Ferguson [39] and the research summarized in Frieden [48]).[2]

Most of the discussion on this issue, however, has focused on the impact of monetary policy on the distribution of personal or household income, and generally has not covered the period since the beginning of the Great Recession and QE. This small and relatively recent literature has found a strong relationship between contractionary monetary policy and increases in inequality. A careful and widely cited paper by Coibion [27] analyzes empirically this question for the United States, but their data ends in 2008, just before the beginning of QE. Drawing on quarterly distributional data from the Consumer Expenditures Survey (CEX), they analyze the distributional impacts of monetary policy shocks (based on the method of Romer and Romer [106] for identifying monetary policy shocks), as well as the impacts of longer term changes in the objectives of the Federal Reserve. They find that restrictive "monetary policy shocks have statistically significant effects on inequality: a con-

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[2] We have undertaken several papers looking at the distributional impacts of QE with respect to a functional or sectoral perspective. In Montecino and Epstein [90] we assess the direct impact of the first round of asset purchases (popularly referred to as "QE1") on the profits of banks that sold MBS to the Federal Reserve, as well as the indirect impact on those that held large quantities of such assets prior to QE. We found that QE1 led to statistically and economically significant increases in bank profitability after controlling for common determinants of bank profits. In Montecino and Epstein [91] we carried out a broader event study of all three rounds of QE (1, 2, and 3) and examined the impact of QE policy announcements on the equity returns of all S&P 500 firms. Our results uncovered substantial heterogeneity in the impact of QE announcements on equity returns across sectors and across QE rounds. Consistent with our previous study, financial institutions were expected to be the big beneficiaries of QE1, with consistently positive and substantial abnormal returns, but were also joined by non-financial firms in the construction and automobile sectors. By the time of QE3, however, the expected impact of the Federal Reserve's asset purchases had waned across most sectors of the economy with the exception of financial firms, which continued to exhibit positive abnormal returns.

tractionary monetary policy shock raises the observed inequality across households in income, labor earnings, expenditures and consumption (emphasis added)... In addition, (contractionary) monetary policy shocks appear to have played a non-trivial role in accounting for cyclical fluctuations in inequality over this time period..." They also "show that permanent decreases in the inflation target also systematically increase income and consumption inequality... Monetary policy therefore may well have played a more significant role in driving recent historical inequality patterns in the US than one might have expected."

Gornemann et al. [54] reach a similar conclusion using a different approach. They build a New Keynesian model which allows for heterogeneous agents, incomplete asset markets and significant labor market frictions. Their approach contrasts with standard models that make assumptions that rule out distributional impacts of monetary policy – assumptions such as homogenous agents, perfect unemployment insurance, and perfect financial markets. Calibrating their model on publicly available US data, they find that contractionary "monetary policy shocks have strikingly different implications for the welfare of different segments of the population." In particular, "while households in the top 5 percent of the wealth distribution benefit slightly from a contractionary monetary policy shock, the bottom 5 percent would lose from this measure. For example, a monetary tightening of 1 percentage point (annualized) induces a loss equivalent to a permanent .1 percent consumption for the lowest 5 percent of the wealth distribution. This heterogeneity in sign and size of welfare losses from monetary policy shocks stands in stark contrast to TFP (total factor productivity) shocks which affect the population more uniformly." (P. 4).

Empirical literature on the distributional impacts of the loose monetary policy undertaken since the Great Financial Crisis is quite thin. Notable contributions include Bell et al. [9], Bivens [14], McKinsey Global [88], Doepka et al. [31], Beraja et al. [11], and Montecino and Epstein [90, 91]. The results are mixed. Part of the challenge in this literature is to distinguish between the impacts of the near-zero interest rate policy pursued by the Fed and QE policies themselves. Distinguishing these policies present both theoretical and empirical challenges. Theoretically, the question is whether the policies have different mechanisms and channels of influence; and empirically, it is difficult to ascertain whether the impacts discerned after the implementation of QE are lagged impacts of zero interest rate policies, or some interaction of the two. Various papers deal with these issues differently.

The literature on the impacts of monetary policy in general and QE in particular has tried to distinguish among the specific channels through which policy could affect income distribution. Ben Bernanke presents a useful list of proposed distributional channels of QE and low interest rates (Bernanke [12]):

1. The "asset price appreciation" channel: Bernanke notes that "The claim that Fed policy has worsened inequality usually begins with the (correct) observation that monetary easing works in part by raising asset prices, like stock prices. As the rich own more assets than the poor and the middle class, the reasoning goes, the Fed's policies are increasing the already large disparities of wealth in the United States."

An additional dis-equalizing aspect of this financial asset channel is the lower interest rate on short term assets, which might disproportionately affect less rich households (Bell et al. [9] and McKinsey Global [88]) emphasize this channel).

Bernanke notes two important caveats about the importance of the asset price appreciation channel in the current context. He argues that middle class households, not just the wealthy, hold financial assets. And Bernanke raises questions about the extent to which asset price increases, and especially stock price increases are due to QE or are, rather, simply a "return to trend." He also notes that wealthy households also hold short term assets whose returns decline due to zero interest rate policies.

Bernanke then goes on to describe what he calls the inequality countervailing channels.

2. The "employment" channel: "...easier monetary policies promote job creation..."

3. The "debtor redistribution and refinancing" channel: "All else equal, debtors tend to benefit (and creditors lose) from higher inflation which reduces the real value of debts. Debtors are generally poorer than creditors, so on this count easier monetary policy...reduces inequality...Debtors are also made better off by low interest rates, all else equal. For example, homeowners with mortgages benefit when they can refinance at a lower rate."

As this list of channels suggest, there are important forces that move in countervailing directions. In our analysis below, we try to measure the size of the impacts of these channels. The real issue of concern, however, is not simply the evolution of these channels over time, but the role of monetary policy and QE: how much of the change in income distribution via these channels is due to QE, and how much is due to other factors?

In fact, there has been an enormous amount of empirical investigation of the effects of QE on many of these channels considered separately. The greatest effort has been expended on analyzing the impact of QE on various asset prices (see, for example, Krishnamurthy and Vissing [76] and Hancock and Passmore [57]; also see Engen et al. [37] and Bivens [14] reviews of this voluminous literature). The consensus in this literature is that QE has lowered mortgage interest rates, lowered short and long term treasury rates, and thereby caused appreciations in long term treasury bonds, and mortgage backed securities (MBS). There is also some evidence that QE has increased the price of corporate bonds. Evidence on the impacts on corporate equities is more mixed, but recent papers suggest that equity prices have increased as a result of QE (Kiley [70]; see our discussion below). As for the employment channel, most evidence indicates that zero-interest rate policy and QE have contributed to employment growth, but real wages have been stagnant, or even declining over this period (Engen et al. [37], Bivens [15]). The over-all impact on income distribution will thus depend on the net effect and the distribution of these two components across income groups.

There has not been much research on the debt redistribution channel during this period. Part of the problem is that inflation has not increased as a result of QE. Hence, this inflation channel has not been operative (see Doepke et al. [31] for a discussion of this channel). The mortgage refinancing channel is more interesting and potentially important; indeed, creating more opportunities for refinancing and lowering refinancing costs, presumably were some of the goals of the low interest rate and QE policies. However, as Beraja et al. [11] and others referenced there show, the steep declines in house prices, which meant that many borrowers were "under water", along with other complex factors, severely limited the ability of many homeowners, and particularly those in the lower quantiles of the income distribution, from taking advantage of the lower interest rates. Thus, the distributional impacts of the refinancing channel are very much up for grabs empirically. Consistent with this effect, Beraja et al. show that there was a large disparity in the regional impacts of QE policy as a function of how far housing prices had fallen in different regions of the country.

The only previous paper that has attempted to put together many of these channels and look at the overall impact of QE on income distribution is Bivens [14]. Bivens does not distinguish in his analysis between the near-zero interest rate policy and the QE policy, arguing that it is impossible to disentangle the effects of these two related efforts. Bivens' approach is to use the secondary literature rather than new empirical work. He has a two stage approach: first Bivens assess the overall impacts on inequality of QE relative to a fiscal policy that has a similar impact on employment. And then, he assesses the impact of low interest rates and QE relative to a neutral monetary policy. In the first case, Bivens argues that QE does not increase inequality relative to a fiscal policy that has a similar labor market outcome.

In the second case – monetary policy vs nothing – Bivens argues that the disequalizing effects of financial asset price increases are more than compensated for by increases in incomes of the non-rich due to increases in employment. Moreover, he argues that non-rich households' major asset is their home, and shows that home price appreciation was considerable over the QE period. The bottom line in the second case, according to Bivens is the following: "As bad and unequal as wage growth was since the onset of the Great Recession, it would have been even slower and less equal had the Fed not pursued its easy money policies. In short, compared to a counterfactual of no change in fiscal policy in response to a recession, monetary stimulus reduces inequality significantly."

Our paper also attempts to draw an overall picture of the net impacts of these several channels on the personal distribution of income.[3] We use data from the Federal Reserve's Survey of Consumer Finances (SCF) to empirically assess the quantitative contribution of each of these theoretical channels to changes in inequality. We focus specifically on the distribution of what we term "net income," which consists of total household income minus debt payments. This makes it possible to integrate the distributional consequences of low interest rates on households' interest burdens. To assess the net impact of channels associated with QE, we implement the distributional decompositions method proposed by Firpo et al. [43]. This approach enables detailed accounting of the observed change in a distributional statistic between two periods and how much of this change is due to channels associated with QE. Specifically, it makes it possible to decompose the change in, for example, the ratio of the

[3]When we can, we distinguish between the low interest policy and the QE policy and mostly focus on QE. At a few points, however, we will discuss the impacts of the broader loose monetary policy since the financial meltdown.

95th to the 10th percentiles of the net income distribution into the contributions of changes in employment, returns on financial assets, and other covariates. Thus, this decomposition method provides well defined estimates of the quantitative contribution of various factors affecting the distribution of household income since the implementation of QE.

Our overall results are the following: we find that while employment changes and mortgage refinancing were highly equalizing during the QE period, these impacts were nonetheless swamped by the large dis-equalizing effects of equity price appreciations. Reductions in returns to short term assets added further to dis-equalizing processes between the periods. Bond price appreciations, surprisingly, had little distributional impact. It is worth emphasizing that this decomposition approach does not yield causal estimates of the impact of QE on the distribution of income. This approach does, however, yield well defined estimates of the relative importance of the various channels through which QE affects inequality and thus makes it possible to precisely frame the upper and lower bound causal impacts of QE under plausible assumptions about the counterfactual paths of employment and stock prices. To get some idea of the causal influences we use the results from our decomposition to carry out a series of "counterfactual exercises" to assess the quantitative range of impacts of QE on the main channels. Drawing on consensus QE impact estimates from the empirical literature, we conclude that, most likely, QE was modestly dis-equalizing, despite having positive impacts on employment and mortgage refinancing.

The rest of our paper is organized as follows. In the next section we describe in more detail the channels of monetary policy we will study and describe the "net income" measure we will use to map these channels onto income changes. In section 3 we discuss important data issues that we must deal with in using our data set. Section 4 presents our empirical methodology for analyzing the evolution of income distribution during the QE period. Section 5 presents our distributional results. Section 6 attempts to frame a causal analysis of the impacts of QE on inequality by using a counter-factual analysis based on consensus impacts from the literature. Section 7 summarizes and concludes with some remarks about the implications for the debate over QE's impacts on income distribution.

