# A Managed Policy on Capital Flows

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**Abstract**

Cross-border capital flows create dilemmas and trade-offs for monetary policy due to their many benefits, like financing economic growth and consumption of households, and their potential adverse macroeconomic effects, which can be caused by real appreciation of a recipient country's currency and a large stock of debt that can cause difficulty in servicing. We examine conditions under which a country will restrict capital inflows to mitigate their adverse macroeconomic effects. Our game-theoretic modelling captures a dynamic interaction between policy and investment. Using the subgame perfect Nash equilibrium concept, we show that the government restricts capital inflows if the local economic conditions are strong enough to discourage a surge in capital inflows but relaxes the restriction if the economic conditions in the investors' home are strong enough to attract capital inflows. The restriction has large impact on short-term capital inflows and is effective in channelling capital inflows into long-term investments.

**Keywords:** capital inflows, subgame perfect Nash equilibrium

## 1. Introduction

In this paper we analyse the conditions under which a country will restrict capital inflows despite their many economic benefits (Note 1). Capital inflows benefit recipient countries in many ways. They can finance investment and stimulate economic growth. They can increase welfare of households by enabling households to smooth their consumption over time. They can enable investors in countries where capital flows originate to achieve better international diversification of their portfolios. But despite their economic benefits, large capital inflows can have less desirable macroeconomic effects, such as real exchange rate appreciation and rapid monetary or debt expansion (Cavlo et al., 1996).

The interconnectedness of global financial markets through asset and liability management strategies of governments, financial institutions, and corporations has brought benefits as well as vulnerabilities (IMF Paper, 2010). The speed with which illiquidity and asset losses in some markets can spill over into other financial markets points to the risks of interconnectedness of global financial markets. The 2007-010 subprime mortgage financial crisis that contributed to the 2007–2008 global financial crisis is a case in point (Jagannathan et al, 2012). This suggests that countries need to consider policies that stabilise their economies. The policies include sound bankruptcy laws and management of capital flows (Note 2). This paper contributes to the debate about management of capital inflows. We focus on the following questions. How can authorities reduce the destabilising effects of short-term capital inflows? Can authorities change the volume and composition of short-term capital inflows? How can authorities respond to the adverse macroeconomic effects of large capital inflows, such as real appreciation and monetary or debt expansion? A real appreciation of a country's currency makes its exports less competitive against its competitors' goods and services (Note 3). A large stock of debt confronts authorities with difficulties in servicing such debt according to the contractually agreed upon terms.

The idea of restricting capital flows has recently grown in popularity among economists and policy makers (Note 4). Capital controls limit the free movement of capital across national borders. There are two broad forms of restricting capital flows. Administrative or direct capital controls are outright prohibitions or restrictions on the approval procedure on cross-border capital transactions. In contrast, market-based or indirect capital controls attempt to

discourage capital movements by making them costlier; the controls include explicit or implicit taxation of cross-border capital flows and dual or multiple exchange rates.

The currency and financial crises during the 1990s, such as the 1992–1993 European Monetary System crises, the 1994 Mexican crisis, and the 1997–1998 Asian financial crisis, have focused world attention on the asset transactions that precipitated these crises. In Appendix A, using data about the 1997–1998 Asian financial crisis, we show that short-term capital flows are more risky than long-term capital flows; we measure risk by the coefficient of variation (CV), which is the ratio of the standard deviation to the absolute value of the mean of capital flows. We also show that short-term capital flows dropped after the crisis as a result of capital flight, and short-term capital flows became riskier after the financial crisis.

Government policies and market-oriented regulations adapt over time to economic conditions and the country's political process. Investors respond strategically to government policies and regulations when making their investment decisions. We model a dynamic strategic interaction between investors and the government of a country that receives capital flows. We choose microeconomics models over standard macroeconomic models to capture asset transactions in a framework where there is strategic interaction between investors and policy makers. We are not the first to use microeconomic techniques to analyse macroeconomic issues. Bris and Koskien (2000) and Chang and Valesco (2000), among others, have used microeconomic techniques to analyse various macroeconomic issues.

We incorporate welfare of the households of a recipient country into the government's objective function. We choose a tax on the exchange rate between the investors' home currency and the recipient country's currency. This tax is commonly known as the Tobin tax, proposed by Maurice J. Tobin in 1972. The Tobin tax is effectively a tax on capital inflows and depends on the economic conditions, the market-oriented regulatory reforms, and the political process in the recipient country. The Tobin tax has many advantages, including balancing trade flexibility, enhancing financial stability and allocating capital more efficiently, unlike tariffs which tend to favour some sectors of the productive economy over others. In fact, tariffs can get highly politicised, as witnessed by the recent trade war between two economic powers, namely China and the United States (https://carnegieendowment.org/chinafinancialmarkets/79641). The optimal tax on the exchange rate will depend on the exchange rate and returns in the recipient country as well as on returns in the investors' home country.