3.2 Net income and the theoretical effects of QE

The onset of the 2007-8 financial crisis led the Federal Reserve to lower short-term interest rates to nearly zero in an effort to prop up the financial sector and prevent the U.S. economy from sliding into a depression. With nominal rates up against the zero lower bound and thus having exhausted the traditional tools of monetary policy, the Fed resorted to "unconventional" measures. In particular, the Federal Reserve announced a program to purchase vast amounts of securities in what is known as the Large Scale Asset Purchase program (LSAP), or alternatively as "Quantitative Easing" (QE). The first round of asset purchases (QE1) was formally announced on November 25, 2008 and initially covered Agency mortgage-backed securities (MBS), long-term Treasuries, and government-sponsored enterprises (GSE) debt. A second round of purchases (QE2) was subsequently announced on November 3, 2010, followed by a third and final round (QE3) beginning in August 2012. The Federal Reserve officially announced the end of QE3 on October 29, 2014.

As already noted, QE is expected to affect the distribution of income through a variety of countervailing channels.[4] The two most commonly cited channels – and perhaps most controversial – are through the effect of asset purchases and low interest rates on employment and the prices of financial assets. The third channel we focus on is on the impact of low interest rates on household debt service.

The employment channel is presumed to decrease inequality, though note that this should not necessarily hold *a priori*. The overall impact of changes in employment on inequality depends both on which parts of the distribution experience the greater increase in employment, as well as the relative returns to employment across the distribution. For instance, it could be the case that firms respond to expansionary monetary policy by increasing total employment but by mostly hiring among high-skilled and high-paying jobs. Similarly, even if the bottom range of the distribution has greater employment gains, if wages in the upper tail are sufficiently larger, the relatively smaller employment gains at the top could still translate into increases in overall inequality.

Financial asset prices are expected to affect income inequality through capital gains and interest and dividend income. The sign of this channel is potentially ambiguous for two reasons. On the one hand, richer households are likely to reap the majority of capital gains from increases in asset prices since ownership of equities and bonds is highly concentrated at the top. On the other hand, QE likely reduced

[4]See Coibion [27] for a detailed discussion for the channels through which traditional monetary policy might affect inequality. For a discussion specifically applied to QE see Bivens [14].

interest rates on short-term and long-term assets, potentially offsetting the capital gains.

In theory, expansionary monetary policy should also benefit debtors at the expense of creditors. Since low income households are more likely to be indebted, expansionary monetary policy should decrease inequality. In practice, this is expected to result from the effects of higher inflation, which reduces the real value of debt, and through the direct impact of lower interest rates on household debt payments. Although interest rates have remained at historically low levels due to the Federal Reserve's crisis response, it is not obvious if most household have been able to take advantage of them. Indeed, a number of commentators have argued that the fall in housing prices and the tightening in lending standards have prevented indebted household from refinancing at a lower interest rate. For instance, a Federal Reserve White Paper on housing noted:

> Many homeowners have been unable to take advantage of historically low mortgage rates because of low or negative home equity, slightly blemished credit, or tighter credit standards. Perhaps only about half of homeowners who could profitably refinance have the equity and creditworthiness needed to qualify for traditional refinancing. (Board of Governors of the Federal Reserve System, 2012 [16])

This relationship between falling home prices and the ability to refinance was investigated by Feroli et al. [42], who showed that states with small declines in home prices experienced booms in refinancing during the post-crisis period while states with large home price declines experienced a collapse in refinancing rates. As Feroli et al. write, "the evidence suggests that a large fraction of homeowners in large house price decline states are unable to take advantage of lower mortgage interest rates."

Standard definitions of income are inadequate to investigate the interest burden channel since they do not include debt payments. Indeed, there is no reason to expect a fall in interest rates to have a direct effect on household income other than through a *negative* effect via interest-paying assets and macroeconomic spillovers. To directly incorporate the distributional consequences of household debt burdens, we alternatively define *net household income*, which consists of total household income – wages, dividends, capital gains, government transfers, and business income – minus total interest payments on debt. The low interest rates associated with expansionary monetary policy should therefore be associated with lower debt service and hence higher net income. Formally, we define net income as:

$$\begin{aligned} \text{\textit{Net Income}} &= Wages + Interest + Business + \text{\textit{Gov}} \\ &\quad + \text{\textit{Capital gains}} - \text{\textit{Debt payments}} \end{aligned} \tag{3.1}$$

In equation (3.1), $Wages$ denotes total wage income, $Interest$ denotes all interest and dividends income, $Business$ stands for any income from owning a controlling share or running a business, *Gov* denotes government transfers, *Capital gains* stands for realized capital gains on financial assets, and *Debt payments* are total annual expenditure on debt service. Defining net income this way has several advantages. First, it is not possible to directly examine the reduced debt burden channel of expansionary monetary policy using traditional definitions of income. Second, including capital gains as a component of net income makes it possible to assess the financial assets price channel.

Summary statistics for household total and net income are presented in Table 3.1. Although broadly similar, it is worth highlighting a few differences between the two definitions of income. As one would expect, net income tends to be lower than total income. Mean total income was approximately \$84,000 in the 2010 SCF sample compared to around \$72,000 for net income. Net income appears to have somewhat different dynamics between periods than total income. For instance, while median total income fell between the 2010 and 2013 SCF samples, median net income actually increased slightly. Finally, net income appears to be more concentrated at the top than total income, indicating that poorer households are either more heavily indebted than richer households, face higher interest rates on debt, or both. Moreover, this discrepancy between the two definitions is even more pronounced at the very top of the distribution. Although ratio of the 90th to 50th percentiles are roughly the same between the two definitions, the 90/10 and 99/10 ratio are much larger for net income.

To examine contribution of each factor to overall changes in household net income we begin by defining functional forms for each relevant component. Fortunately for our purposes, each of the three channels through which QE might affect the distribution of net income maps cleanly onto a component of net income: unemployment drives wage income, financial assets drive capital gains, and debt refinancing affects interest payments. The wage income of household i during period t is assumed to depend on:

Table 3.1: Summary statistics for household total income and net income by period.

	Total Income		Net Income	
	Pre QE (2008-11)	Post QE (2011-13)	Pre QE (2008-11)	Post QE (2011-13)
Mean	83,949	86,596	71,595	76,116
Percentiles				
10	14,162	14,203	11,393	11,160
20	21,788	20,291	17,619	17,247
50	49,022	46,668	39,218	39,422
80	101,313	101,453	83,363	86,639
90	152,514	154,209	129,989	133,711
99	659,079	692,925	608,486	664,943
Percentile ratios				
99/10	46.54	48.79	53.41	59.58
90/10	10.77	10.86	11.41	11.98
90/50	3.11	3.30	3.31	3.39
50/10	3.46	3.29	3.44	3.53

Note: All the distributional statistics presented above were calculated using the sampling weights provided by the SCF. Total income refers to the sum of wage earnings, interest and dividends, government transfers, business income, and realized capital gains. Net income refers to total income minus debt service.

$$Wages_{it} = \alpha_t EMP_{it} + \boldsymbol{\tau X}_{it} + \epsilon_{it} \tag{3.2}$$

where EMP is a dummy variable that is equal to one if the head of the household is employed and equal to zero otherwise. The wage function also includes a vector of controls for demographic and human capital factors, including race, age, and education. Total financial income, which combines interest and dividend income and realized capital gains, is assumed to depend linearly on the ownership of various financial assets:

$$Capital\ gains_{it} = A_{it}\beta_t + \varepsilon_{it} \tag{3.3}$$

where A_{it} is a vector of dummy variables for whether or not household i owns a non-zero amount of each type of financial asset. We specify our model using ownership dummies due to the highly skewed distribution of the levels of the financial assets we consider, as well as the large proportion of households with financial balances of zero. Financial assets ownership is broken up into three broad categories: (1) equities, either directly held stocks or in mutual funds; (2) directly held bonds; and (3) short-term/liquid assets. Each element of the vector β_{it} can be interpreted as the rate of return on each financial asset in A_{it}.

Debt service is assumed to be a linear function of mortgage refinancing as well as overall credit worthiness, which we capture by including variables for whether or not a survey respondent has feared or actually been denied credit during the period or has recently filed for bankruptcy. Household interest payments thus depend on:

$$Debt\ payments_{it} = \gamma_t RF_{it} + \eta_t D_{it} + \mu_t B_{it} + \nu_{it} \tag{3.4}$$

where RF_{it} is dummy for having refinanced the primary mortgage within the last three years, D_{it} is a dummy for fearing or having been denied credit during the period, and B_{it} is a dummy for having recently filed for bankruptcy. Adding the components together, we arrive at a functional form for net household income:

$$\textit{Net Income}_{it} = b_{1t}EMP_{it} + \boldsymbol{\tau X}_{it} + b_{2t}A_{it} + b_{3t}RF_{it} + b_{4t}D_{it} + b_{5t}B_{it} + e_{it} \tag{3.5}$$

where e_{it} is a composite error term of ε_{it}, ϵ_{it}, and ν_{it}. In order to identify the contribution of each factor in the decomposition exercises reported below, we will assume:

$$\mathbb{E}\{e_{it}|EMP_{it}, X_{it}, A_{it}, RF_{it}, D_{it}, B_{it}, t\} = \lambda \quad \text{for} \;\; t = 0, 1 \tag{3.6}$$

for some constant λ. This is often referred to as the ignorability assumption and is weaker than the more common assumption that unobservables are conditionally independent. Ignorability does not assume that unobservables are mean independent of covariates but instead that this dependence is the same across both groups t. For example, for our purposes we are interested in changes in net income between the pre-QE ($t = 0$) and post-QE ($t = 1$) periods. In this context ignorability means that any correlation between unobservable factors contributing to net income and, say, stock ownership, is constant across both periods.

3.3 Data Issues

The Survey of Consumer Finances (SCF) is almost ideal for assessing the impact of financial and labor market factors on the distribution of income. The SCF offers an unparalleled level of detail on a household's balance sheet. It also contains a full set of standard demographic and labor market variables. The SCF also records information on mortgage refinancing, allowing us to answer questions about the role of refinancing on household interest payments.

Nevertheless, the SCF is "almost" ideal due to several shortcomings that complicate its usage. First, due to its relatively small sample size, many variables that would be useful are withheld from the public data releases in order to prevent users from identifying the survey respondents. Specifically, geographical data and interview dates are omitted. The former makes it impossible to control for geographic-specific unobserved effects. Second, the SCF is only released every 3 years and the cross-sectional sample for each release spans the entire 3 year window. Combined with the absence of publicly available interview dates, this makes it very difficult to split the survey data across precise event dates. Specifically, the 2007 release includes interviews collected from 2005 to 2007, the 2010 release includes 2008 to 2010, and the 2013 release includes 2011 to 2013. Therefore, it is not possible to cleanly split the data between the pre and post QE period, which began at the end of 2010.

We settle on treating the observations in the 2010 survey as the pre QE period ($t = 0$) and the 2013 survey as the post period ($t = 1$). Admittedly, our "pre QE" period is not ideal since it is contaminated by the first round of QE, which took place between the end of 2009 and 2010. Nevertheless, this choice of periods is unavoidable given the data constraints and reasonably captures the timing of the fallout from the crisis and the path of the subsequent recovery. In other words, the 2010 SCF release, which includes 2009 and 2008, is the only release that includes real crisis years.[5] This problem, however, is not as severe as it may first seem. This is because the macroeconomic effects of QE likely occurred with substantial lags. For instance, Engen et al. [37] found that the peak impact of QE on employment did not take place until as late as 2015. Moreover, the second and third rounds of QE took place after 2010, as did most of the post-crisis growth in stock prices.

A third issue that causes more technical problems for estimation and inference is that the SCF is released as a set of multiple imputed datasets. This means that each data release contains 5 versions of each observation for each different method used to impute the missing variables. Informally, this is difficult to deal with because it means that the SCF is actually five different datasets instead of one. More precisely, the presence of five imputations causes the coefficients to be biased and the standard errors to be too small. Although there is no perfect solution to the first two problems, there exists a more or less standard solution to estimating and carrying out inference with multiple imputations. This is the repeated imputations inference (RII) method pioneered by Rubin [109], which first estimates the empirical model separately for each imputation and then combines the estimated coefficients and standard errors

[5] Specifically, unemployment only increases during the 2010 SCF release and falls during the 2013 release. The unemployment rate for the head of the household in the 2007 release is 4.1 percent. This increased to 7.1 percent in the 2010 release and fell to 5.9 percent in the 2013 release.

to carryout inference.[6] All coefficients and standard errors reported below have been adjusted using the RII method.

A final complication arises due to our definition of net income. It is common in applied work to transform earnings variables by taking logs as this renders its distribution approximately normal. This is not possible however in this case since net income can also take on large negative values if debt service sufficiently exceeds income. Since negative observations would be undefined in logs, the transformation would result in a significant loss of information. Note that this is also a problem for stock variables with a significant number of zero observations. An alternative transformation useful in this context is the inverse hyperbolic sine (IHS) function, which was first proposed by Johnson [67].[7] The IHS transformation is similar to transforming variables using logs but has the added advantage of being continually defined

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[6] Formally, let $\hat{\beta}_i$ and $\hat{se}_i$ denote the estimated coefficients and standard errors for implicates $i = 1, 2, \ldots, M$. Rubin's RII method is to estimate all $\hat{\beta}_i$'s separately and then combine them by simply averaging over every implicate:

$$\bar{\beta} = \frac{1}{M}\sum_{i=1}^{M}\hat{\beta}_i$$

Correct standard errors can then be derived by combining the standard errors obtained from each implicate separately as follows:

$$\tilde{se} = \bar{se} + \left(1 + \frac{1}{M}\right) Var(\hat{\beta}_i)$$

where

$$\bar{se} = \frac{1}{M}\sum_{i=1}^{M}\hat{se}_i \quad \text{and} \quad Var(\hat{\beta}_i) = \left(\frac{1}{M-1}\right)\sum_{i=1}^{M}(\hat{\beta}_i - \bar{\beta})^2$$

The correct combined standard error is the sum of the average of the M estimated standard errors and the variance of the coefficients across implicates.

[7] For a variable y_i, the IHS transformation is calculated as $IHS(y) = \ln\left(y + \sqrt{y^2+1}\right)$.

everywhere along the real numbers line. Moreover, coefficients of IHS transformed variables can also be interpreted roughly as elasticities. The IHS transformation has also been shown to outperform other common transformations in empirical applications related to household income and wealth. (Burbidge et al. [20], Pence [97]). Given these advantages, in what follows net income and all stock variables have been transformed using the IHS transformation.

3.4 The distributional decomposition

In order to decompose changes in the distribution of net income between the pre and post QE periods we implement an approach proposed by Firpo et al. [43], which combines recentered influence functions (RIF) regressions with the popular Oaxaca-Blinder decomposition method. This approach is easy to implement and makes it possible to decompose changes in distributional statistics into the contribution of changes in covariates or endowments and the contribution of changes in the coefficients or returns to factors. These components can also be further decomposed into the contribution of each individual covariate, enabling comparisons of the relative contributions of different factors to the overall observed change in the distributional statistic of interest.

First proposed by Firpo et al. [44], a RIF regression is essentially the same as a standard regression except that it replaces the dependent variable Y with the recentered influence function for a chosen distributional statistic. Adopting the notation from Firpo et al. [43], let ν denote a given distributional statistic (e.g. the gini coefficient or 90th quantile). The RIF for statistic ν is defined as

$RIF(y;\nu) = \nu(F_y) + IF(y;\nu)$, where y is an individual observation of Y, F_y is the cumulative density function of Y, and $IF(y;\nu)$ denote the influence function corresponding to statistic ν at y. The advantage of using the recentered influence function is that its expectation yields the original statistic of interest, so that $\mathbb{E}\{RIF(y;\nu)\} = \nu$. The RIF regression assumes that the conditional expectation of $RIF(y;\nu)$ is a linear function of the explanatory variables X:

$$\mathbb{E}\{RIF(Y;\nu)|X\} = X\gamma + \epsilon$$

where the coefficients γ can be estimated using OLS.

Therefore, all that is necessary to estimate the partial effects of the dependent variables X on a statistic ν to first calculate the $\widehat{RIF}$ for ν and then run a standard regression of $\widehat{RIF}$ on X. For example, for the τth quantile, Q_τ, one first calculates the RIF as

$$\widehat{RIF}(y;\hat{Q}_\tau) = \hat{Q}_\tau + \frac{\tau - \mathbb{1}\{y \leq \hat{Q}_\tau\}}{\hat{f}_y(\hat{Q}_\tau)} \tag{3.7}$$

where $\hat{Q}_\tau$ and $\hat{f}_y(\cdot)$ are, respectively, estimates of quantile τ and the probability density function of Y, and $\mathbb{1}\{\cdot\}$ is an indicator function. In practice, the density $\hat{f}_y$ is estimated using Kernel methods.

As shown by Firpo et al. [43], the linearity assumption for $\mathbb{E}\{RIF(Y;\nu)|X\}$ makes it possible to apply the classic Oaxaca-Blinder decomposition method to RIF regressions and decompose general distributional statistics other than just the mean.[8]

[8] In order to identify the each component of the decomposition it is also necessary to assume common support for both comparison groups, as well as either conditional independence on observables or ignorability.

Let $t = 0, 1$ denote the pre and post QE time periods. The change in, say, the 90th net income quantile between the two periods can be written as

$$\Delta_{90} = \hat{Q}_{1,90} - \hat{Q}_{0,90} = \bar{X}_1 \hat{\gamma}_1 - \bar{X}_0 \hat{\gamma}_0$$

The decomposition is given by:

$$\begin{aligned} \Delta_{90} &= \Delta_X + \Delta_\gamma + \Delta_{X\gamma} \\ \Delta_{90} &= \underbrace{\left(\bar{X}_1 - \bar{X}_0\right) \hat{\gamma}_0}_{\text{endowments}} + \underbrace{\left(\hat{\gamma}_1 - \hat{\gamma}_0\right) \bar{X}_0}_{\text{coefficients}} + \underbrace{\left(\bar{X}_1 - \bar{X}_0\right) \left(\hat{\gamma}_1 - \hat{\gamma}_0\right)}_{\text{interaction}} \end{aligned} \tag{3.8}$$

The components Δ_X and Δ_γ capture, respectively, the contribution of changes in endowments and the the contribution of changes in returns. The term $\Delta_{X\gamma}$ is referred to as the "interaction" component. Each component can be further decomposed into the contribution of each variable in X. For example, the contribution of changes in the coefficients of the k-th independent variable can be calculated simply as $\Delta_{\gamma,k} = \left(\hat{\gamma}_{1,k} - \hat{\gamma}_{0,k}\right) \bar{X}_{0,k}$.

The endowments and coefficients components of the decomposition have intuitive interpretations. The endowment component can be interpreted as the contribution of a change in the endowment of a factor X_k between the two periods holding its return constant. For instance, in the case of the stock of financial assets held by a household, the endowments component can be interpreted as the extra interest or capital gains income the household would receive from increasing its financial assets by $X_1 - X_0$ obtaining last period's rate of return γ_0. The coefficients component, on the other hand, can be interpreted as the contribution to household net income of a change in the return to a given factor holding the endowment constant at last period's level. In the case of financial assets, it is the extra income received from a change $\gamma_1 - \gamma_0$ in the rate of return on financial assets holding the stock fixed. The interaction component, which is perhaps harder to interpret, captures the contribution of simultaneous changes in endowments and coefficients. Keeping with the example of financial assets, the interaction component measures the contribution of both changes in returns and the amount owned.

Putting the pieces together, the steps necessary to carry out the decomposition can be summarized as follows:

- Calculate the recentered influence function for net income for each period $t = 0, 1$.
- Run separate RIF regressions for each period, for a set of quantiles $Q_{t,\tau}$, and obtain the coefficients $\hat{\gamma}_{0,\tau}, \hat{\gamma}_{1,\tau}$.
- Calculate the means of the explanatory variables in each period, $\bar{X}_0, \bar{X}_1$.
- Algebraically combine the estimated coefficients and means to obtain each component of the decomposition.

3.5 Decomposition results

We start by calculating the recentered influence functions of net income for quantiles Q_t^τ, $\tau = \{5, 10, \ldots, 95\}$.[9] In addition, we calculate the RIFs for the gini coeffi-

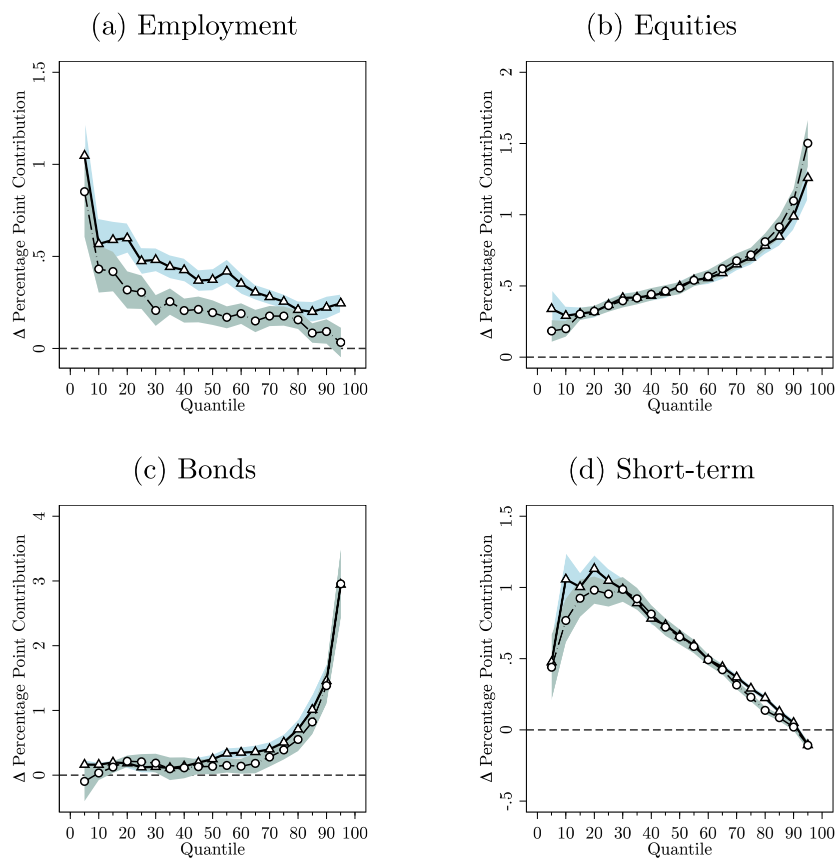
[9] For all RIF calculations, we use the default Epanechnikov kernel when obtaining the probability density of net income.

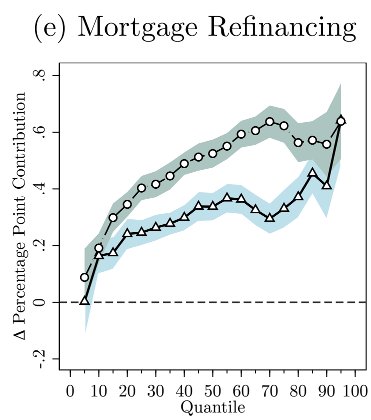
cient. Next, we estimate (3.5) replacing the dependent variable N_{it} with its RIF for each quantile τ and for both periods $t = 0, 1$. The coefficients from the RIF regressions are shown by quantile in Figure 3.1. The pre QE period (2008-10) coefficients are depicted with triangles, while the circles depict the coefficients during the post QE period (2011-13).