We model investors who have logarithmic utility functions. The investors face a tax on the exchange rate when they convert their investment funds into the recipient country's currency. For simplicity of our model, there are no taxes in the investors' home country, which enables us to examine the efficacy of the recipient country's policy to regulate capital inflows. Investors allocate their investment funds between their home country and the recipient country, and they must decide on the fraction of returns in the recipient country to repatriate to their home country at the end of each investment period. The investors maximise their utility. We solve a dynamic game by solving the associated subgames through backward induction. Using a subgame perfect Nash equilibrium concept, the Nash equilibrium for the game consists of the Nash equilibria obtained for the associated subgames.

We show that the government will increase the tax on exchange rate if the returns in the country are high in order to discourage a rash of capital inflows. Conversely, the government will decrease the tax on the exchange rate if returns in the investors' home country are high in order to attract capital inflows. The results are consistent with empirical evidence: the government of Brazil restricted capital inflows when its economy did well and relaxed the restriction on capital inflows when its economy did poorly (Cardoso & Goldfajn, 1998).

The impact of restricting capital inflows is large if the periods in the multiperiod economy are short. Indeed, one of the objectives of regulating capital inflows is to discourage short-term investment funds, which are largely speculative. This insight is consistent with empirical evidence suggesting that controls on capital flows have short-term effects (Edwards, 1999; Eichengreen, 1999). Due to the dynamic application of control on capital inflows, our model can deliver insights on piecemeal removal of capital controls as market-oriented regulatory reforms evolve over time.

Our work is related to three strands of the literature on capital flows. The literature on management of capital flows argues that a country may use capital controls to maintain the autonomy of its monetary policy and to reduce pressures on its currency (Akira et al., 2000; Eichengreen & Choudhry, 2005).

Another strand of literature argues that policy makers can use controls on short-term capital inflows to avoid financial market instability (Edwards, 1999; Eichengreen, 1999).

A third strand of literature on sequencing and speed of reforms argues that the relaxation of capital controls should take place towards the end of market-oriented reforms when a sound regulatory system for the local market is in

place (Cavlo, 1998; Fisher, 1998; Hanson, 1995; Ito & Portes, 1998; McKinnon, 1991; McKinnon, 1973; McKinnon & Phil, 1995).

Our work differs from these studies in important ways. Our work proposes a dynamic, strategic application of control on capital inflows. Applying the restriction on capital inflows trades off the benefits of capital inflows against their associated costs, considering several factors in applying capital control given the complexity of macroeconomic issues.

We have organised the remainder of the paper as follows. In Section 2 we provide a detailed description of the model. In Section 3 we provide a summary of our results. We provide proofs of technical results in the appendix.

## 2. The Model

A monetary policy to manage capital inflows trades off their benefits against their associated costs caused by adverse macroeconomic effects. We examine conditions under which authorities will restrict capital inflows. We focus on a government's objectives to mitigate the destabilising effects of short-term capital inflows and to prevent real currency appreciation and expansion of national debt.

We conduct a game-theoretical analysis of a control on capital inflows in a two-country open economy. We assume that capital flows originate in a developed country with their destination in an emerging market or developing country. The recipient country could also be a developed country (https://carnegieendowment.org/chinafinancialmarkets/79641). Investors are domiciled in the developed country, and they consist of institutions such as mutual funds (Note 5). Retail investors can invest their funds through mutual funds. In contrast, residents of the recipient country are passive; their welfare is incorporated into the authorities' objective function.

The financial side of the economy is characterised by two assets, one asset in each country. The asset in the recipient country may be risk-free in local terms, such as a treasury security, but risky from the perspective of investors who must convert returns from their investments into their home currency. We assume that returns in each country are uncorrelated over time and that returns in both countries also are uncorrelated over time.

The multiperiod open economy is indexed by the dates $t \in \{1,..,T\}$ where $T-1>0$ is the number of periods. Period $t$ is specified by the dates $t$ and $t+1$ where date $t$ identifies the beginning of the period and date $t+1$ identifies the end of the period. The dates link together the periods. For instance, date $t$ identifies both the end of period $t-1$ and the beginning of period $t$.