Intuitively, the RIF regression graphs show the unconditional partial effect of a variable of interest on each quantile of the distribution. For example, let's consider the employment graph (panel a). The level of the curve at the very middle of the distribution (quantile 50) indicates the size of the coefficient on the employment dummy for the median. In other words, the graph shows the effect of employment on median income. Similarly, going right on the graph – towards, say, quantile 90 – shows the impact of employment on the net income of richer households. A smaller coefficient on quantile 90 indicates that employment has a smaller impact on the net income of the rich relative to the middle class. Thus, a downward sloping curve in this context indicates that a given independent variable is equalizing in the sense that it increases the bottom end of the distribution relative to the top. Conversely, an upward slope indicates a disequalizing or regressive impact on the distribution of net income.

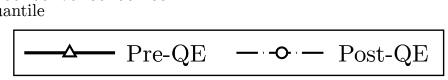
Employment has a strong equalizing effect on net income, as can be seen from the downward sloping coefficients curve. This reflects the fact that wage income makes up a much bigger share of total income for lower income households than for richer ones. Since the income of households near the bottom of the distribution consists almost entirely of wage earnings, the coefficient on EMP is close to one for the

Figure 3.1: RIF regression coefficients during pre and post QE periods





Note: These figures show the coefficients from the RIF regressions by period and by quantile. The pre QE period (2010-08), is represented by the solid line with triangles while the post QE period (2013-11) is represented by the dashed line with circles. The shaded areas show the 95 percent confidence intervals for both periods.



poorest households. In other words, households where the primary income earner is employed have net incomes around 100 percent higher compared to those with an unemployed primary earner. The importance of employment status decreases as one moves higher up in the distribution of net income. Employment increases real median income by around 40 percent and has an even smaller impact on the 90th quantile – roughly 20 percent. The "return" to employment appears to have decreased between the two periods, as indicated by the downward shift in the coefficients curve. This can be interpreted as a fall in real wages over the two periods.

As expected, equity and bond ownership are highly disequalizing. This reflects the fact that ownership of these types of assets is highly concentrated at the top. The return on equities increased during the post QE period for the upper quantiles. This increase was most pronounced for the 90th and above quantiles. Curiously, despite the consensus in the empirical literature that QE boosted bond prices, the return on directly held bonds was essentially flat over the two periods and actually decreased mildly in the middle of the distribution. One possible explanation for this result is that bond ownership impacts household income through interest revenue and not through capital gains. As a result, households would not benefit from increases in bond prices.

The RIF regression results also suggest that mortgage refinancing, as anticipated, is associated with higher household net income, and this holds across most quantiles. Nevertheless, mortgage refinancing appears to be regressive, with a much greater impact near the top of the net income distribution. This implies that even if poor households in need of refinancing gain access to credit, they may not receive as favorable terms as those received by richer households. The coefficients for refinancing also increase during the post QE period for middle quantiles, which is consistent with the fall in interest rates brought on by QE.

To assess the actual quantitative contributions of each channel on inequality, we now turn to the detailed decomposition results. Recall that the point of this exercise is to decompose the overall estimated change in a distributional statistic into a component explained by the change in levels of the independent variables, and a second component due to the change in the coefficients. Also, note that in the case of financial assets, the coefficients component can be interpreted as the contribution of changes in the rate of return on financial assets. Thus, for example, the coefficients component of equities is the contribution of rising stock prices on net income via capital gains.

As alluded to in the introduction, it is worthwhile analytically to distinguish between monetary policy in general and specific channels associated with QE. For example, returns on short-term or liquid financial assets are clearly one channel through which monetary policy may generally affect the distribution of income but is arguably not a channel specific to QE, which aimed to boost the economy through purchases of longer-term assets. Therefore, it is useful to consider the contribution of QE as a subset of the broader contribution of monetary policy. To focus the discussion on the most hotly debated channels through which QE is expected to influence inequality, we will refer to *QE channels* as the contributions of (1) the change in the employment rate, (2) the change in the return on stocks, and (3) the overall contribution of mortgage refinancing. Thus, we are intentionally distinguishing these specific channels from those associated with monetary policy more generally. We are also excluding from this tally the contributions of returns on short-term assets, for reasons already mentioned, and bonds. Bonds are excluded from the tally because it is not possible to identify their maturity composition using the SCF data and therefore it is not clear what share of the observed bond holdings would be sensitive to price changes due to QE. The unexplained component of employment is also excluded from the QE channels tally. This is because it is not clear how QE should affect this component. It is also worth emphasizing that restricting our attention to these specific channels results in a conservative estimate of the overall contribution of QE channels to inequality during this period.

For expositional ease, Table 3.2 reports the decomposition results for the main theoretical channels.[10] Intuitively, each column reports the observed percentage change ("total change") in a given distributional measure and breaks up this total into the percentage point contribution of each sub-component. Note that nothing in this exercise precludes a component from "subtracting" from the total, which means that a given channel may reduce inequality. Moreover, the total change in inequality may actually be smaller than the contribution of a component. This would imply that some components have a tendency to strongly increase inequality but are offset by other equalizing factors that subtract from the measure of inequality during this

[10]The complete set of results for every variable in the specification, all distributional statistics, and every decomposition component are available in the Appendix. Table C.3 reports the full results for a range of inequality measures. Tables C.4 and C.5 report the decomposition results for the bottom and top halves, respectively, of the distribution. These tables also include bootstrapped standard errors for the decomposition components.

period. Each column presents the decomposition result for a separate distributional statistic, where the first three columns are devoted to inequality measures, including ratio of the 95th to 10th percentiles, the 90/10 ratio, and the Gini coefficient. The second set of columns report the level effects on the 10th, 50th and 95th percentiles. For each decomposed statistic, the first two rows report the total change in that statistic and how much the combined QE channels contributed to that change.

The contributions of the three main theoretical channels are also depicted graphically by quantile in Figures 3.2 through 3.4. The graphs show how much of the change in net income of a given quantile is due to the component in question. As with the RIF regression graphs discussed above, a downward sloping curve indicates that the component is equalizing, in the sense that it contributed to a decrease in inequality. Conversely, an upward sloping curve indicates that the component in question increased inequality.

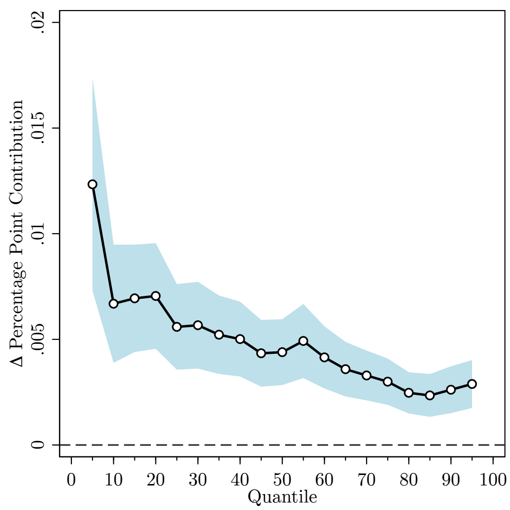
No matter what measure of inequality one uses, changes in the level of employment unambiguously decreased net income inequality. As can be seen in the fist column of Table 3.2, although the ratio of the 95th to 10th quantiles grew by 5 percent, the increased employment rate (i.e. the endowment component) partially offset this trend, subtracting nearly half a percentage point. Changes in employment also had equalizing effects on other measures of inequality. Specifically, the endowments component of employment contributed -0.5 percentage points to the 90/10 ratio and -0.001 to the Gini coefficient. All three of these negative contributions are

Table 3.2: Decomposition results – contributions of the three main theoretical channels.

		Δ Inequality			Δ Level by quantile		
		95/10 ratio	90/10 ratio	Gini	Q = 10	Median	Q = 95
1	**Total Change**	0.050	0.045	0.016*	0.015	0.003	0.049**
		(0.043)	(0.033)	(0.009)	(0.025)	(0.012)	(0.022)
2	**QE Channels**†	0.071**	0.057**	0.011	-0.003	0.030***	0.070***
		(0.033)	(0.023)	(0.009)	(0.007)	(0.007)	(0.021)
3	**Employment Channel**	-0.004***	-0.005**	-0.001***	0.007***	0.004***	0.003***
		(0.002)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)
4	**Financial Returns**	0.264**	0.218*	0.016	-0.288**	-0.012	0.046*
		(0.120)	(0.113)	(0.012)	(0.125)	(0.032)	(0.024)
4a	*Equities*	0.063**	0.041**	0.013*	-0.018***	-0.002	0.047***
		(0.030)	(0.020)	(0.007)	(0.006)	(0.006)	(0.018)
4b	*Bonds*	0.000	0.002	0.004	-0.002**	-0.002	0.000
		(0.010)	(0.005)	(0.005)	(0.001)	(0.001)	(0.006)
4c	*Short-term Assets*	0.201*	0.175	-0.002	-0.268**	-0.007	-0.001
		(0.115)	(0.113)	(0.010)	(0.124)	(0.031)	(0.021)
5	**Mortgage Refinancing**	0.012	0.021	-0.002	0.008	0.028	0.020
		(0.016)	(0.010)	(0.004)	(0.003)	(0.003)	(0.008)
5a	*Endowments*	0.016***	0.008**	0.001	0.005***	0.011***	0.021***
		(0.006)	(0.003)	(0.001)	(0.001)	(0.001)	(0.003)
5b	*Coefficients*	-0.004	0.012	-0.002	0.003	0.017***	-0.000
		(0.020)	(0.012)	(0.005)	(0.004)	(0.003)	(0.010)

Note: This table reports the change in a given distributional statistic between the pre and post-QE periods as well as the decomposed contributions of each of the three main theoretical channels: unemployment, financial asset returns, and mortgage refinancing. The employment channel refers to the contribution of the endowments component (Δ_X). All financial return contributions refer to the coefficients component of each financial asset (Δ_γ). Bootstrapped standard errors with 300 repetitions are reported in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$). †QE channels = 3+4a+5.

Figure 3.2: Contribution of changes in employment (Δ_X) by quantile



Note: This figure shows the endowments component of employment (Δ_X) by quantile. The vertical axis measures the percentage point change in each net income quantile that is attributable to the change in the employment rate. The decomposition corresponds to the same specification presented in Tables C.3 through C.5. The shaded area represents the 95% confidence interval.

statistically significant at standard significance levels using bootstrapped standard errors.[11]

The equalizing contribution of employment to the distribution of net income can also be inferred from Figure 3.2. The downward sloping curve for the explained component indicates that employment gains contributed to much larger increases in net income for bottom quantiles than for top quantiles. Changes in employment contributed 0.7 percentage points of growth to the 10th quantile. The contribution

[11] Standard errors were calculated using the bootstrap replication weights provided by the SCF dataset combined with the RII technique for datasets with repeated imputations. All specifications include 300 repetitions.

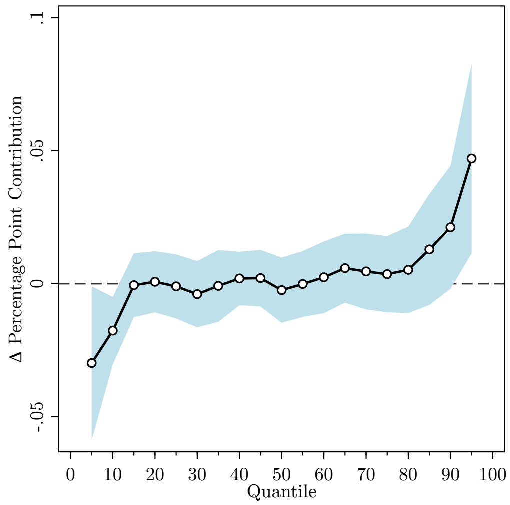
to median income growth was roughly 0.4 of a percentage point. By contrast, the contribution of higher employment to the net income of the top was much smaller. A surprising result from the decompositions is that the coefficients component of employment – the contribution attributable to changes in the returns to employment – has no statistically significant effect on inequality (see Table C.3 in the Appendix). Concretely, this means that changes in real wages were distributionally neutral between these two periods, or at least not pronounced enough to detect in this data and framework.

Equity ownership appears to have contributed to an increase in the incomes of the top of the distribution (see Figure 3.3). The main component of interest is the coefficients component, which can be interpreted as the increase in stock returns during the post-QE period. This component contributed a whopping 6.3 percentage points to the 95/10 ratio and thus was highly disequalizing, dwarfing the comparatively modest equalizing impact of increasing employment. This 6.3 percent contribution is actually larger than the observed growth of the 95/10 ratio, suggesting that this positive contribution was offset by other equalizing factors. Similarly, equity returns also had an oversized impact on the gini coefficient, contributing 0.013, or roughly four fifths of the 0.016 observed change. Nevertheless, the large contribution of stock returns is due to large effects at the upper end of the distribution. Indeed, the coefficients component is only statistically significant for the 90th percentile and above.

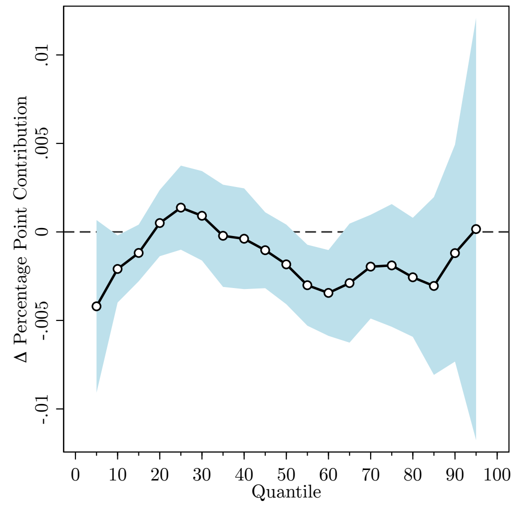
Other financial assets had a mixed contribution to inequality. As expected, the return on short-term financial assets, which consist of checking accounts, certificates

Figure 3.3: Contributions of financial assets returns (Δ_γ)

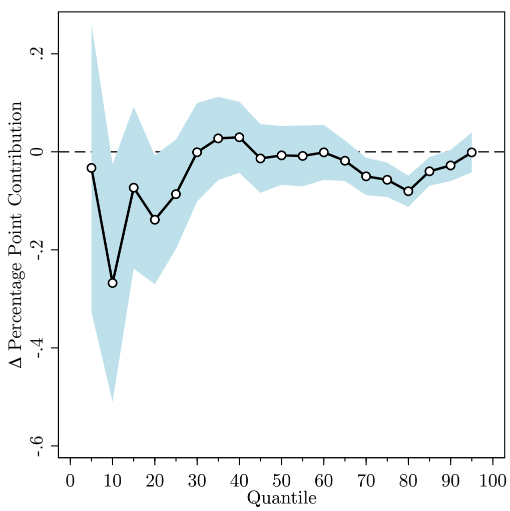
(a) Equities



(b) Bonds

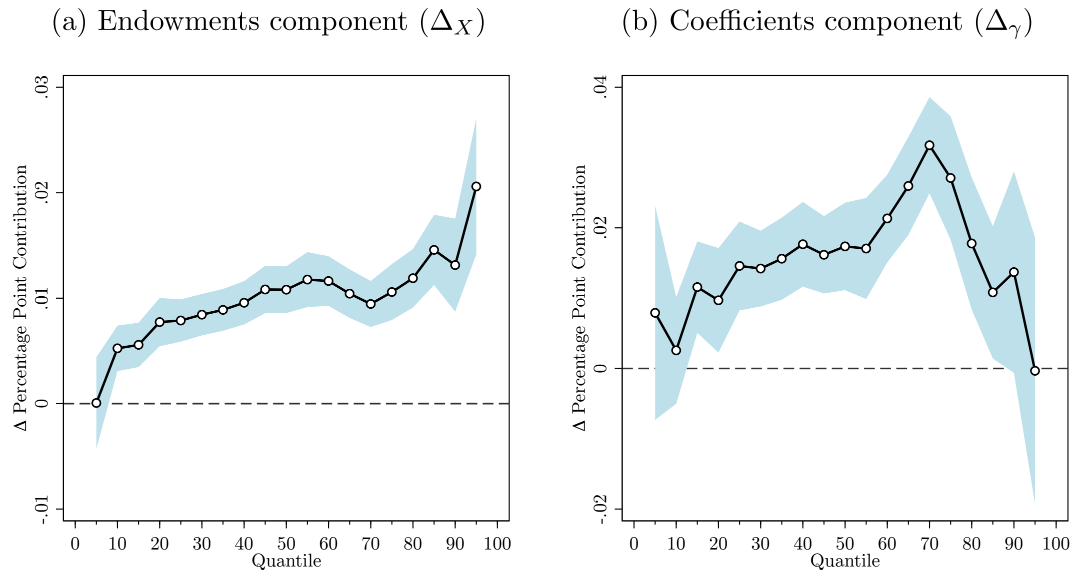


(c) Short-term Assets



Note: This figure shows the coefficients component of various financial assets (Δ_γ) by quantile. The vertical axes measure the percentage point change in each net income quantile that is attributable to the change in the return on the given financial asset. The decomposition corresponds to the same specification presented in Tables C.3 through C.5. The shaded area represents the 95% confidence interval.

Figure 3.4: Contribution of mortgage refinancing



Note: This figure shows both the endowments (Δ_X) and coefficients (Δ_γ) components of mortgage refinancing by quantile. The vertical axes measure the percentage point change in each net income quantile that is attributable to refinancing. The decomposition corresponds to the same specification presented in Tables C.3 through C.5. The shaded area represents the 95% confidence interval based on bootstrapped standard errors with 100 repetitions.

of deposit, and ordinary savings accounts, disproportionately decreased the income of poorer households around the 10th percentile of the distribution while having a nearly neutral effect on richer households. As a consequence, the contribution of short-term asset returns to the 90/10 ratio was sizable – roughly 17 percentage points – though this amount is not statistically significant. Changes in bond returns do not appear to have a significant effect on any of the distributional statistics we consider.

While nearly all quantiles benefitted from both higher refinancing rates – reflecting easier access to credit – as well as a greater return on refinancing – reflecting lower interest rates on refinanced mortgage debt (Figure 3.4), the distributional impact of mortgage refinancing is nuanced. For example, the greater availability of refinancing credit was highly regressive, as can be seen by the upward sloping contribution of the endowments component in panel (a) of Figure 3.4. For instance, changes in the number of households who refinanced contributed to a 0.8 percentage point increase in the 90/10 ratio and an increase of 1.6 in the 95/10 ratio. In contrast, changes in the returns to refinancing – that is, the effect of refinancing at a lower interest rate – only impacted the middle of the income distribution. As can be seen in panel (b), the largest gains from obtaining refinancing went to households between the 50th and 80th percentiles, while the effects on the tails of the distribution were not significantly different from zero. Adding these two components together, the overall contribution of refinancing to inequality is modestly positive (see row 5 of Table 3.2), though not statistically significant for any of the distributional measures considered.

Taking a step back, the decomposition results support the proposition that the disequalizing effects of increasing equity returns outweighed the equalizing effects of falling unemployment during the post-QE period. Netting out the equalizing impact of declining unemployment, the estimated impact of increasing equity returns on the 95/10 ratio is still around 6 percentage points. If this were the end of the story the unavoidable conclusion would be that QE, and expansionary monetary policy more generally during this period, greatly contributed to rising inequality. However, this conclusion is incorrect since the decomposition results only account for the *observed* changes in the explanatory variables and are completely silent on the counterfactual changes in these variables that would have been observed in the absence of QE. We address this issue in Section 3.6 below.

3.5.1 Contribution to growth of real median income

Although the combined contributions of all three channels – financial returns, declining unemployment, and mortgage refinancing – appear to have increased inequality between the two periods, it is important to emphasize that these channels nevertheless boosted real median income. Indeed, while median income growth was flat during the post-QE period, as reported in the second to last column of Table 3.2, the three QE channels contributed a net 3 percentage points to median real income. Put differently, the contribution of the three QE channels offset a 3 percent decline of median income.

Mortgage refinancing played the biggest role, contributing 2.8 percentage points. This reflects both changes in the volume of refinancing (the endowments component) and reduced borrowing costs (the coefficients component). Assuming that the demand for credit has remained more or less constant between the two periods, the increase in refinancing rates implies an improvement in credit availability. These improved credit conditions contributed nearly 1.1 percentage points to median income growth. At the same time, a fall in mortgage rates boosted median net income by lightening households' debt burden. This effect contributed around 1.7 percentage points to median income growth.

In contrast, financial asset returns had no significant effect on median income. Although the combined contribution of financial asset returns on median net income was -1.2 percentage points, led by the falling returns on short-term / liquid financial assets, these estimates are not statistically significant at standard confidence levels. Finally, increased employment contributed nearly half a percentage point to real median income growth.

3.6 Counterfactual scenarios

As already noted, while our decomposition provides a detailed picture of the contribution of each channel to the actual change in the distribution of net income between the two periods, it lacks a causal interpretation. This is because the decomposition was carried out using the observed changes in the independent variables and not the counterfactual changes that would have prevailed had the Federal Reserve abstained from intervening to boost employment and prop up financial markets. In other words, our decomposition estimates do not answer the question: "what would the distribution of income look like if the Federal Reserve had not undertaken QE?" Nevertheless, it is possible to use the decomposition estimates to provide a precise framing of the relative magnitudes of each causal channel under alternative counterfactual scenarios. This requires making assumptions about the path of, say, unemployment in the hypothetical absence of QE; or about changes in stock returns had QE not taken place.

Though not settling the issue of causality, this exercise places well defined upper and lower bounds on the effects of QE, as well as the net tradeoff between equity returns – which, as we have seen, led to dramatic increases in inequality – and changes in employment, which modestly decreased inequality. What emerges from this exercise is that for QE to have actually decreased inequality relative to a hypothetical counterfactual, it is necessary to either strongly downplay the potential impact of QE on stock returns or assume very large employment effects. In other words, it is necessary to either assume that the large disequalizing impact of stock returns was mostly not due to QE but a "normal" feature of the economic recovery, or that the Federal Reserve prevented an implausibly large increase in the unemployment rate.

Consider the "causal" effect of QE on channel k for a given inequality statistic,

$$\tilde{\Delta}_k = \Delta_k - \Delta_k^C$$

where Δ_k^C denotes the counterfactual change of channel k (e.g. the change in employment that would have taken place without QE). To focus on the most controversial channels, let's consider the contribution of changes in the return of owning stocks ($\Delta\gamma_S$) and changes in employment ($\Delta\bar{X}_E$). For simplicity, let's assume that counterfactual stock returns can be modeled by replacing the estimated change in the return on stocks ($\Delta\gamma_S$) with a parameter θ that stands for the percentage increase in stock prices due to QE. That is, we assume that the "causal" contribution of stock returns is given by:

$$\tilde{\Delta}_{\gamma,S} = \theta\hat{\gamma}_{0,S}\bar{X}_{0,S} \tag{3.9}$$

where $\hat{\gamma}_{0,S}$ is the return on stocks during the pre-QE period.[12] Intuitively, equation (3.9) yields the causal contribution of QE to inequality through stock returns if one assumes that QE was responsible for a θ percent increase in stock prices.