Let $e_t$ denote the date $t$ exchange rate; it is the unit price of the currency of the investors' home country in terms of the currency of the recipient country. Let $r_{t+1}$ denote the gross return on date $t$ investments in the investors' home country. Let $r^r_{t+1}$ denote the gross return on date $t$ investments in the recipient country. Let $\tau_t$ denote the date $t$ tax levied on the exchange rate $e_t$, meaning one unit of the investors' home currency earns $(1-\tau_t)e_t$ units of the currency of the recipient country. Let $y_t$ denote the amount of date $t$ funds invested in the recipient country. The investor repatriates into the home country the fraction $\alpha_t r^r_{t+1}(1-\tau_t)e_t y_t$ of the returns on investment in the recipient county, with the fraction $(1-\alpha_t)r^r_{t+1}(1-\tau_t)e_t y_t$ reinvested in the recipient country. On conversion into the home currency, we get

$$\alpha_t r^*_{t+1}(1-\tau_t)y_t = \alpha_t e^{-1}_{t+1} r^r_{t+1}(1-\tau_t)e_t y_t \quad (1)$$

$$r^*_{t+1} = e^{-1}_{t+1} r^r_{t+1} e_t \quad (2)$$

The gross return $r^*_{t+1}$ expressed in the investors' home currency depends on the exchange rates in two periods and returns on investment in the recipient country.

Several factors influence capital flows, including returns on investment and exchange rates. If gross returns in the recipient country are high, investors get high returns from their investments in that country. The exchange rate affects the returns when they are converted into the investors' home currency. If the investors' home currency is

relatively weak, investors get high returns on their investments in the recipient country, which may lead to more investment funds flowing into the recipient country.

We solve the multiperiod game through backward induction. We solve a subgame in each period. Starting with the last period, we work our way backwards. The Nash equilibria for the subgames constitute a subgame perfect Nash equilibrium for the dynamic game. We formalise the subgames below.

We specify the period $t$ subgame played by the authorities and investors.

**Problem 1.** Given an investor's investment period $t$ strategy $(x_t, y_t, \alpha_t)$, where $\alpha_t r^*_{t+1}(1-\tau_t)y_t$ is the fraction of the period $t$ returns denominated in the investor's home currency that the investor repatriates from the recipient country, and the fraction $(1-\alpha_{t-1})r^r_t y_{t-1}$ is reinvested in the recipient country, the authorities levy a tax $\tau_t$ on the exchange rate $e_t$ to lower the investor's home currency denominated returns from investment in the recipient country.

**Problem 2.** An investor facing date $t$ tax $\tau_t$ on the exchange rate $e_t$ allocates the investor's investment funds in the following manner. The investor allocates $x_t$ to the home country and $y_t$ to the recipient country and repatriates to the home country the fraction $\alpha_t$ of the returns in the recipient country to maximise the end of horizon expected utility

$$E\left[U(W_T)\right] = \log\left(r_T x_{T-1} + \alpha_{T-1} r^*_T (1-\tau_{T-1}) y_{T-1}\right) \tag{3}$$

The investor's budget constraints are

$$x_t + y_t \le r_t x_{t-1} + \alpha_{t-1} r^*_t (1-\tau_{t-1}) y_{t-1} \tag{4}$$

$$x_t, y_t \ge 0 \tag{5}$$

Consuming money is a common feature of finance models; the idea is that there is a correspondence between money and a unit of consumption. Also, consuming at the end of period is common in the finance literature (Liu & Loewenstein, 2002). The manager of a mutual fund could be an example that rationalises this assumption. The nonnegative investment allocations given by condition (5) exclude short sales. The investors consume a home good, so returns in the recipient country are converted into the home currency to finance consumption of the domestic good. The operator $E$ denotes the expectation operator. Investors form date $1$ expectations about random variables.

**Proposition.** The period t optimal tax $\tau_t$ on the exchange rate is

$$\tau_t = 1 - \frac{r_{t+1}}{r^*_{t+1}} \tag{6}$$

The investor's period t optimal utility is

$$E\left[U(W_T)\right] = \log\left(r_T r_{T-1} \ldots r_{T-t+1} r_{T-t} x_{T-t-1} + r_T r_{T-1} \ldots r_{T-t+1} \alpha_{T-t-1} r^*_{T-t} (1-\tau_{T-t-1}) y_{T-t-1}\right) \tag{7}$$

If the investors' home return is high, the authorities reduce the tax to attract capital inflows. If returns in the recipient country are high, the authorities increase the tax to discourage a surge in capital inflows.

The investor's utility in period t depends on returns from the end period up to period t because a complete utility maximisation should involve all the periods—the end period up to period t.