[12] Algebraically, this follows from the definition of the change in the return on stocks and of θ, which is the percentage change. Since $(\hat{\gamma}_{1,S} - \hat{\gamma}_{0,S})/\hat{\gamma}_{0,S} = \theta$, it is easy to see that $\Delta\gamma_S = \theta\hat{\gamma}_{0,S}$.

Turning next to the employment channel, it is extremely likely that unemployment would have continued to increase, instead of slowly coming down, in the absence of QE. We do not take a stand on precisely how much employment would have hypothetically decreased but instead present a range of estimates for the effect of QE via employment based on counterfactual levels of employment. Below we will discuss estimates reported in the literature and how these translate into contributions to inequality in our framework. Specifically, starting with the definition of the endowment component for employment in the Oaxaca-Blinder decomposition, we replace the change in mean endowments, $\Delta \bar{X}_E$, with the hypothetical change causally attributable to QE, $\Delta \bar{X}_E - \Delta \bar{X}_E^C$. The causal contribution of QE to inequality via employment is thus given by:

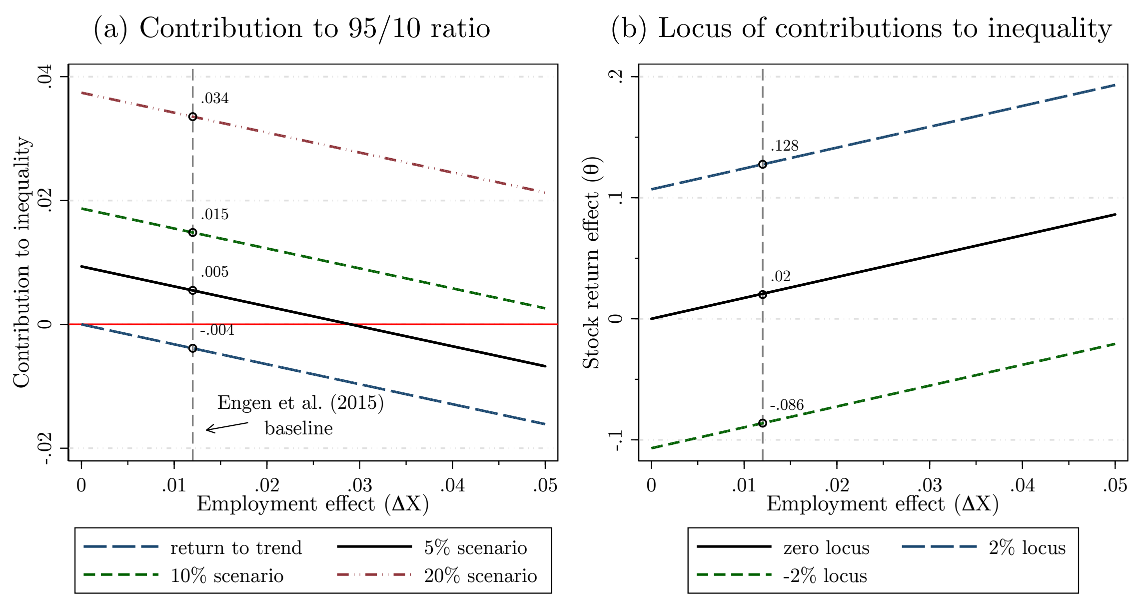
$$\tilde{\Delta}_{X,E} = \tilde{\Delta} \bar{X}_E \hat{\gamma}_{0,E} \tag{3.10}$$

where $\hat{\gamma}_{0,E}$ is the RIF regression coefficient for employment during $t = 0$. Combining the effects of stock returns and employment, we arrive at the net effect QE relative to the counterfactual:

$$\tilde{\Delta} = \tilde{\Delta}_{X,U} + \tilde{\Delta}_{\gamma,S} \tag{3.11}$$

Using the decomposition results, we consider two counterfactual exercises to assess the plausibility that QE may have decreased or increased inequality given these well defined impacts on employment and stock returns. Specifically, we take the coefficients from the RIF regressions and combine them with alternative assumptions about changes in endowments and returns to calculate the hypothetical contribution of QE to inequality under various counterfactual scenarios.

Figure 3.5: Impact of QE relative to various counterfactual scenarios



Note: Panel (a) shows the net contribution of QE to the 99/10 ratio through its effect on employment and stock returns under alternative scenarios about the causal impact of QE on these two channels. The "return to trend" scenario assumes that all observed stock returns were due to stock prices returning to their trend level ($\theta = 0$). The "5 percent" scenario assumes that QE increased stock prices by 5 percent. The 10 and 20 percent scenarios are defined analogously. Panel (b) reports the combinations of stock return and employment effects that yield a zero net impact on inequality. In both panels, "employment effect" refers to the hypothetical causal impact of QE on employment relative to the counterfactual absence of QE ($\Delta\bar{X}_E - \Delta\bar{X}_E^C$). In panel (b), "stock returns effect" refers to the percentage increase in stock prices causally attributable to QE.

First, we examine the net causal contribution to inequality as a function of the causal effect of QE on employment ($\Delta\bar{X}_E - \Delta\bar{X}_E^C$) holding constant the effect on stock returns at different levels. This exercise is intended to answer the question: "how much would QE have contributed to inequality if its causal impact on employment had been x points and we assume that QE was responsible for a y percent increase in stock prices?" Thus, panel (a) of Figure 3.5 graphs the net contribution to the 95/10 ratio ($\tilde{\Delta}$) as a function of the hypothetical causal effect on the employment rate ($\tilde{\Delta}_{X,U}$), holding constant the causal effect of QE on stock returns ($\theta\hat{\gamma}_{0,S}\bar{X}_{0,S}$). As in the decomposition figures presented above, the vertical axis measures the percentage point change in inequality due to the factors under consideration. We consider four alternative scenarios for stock prices in this exercise. The "return to trend" scenario makes the extreme assumption that none of the stock price growth observed during the recovery is causally attributable to QE and instead simply reflects the stock prices returning to their pre-crisis trend. This scenario is broadly compatible with Bernanke's views (cited above) and corresponds to setting $\theta = 0$. We then consider three intermediate scenarios where QE was causally responsible for 5, 10, and 20 percent increases in stock prices.

Second, we consider the locus of combinations of employment and stock returns effects necessary for the contribution of QE to inequality to equal zero. This second exercise answers questions of the type: "If QE had a zero causal impact on inequality, what combinations of stock returns and employment effects are consistent with this zero impact?" Phrased differently, this exercise answers: "If we assume that QE was only responsible for a y percent change in stock prices, how big does the effect on employment need to be to ensure a zero net impact on inequality?" Concretely, this exercise simply consists of setting $\tilde{\Delta} = 0$ from equation (3.11) and graphing the zero locus in $(\tilde{\Delta}\bar{X}_E, \theta)$-space. This is shown in panel (b) of Figure 3.5.

Although the jury is still out on the overall macroeconomic impact of QE, there have been a number of studies quantifying its effects on employment and stock prices. These are thoroughly reviewed in Bivens [14]. A general reading of this literature is that QE had non-trivial effects on the unemployment rate and relatively modest effects on stock prices. Using estimates of the effect of QE on the term-premium and simulations based-on the Federal Reserves' FRB-US model, Chung et al. [26] report that QE likely lowered the unemployment rate by 1.5 percentage points. Engen et al. [37] report estimates ranging from a 0.8 percentage point decrease to an upper bound of 1.5 points, with a baseline impact of 1.2. Estimates of the impact of QE on stock prices come from event-style studies measuring the response of stock prices to surprise monetary policy announcements related to QE (Rosa [107], Rogers et al. [105], Kiley [70], Engen et al. [37]). In these types of studies, stock prices are estimated to have grown between 3 percent to around 9 percent because of QE.[13]

Considering these estimates for the employment and stock prices effects, QE would have mildly increased inequality or have had an approximately neutral effect. Taking the 5 percent causal effect on stock prices scenario as the baseline (the solid black curve in panel (a) of Figure 3.5), it is evident that the net contribution of

[13]One limitation of these estimates is that event-studies, by design, only capture the response of stock prices during the immediate time-period of the policy announcement and as such may not capture the full effect of QE, via, for example, general financial market conditions. Due to this uncertainty, event-studies may understate the full effect of QE on stock prices.

Table 3.3: Counterfactual contributions to the 95/10 ratio under various scenarios

	Employment effect ($\tilde{\Delta}\bar{X}$)			
	1 pp	2 pp	3 pp	4 pp
Equity Return Scenarios (θ)				
0% scenario	-0.3	-0.6	-1.0	-1.3
5% scenario	0.6	0.3	0.0	-0.4
10% scenario	1.5	1.2	0.9	0.6
20% scenario	3.4	3.1	2.8	2.5

Note: This table reports the combined contribution of returns to equities and changes in the employment rate to the 95/10 ratio under various counterfactual scenarios. The contributions are presented as percentage changes. Each counterfactual contribution is calculated according to equation (3.11) in the text. A one pp employment effect refers to a one percentage point causal change in the employment rate.

QE to inequality through employment and stock returns is positive for a substantial range of effects on employment. For example, let's consider the net contribution to inequality assuming that the causal effect of QE on employment was 1.2 percentage points. This change in employment is consistent with the baseline estimates reported by Engen et al. [37]. As can be seen in panel (a), this corresponds to a 0.5 percentage point increase to the 95/10 ratio under the 5 percent stock returns scenario, a 1.5 percentage point contribution under the 10 percent scenario, and as high as 3.4 percentage points under the 20 percent scenario.

Indeed, under the 5 percent stock returns scenario, the contribution to the 95/10 ratio only becomes negative for assumed employment effects exceeding 3 percentage points, which is more than double the baseline effect reported by Engen et al. [37]. Making the less conservative assumption that 10 percent of the change in stock returns was due to QE, the employment effects necessary to yield a neutral or negative impact on inequality become highly implausible. Perhaps the easiest way to appreciate the tradeoff between the equalizing effects of employment and the disequalizing effects of stock returns is by looking at panel (b) of Figure 3.5. There, the solid black curve plots the combinations of stock return effects and employment effects that are consistent with a neutral QE impact on inequality. A 1.2 percentage point employment effect would only result in a zero net impact on inequality if as little as 3.2 percent of the change in stock prices were attributable to QE. These points are also illustrated in Table 3.3, which reports the combined contribution of equity returns and changes in employment under various counterfactual scenarios.

3.7 Concluding Remarks

The unavoidable conclusion from the detailed decomposition exercise and the counterfactual analysis carried out above is that the impact of quantitative easing on the distribution income was at least modestly regressive. Our decomposition results imply that the disequalizing effects of equity returns far outweighed the equalizing effects of employment gains. While these decomposition results cannot be interpreted causally, the counterfactual scenarios presented in the previous section suggest that, for reasonable assumptions about the employment effects of QE, the causal impact of QE on stock prices would have to be implausibly small for the net effect to be distributionally neutral.

These dis-equalizing impacts were due to both policy choices and deep seated structural problems. Policy wise, the Federal Reserve and Treasury Department did not design effective mechanisms to clear away obstacles for lower income households to refinance loans at lower rates. As Bair [5] and Barofsky [7] show, helping underwater homeowners refinance their mortgages or stay in their homes was not a top priority of the Treasury Department. Nor did the Federal Reserve try to implement any regulatory programs to do so. In addition, the Federal Reserve did not try to develop innovative programs to use its lending facilities to lend directly to state and local governments or others who would preserve or expand employment. This direct lending could have lessened the Fed's dependence on bidding up asset prices in an attempt to generate employment and wage increases.

Finally, while our results tend to support the critics who argue that QE did increase inequality, there is nothing in our analysis which supports those who argue that raising interest rates will have a desirable, equalizing impact. Tighter monetary policy would likely reduce employment growth, and make mortgage refinancing more expensive. While it might reduce asset price growth and raise returns on short term assets, the employment and refinancing impacts are likely to be dominant as earlier work on monetary policy and income distribution has demonstrated (e.g. Coibion [27]).

This suggests a paradox. Given the current structure of the economy and monetary policy strategies, both loose and tight monetary policy are likely to be disequalizing. Future research should focus on better understanding the reason for this paradoxical situation. It is likely that more direct tools of monetary policy are needed. Perhaps more importantly, fiscal policy, and labor market policies such as changes in labor laws, tax laws, and minimum wage legislation will be needed to reduce the massive levels of inequality that we are experiencing today.

APPENDIX A

ADDITIONAL TABLES FOR CHAPTER 1

A.1 ECMs with additional capital control measures

This appendix presents additional error-correction models with finer breakdowns of capital control transaction categories. Tables A.1 and A.2 report the error-correction term and its interaction with various measures of capital controls. The ECM specification is the same as the benchmark specification (1.2). Each specification in Tables A.1 and A.2 features a different Schindler subindex corresponding to the presence of restrictions on a financial instrument category j. The full list of instruments reported are: equities, bonds, money market accounts, and collective investment instruments. For controls on capital inflows, IN refers to average controls on capital inflows, while $PLBN$ and $SIAR$, respectively, stand for restrictions on the purchase locally by non-residents and the sale or issue abroad by residents. For controls on capital outflows, OUT refers to average restrictions on capital outflows. $SILN$ stands for "sale or issue locally by non-residents" while $PABR$ stands for "purchase abroad by residents."

Table A.1: ECM with controls on capital inflows, by instrument.

Dependent Variable: $\Delta REER$												
Instrument:	Equities			Bonds			Money Market			Collective Investments		
Control Type j:	IN	$PLBN$	$SIAR$	IN	$PLBN$	$SIAR$	IN	$PLBN$	$SIAR$	IN	$PLBN$	$SIAR$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\hat{e}_{t-1}$	-0.265***	-0.251***	-0.267***	-0.324***	-0.316***	-0.329***	-0.261***	-0.261***	-0.252***	-0.271***	-0.259***	-0.270***
	(0.034)	(0.033)	(0.033)	(0.031)	(0.031)	(0.033)	(0.035)	(0.033)	(0.034)	(0.035)	(0.032)	(0.035)
$\hat{e}_{t-1} \cdot SCH_j$	0.058	0.019	0.049*	0.028	0.005	0.029	0.055	0.064*	0.017	0.096**	0.079***	0.065**
	(0.038)	(0.035)	(0.030)	(0.045)	(0.031)	(0.040)	(0.041)	(0.034)	(0.033)	(0.039)	(0.030)	(0.033)
Observations	707	707	707	619	619	619	707	707	707	707	707	707
Countries	48	48	48	48	48	48	48	48	48	48	48	48
R-squared	0.412	0.41	0.413	0.44	0.439	0.441	0.412	0.414	0.41	0.418	0.416	0.416
RMSE	0.056	0.056	0.056	0.054	0.054	0.054	0.056	0.056	0.056	0.055	0.056	0.056

Note: IN: average controls on capital inflows. $PLBN$: purchase locally by non-residents. $SIAR$: sale or issue abroad by residents. Short-run control variables and lagged first-differences of long-run variables not reported. Robust HAC standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2: ECM with controls on capital outflows, by instrument.

Dependent Variable: $\Delta REER$												
Instrument:	Equities			Bonds			Money Market			Collective Investments		
Control Type j:	OUT	$SILN$	$PABR$	OUT	$SILN$	$PABR$	OUT	$SILN$	$PABR$	OUT	$SILN$	$PABR$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\hat{e}_{t-1}$	-0.305***	-0.285***	-0.286***	-0.348***	-0.344***	-0.330***	-0.272***	-0.248***	-0.283***	-0.277***	-0.262***	-0.276***
	(0.037)	(0.032)	(0.038)	(0.039)	(0.035)	(0.036)	(0.037)	(0.034)	(0.038)	(0.035)	(0.033)	(0.036)
$\hat{e}_{t-1} \cdot SCH_j$	0.105***	0.071**	0.070**	0.06	0.05	0.03	0.053	0.003	0.074*	0.06	0.026	0.065*
	(0.037)	(0.028)	(0.033)	(0.049)	(0.038)	(0.036)	(0.042)	(0.034)	(0.039)	(0.037)	(0.028)	(0.037)
Observations	707	707	706	619	619	619	707	707	707	707	707	707
Countries	48	48	48	48	48	48	48	48	48	48	48	48
R-squared	0.419	0.416	0.415	0.442	0.442	0.441	0.412	0.41	0.415	0.413	0.411	0.414
RMSE	0.055	0.056	0.056	0.053	0.054	0.054	0.056	0.056	0.056	0.056	0.056	0.056

Note: OUT: average controls on capital outflows. $SILN$: sale or issue locally by non-residents. $PABR$: purchase abroad by residents. Short-run control variables and lagged first-differences of long-run variables not reported. Robust HAC standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

A.2 Sample List

Industrial – Australia, Austria, Belgium, Canada Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Malta, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Europe and Central Asia – Bulgaria, Czech Republic, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Moldova, Russia, Slovenia, Turkey.

East Asia and Pacific – Brunei Darussalam, China, Hong Kong, Indonesia, Republic of Korea, Malaysia, Philippines, Singapore, Thailand.

Latin America and Caribbean – Argentina, Bolivia, Brazil, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Panama, Paraguay, Peru, Uruguay, Venezuela.

Middle East and North Africa – Bahrain, , Egypt, Israel, Kuwait Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, Republic of Yemen.

South Asia – Bangladesh, India, Pakistan, Sri Lanka.

Sub-Saharan Africa – Angola, Burkina Faso, Côte d'Ivoire, Kenya, Mauritius, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia.

A.3 Exchange Rate Regime Classification

Data on *de facto* exchange rate regime classifications was obtained from Ilzetzki et al. [60]. Details on the different classification codes are provided in Table A.3. Following Eguren [34], "floating" regimes are those with category codes 10 through 13. Freely falling regimes (code 14) and dual market regimes with missing data (code 15) are excluded from the analysis.

Table A.3: Ilzetzki et al. [60] *de facto* exchange rate regime classification

Code	Description
1	No separate legal tender
2	Pre announced peg or currency board arrangement
3	Pre announced horizontal band that is narrower than or equal to +/-2%
4	De facto peg
5	Pre announced crawling peg
6	Pre announced crawling band that is narrower than or equal to +/-2%
7	De factor crawling peg
8	De facto crawling band that is narrower than or equal to +/-2%
9	Pre announced crawling band that is wider than or equal to +/-2%
10	De facto crawling band that is narrower than or equal to +/-5%
11	Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time)
12	Managed floating
13	Freely floating
14	Freely falling
15	Dual market in which parallel market data is missing.

A.4 Inflation Targeting Countries

Table A.4: List of inflation targeting countries and year of adoption

Country	Year of Adoption
New Zealand	1990
Canada	1991
United Kingdom	1992
Australia	1993
Sweden	1993
Czech Republic	1997
Israel	1997
Poland	1998
Brazil	1999
Chile	1999
Colombia	1999
South Africa	2000
Thailand	2000
Hungary	2001
Mexico	2001
Iceland	2001
Korea, Republic of	2001
Norway	2001
Peru	2002
Philippines	2002
Guatemala	2005
Indonesia	2005
Romania	2005
Serbia	2006
Turkey	2006
Armenia	2006
Ghana	2007

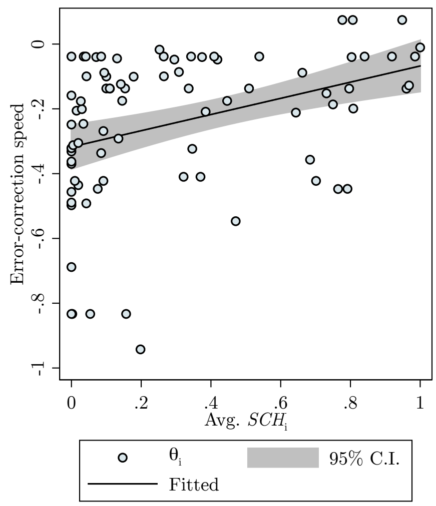
Note: This table reports the list of countries with an inflation targeting regime and the year this regime was adopted, as presented in Roger [104].

APPENDIX B

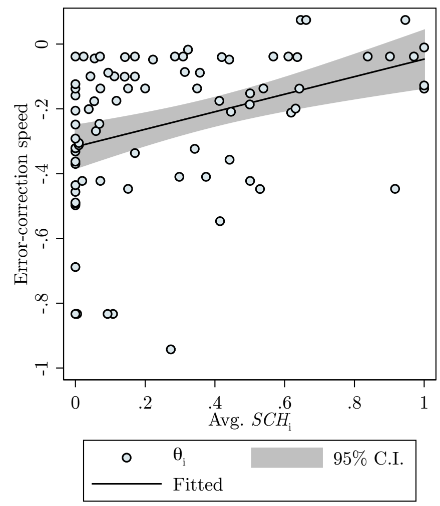
ADDITIONAL FIGURES FOR CHAPTER 1

Figure B.1: Country-specific error-correction speeds and average capital controls

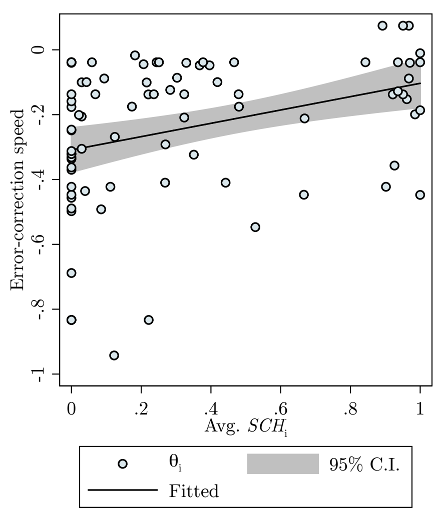
(a) Overall



(b) Inflows

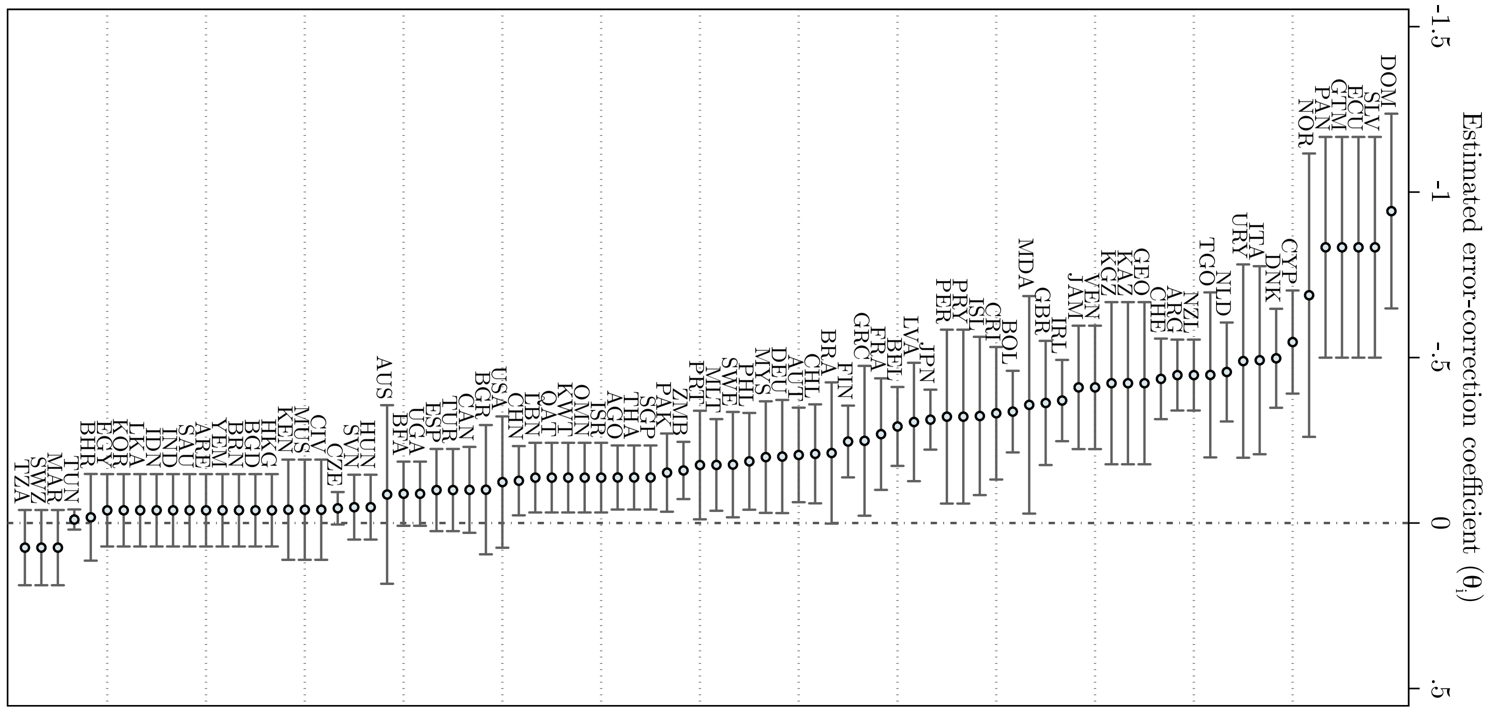


(c) Outflows



Note: This figure shows scatter plots and fitted values of the estimated country-specific error-correction terms against various measure of capital controls. The shaded area represents the 95 percent confidence interval. The error-correction term is obtained from a country-specific regression of the following form: $\Delta\hat{e}_{i,t} = \theta_i \hat{e}_{i,t-1} + \alpha_{i,0} + u_{i,t}$, where $\hat{e}_{i,t}$ are the residuals from specification (4) in Table 1.5 and θ_i is the error-correction term for country i.

Figure B.2: Country-specific error-correction speed



Note: This figure reports the country-specific error-correction term for all countries in the sample. The error-correction term is obtained from a country-specific regression of the following form: $\Delta\hat{e}_{i,t} = \theta_i \hat{e}_{i,t-1} + \alpha_{i,0} + u_{i,t}$, where $\hat{e}_{i,t}$ are the residuals from specification (4) in Table 1.5 and θ_i is the error-correction term for country i.

APPENDIX C

ADDITIONAL TABLES FOR CHAPTER 3

Table C.1: Description of covariates

Variable	Definition
Employment	Indicator variable for the employment status of the head of the household.
Equity Ownership	Indicator for whether or not the household holds any type of equity, either directly or indirectly through mutual funds.
Bonds, directly held	Indicator for whether or not the household directly owns any bonds.
Short-term / liquid assets	Indicator for owning any short-term or liquid assets. These include checking accounts, cash, certificates of deposit, and other liquid assets.
Mortgage refinancing	Indicator for whether or not the household obtained refinancing for their primary mortgage during the previous three years.
College	Indicator for whether the head of the household has completed college.
Age	Age, in years, of the household head.
Credit denial / fear of denial	Indicator for whether or not the household has been denied or feared being denied credit during the previous 5 years.
Bankruptcy	Indicator for whether or not the household filed for bankruptcy during the previous 5 years.
Race	Categorical variable indicating the stated race of the household head.

Table C.2: Covariate means – before and after QE

	Pre-QE (2008-10)	Post-QE (2011-13)	Change
Employment	0.929	0.941	0.012
Equities	0.193	0.192	-0.011
Bonds	0.016	0.014	-0.002
Short-term / liquid assets	0.926	0.932	0.006
Mortgage refinancing	0.093	0.125	0.032

Table C.3: Detailed decomposition results by distributional statistic

Dependent Variable: Net Income (IHT)	(1)	(2)	(3)	(4)	(5)
	90/10	95/10	90/50	50/10	Gini
			Overall		
Pre-QE	2.467***	2.869***	1.232***	1.235***	0.600***
	(0.024)	(0.030)	(0.019)	(0.019)	(0.007)
Post-QE	2.422***	2.819***	1.184***	1.238***	0.583***
	(0.026)	(0.029)	(0.019)	(0.017)	(0.006)
Change	0.045	0.050	0.048*	-0.003	0.016*
	(0.033)	(0.043)	(0.028)	(0.026)	(0.009)
			Endowments (Δ_X)		
Employment	-0.005**	-0.004***	-0.002***	-0.003**	-0.001***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)
Equities	-0.007*	-0.010*	-0.005*	-0.002*	-0.002*
	(0.004)	(0.006)	(0.003)	(0.001)	(0.001)
Bonds	-0.003	-0.007	-0.003	-0.000	-0.002
	(0.002)	(0.005)	(0.002)	(0.000)	(0.002)
Short-term Assets	-0.006*	-0.007	-0.003	-0.002	-0.001
	(0.003)	(0.005)	(0.003)	(0.002)	(0.001)
Mortgage Refinancing	0.008**	0.016***	0.003	0.006***	0.001
	(0.003)	(0.006)	(0.003)	(0.002)	(0.001)
			Coefficients (Δ_γ)		
Employment	0.037	-0.033	0.047	-0.010	-0.005
	(0.147)	(0.168)	(0.063)	(0.130)	(0.029)
Equities	0.041**	0.063**	0.020	0.021*	0.013*
	(0.020)	(0.030)	(0.018)	(0.011)	(0.007)
Bonds	0.002	0.000	0.002	0.000	0.004
	(0.005)	(0.010)	(0.005)	(0.002)	(0.005)
Short-term Assets	0.175	0.201*	-0.035	0.210*	-0.002
	(0.113)	(0.115)	(0.039)	(0.116)	(0.010)
Mortgage Refinancing	0.012	-0.004	-0.004	0.016***	-0.002
	(0.012)	(0.020)	(0.011)	(0.005)	(0.005)
Constant	-0.317	-0.298	0.078	-0.396**	-0.005
	(0.210)	(0.252)	(0.093)	(0.199)	(0.033)

Note: This table reports the results from the detailed decomposition for various distributional statistics. Detailed decomposition results for the interaction component are not reported. Each specification corresponds to the results reported in Figures 3.2 - 3.4. Every model includes standard demographic controls, including age, race, education, as well as household access to credit. Bootstrapped standard errors with 300 repetitions are reported in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).

Table C.4: Detailed decomposition results by quantile, bottom half of the distribution

Dependent Variable: Net Income (IHT)	(1)	(2)	(3)	(4)
	$Q = 10$	$Q = 20$	$Q = 40$	$Q = 50$
Overall				
Pre-QE	10.044***	10.461***	11.039***	11.275***
	(0.012)	(0.012)	(0.010)	(0.008)
Post-QE	10.029***	10.471***	11.051***	11.272***
	(0.019)	(0.011)	(0.010)	(0.009)
Change	0.015	-0.010	-0.012	0.003
	(0.025)	(0.014)	(0.015)	(0.012)
Endowments (Δ_X)				
Employment	0.007***	0.007***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Equities	-0.003***	-0.004***	-0.005***	-0.006***
	(0.001)	(0.001)	(0.002)	(0.002)
Bonds	-0.000*	-0.000*	-0.000	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
Short-term Assets	0.006***	0.006***	0.004***	0.004***
	(0.002)	(0.002)	(0.002)	(0.001)
Mortgage Refinancing	0.005***	0.008***	0.010***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)
Coefficients (Δ_γ)				
Employment	-0.127	-0.261***	-0.205***	-0.166***
	(0.094)	(0.061)	(0.047)	(0.041)
Equities	-0.018***	0.001	0.002	-0.002
	(0.006)	(0.006)	(0.005)	(0.006)
Bonds	-0.002**	0.001	-0.000	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Short-term Assets	-0.268**	-0.139**	0.030	-0.007
	(0.124)	(0.067)	(0.037)	(0.031)
Mortgage Refinancing	0.003	0.010**	0.018***	0.017***
	(0.004)	(0.004)	(0.003)	(0.003)
Constant	0.510**	0.376***	0.042	0.058
	(0.209)	(0.104)	(0.060)	(0.056)

Note: This table reports the results from the detailed decomposition for the bottom half of the distribution. Detailed decomposition results for the interaction component are not reported. Each specification corresponds to the results reported in Figures 3.2 - 3.4. Every model includes standard demographic controls, including age, race, education, as well as household access to credit. Robust standard errors are reported in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).

Table C.5: Detailed decomposition results by quantile, top half of the distribution

Dependent Variable: Net Income (IHT)	(1)	(2)	(3)	(4)
	$Q = 60$	$Q = 80$	$Q = 90$	$Q = 95$
Overall				
Pre-QE	11.509***	12.064***	12.496***	12.910***
	(0.008)	(0.009)	(0.015)	(0.016)
Post-QE	11.508***	12.025***	12.469***	12.861***
	(0.010)	(0.011)	(0.013)	(0.015)
Change	0.000	0.038**	0.027	0.049**
	(0.013)	(0.015)	(0.023)	(0.022)
Endowments (Δ_X)				
Employment	0.004***	0.002***	0.003***	0.003***
	(0.001)	(0.000)	(0.001)	(0.001)
Equities	-0.006***	-0.009***	-0.011***	-0.014***
	(0.002)	(0.003)	(0.004)	(0.005)
Bonds	-0.001*	-0.001*	-0.003*	-0.006*
	(0.000)	(0.001)	(0.002)	(0.003)
Short-term Assets	0.003***	0.001***	0.000**	-0.001**
	(0.001)	(0.000)	(0.000)	(0.000)
Mortgage Refinancing	0.012***	0.012***	0.013***	0.021***
	(0.001)	(0.001)	(0.002)	(0.003)
Coefficients (Δ_γ)				
Employment	-0.152***	-0.051*	-0.121***	-0.197***
	(0.038)	(0.030)	(0.040)	(0.045)
Equities	0.002	0.005	0.021*	0.047***
	(0.007)	(0.008)	(0.012)	(0.018)
Bonds	-0.003***	-0.003	-0.001	0.000
	(0.001)	(0.002)	(0.003)	(0.006)
Short-term Assets	-0.001	-0.081***	-0.028*	-0.001
	(0.029)	(0.016)	(0.016)	(0.021)
Mortgage Refinancing	0.021***	0.018***	0.014*	-0.000
	(0.003)	(0.005)	(0.007)	(0.010)
Constant	-0.028	0.053	0.064	0.092
	(0.062)	(0.044)	(0.064)	(0.078)

Note: This table reports the results from the detailed decomposition for the top half of the distribution. Detailed decomposition results for the interaction component are not reported. Each specification corresponds to the results reported in Figures 3.2 - 3.4. Every model includes standard demographic controls, including age, race, education, as well as household access to credit. Robust standard errors are reported in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$).

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