## 3. Conclusion

Despite the benefits of cross-border capital flows, there are costs as well, confronting policy makers with dilemmas. We model a dynamic, strategic application of a control on capital inflows by authorities of recipient countries that seek to regulate capital inflows due to their adverse macroeconomic effects. We examine conditions under which authorities will restrict capital inflows. Our theoretical analysis in a dynamic game framework using the subgame perfect Nash equilibrium concept in an open economy yields insights that are supported by empirical evidence (Cardoso & Goldfajn, 1998). If the local economic conditions are strong, the government restricts capital inflows to mitigate the adverse macroeconomic effects of capital inflows. If the local economic conditions are weak, the government decreases the restriction on capital inflows to attract them.

The dynamic and strategic application of capital controls makes the predictions of our model consistent with recommendation of piecemeal liberalisation of the current account. The tax on the exchange rate is effective in channelling capital inflows towards long-term investments, which tend to be beneficial to the recipient country.

**Notes**

Note 1. Capital flows consist of equity portfolio, debt flows, commercial lending, official flows, and foreign direct investment. Foreign direct investment is the net inflow of investment funds to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investors. It is the sum of equity capital, reinvestment of earnings, and other short-term and long-term capital.

Capital flows are influenced by external and internal factors. Internal factors are related to countries' domestic policies. For example, a country's inflation stabilisation programme can reduce macroeconomic risks. As a result, foreign investment funds will flow to the country. Other internal factors include institutional reforms such as the liberalisation of domestic capital markets (Obstfeld, 1986), the opening of trade accounts (Cavlo, 1988), and policies like tax cuts to increase rates of return.

Fluctuations in world interest rates are a key external factor that induces capital flows. When a country's interest rates are high, capital flows into the country in search of higher returns. Other external factors include the exchange rate, international business cycle, and regulatory developments that affect international diversification of portfolios.

Note 2. On July 31, 2019, U.S. Senators Tammy Baldwin and Josh Hawley submitted a bill "to establish a national goal and mechanism to achieve a trade-balancing exchange rate for the United States dollar, to impose a market access charge on certain purchases of United States assets, and for other purposes." According to an earlier memo that further explains the bill, the Competitive Dollar for Jobs and Prosperity Act would task the Federal Reserve with achieving and maintaining a current account balancing price for the dollar within five years. It would create an exchange rate management tool in the form of a Market Access Charge (MAC)—a variable fee on incoming foreign capital flows used to purchase dollar assets. The Federal Reserve would set and adjust the MAC rate. The Treasury Department would collect the MAC revenue. The result would be a gradual move of the dollar toward a trade-balancing exchange rate. The legislation would also authorize the Federal Reserve to engage in countervailing currency intervention when other nations manipulate their currencies to gain an unfair trade advantage (https://carnegieendowment.org/chinafinancialmarkets/79641 tackling trade imbalances through investment)

Note 3. Krugman (1999) argues that countries facing a major crisis could benefit from the temporary use of controls on capital outflows. Controls on capital outflows were recommended during the Asian crisis (Fortune, 28 September 1998) and during Iceland's banking and currency collapse (Financial Times, 21 February 2009). Historical evidence suggests that controls on capital outflows are largely ineffective. Indeed, empirical evidence suggests that the private sector finds ways to circumvent capital controls in the months prior to a devaluation crisis (Edwards, 1989; Edwards & Santaella, 1993). The main drawback is that, in most cases, controls on capital outflows are not used as a temporary tool during a crisis. Kaplan and Rodrik (2001) showed that the Malaysian controls produced better results than the alternative in almost all dimensions. On the real side, the economic recovery was faster, and employment and real wages did not suffer as much. On the financial side, the stock market did better, interest rates fell more, and inflation was lower.

Note 4. Chinese Premier Wen Jiabao has said the yuan cannot be allowed to rise sharply. In a speech to top EU officials, Mr. Wen argued that a big change in the value of the yuan could cause "social and economic turbulence" in China (BBC News, 6 October 2010).

Note 5. Institutions have investment strategies like mutual funds. Institutions show preference for stocks that are large and liquid (Gompers & Merrick, 2001; He et al., 2004).

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**Appendix A: Empirical Motivation for the Study**

A report of statistical measures of net capital inflows computed over the period 1990–2019 for a sample of East Asian countries affected by the 1997 Asian crisis. The East Asian countries include China, Indonesia, Laos, Philippines, Thailand and Vietnam. The flow variables are foreign direct investment, equity flow and debt flow (total of short-term and long-term). All the variables are reported as a share of GDP. The data are compiled from the World Bank and IMF statistics. The coefficient of variation (CV) is the ratio of the standard deviation to the absolute value of the mean of the flows. The short-term debt relative to stock and change is higher before the Asian crisis of 1997 and the difference in means is significant at the 1% level.

| Variable | Obs. | Mean (%) | Std. Dev. (%) | Min (%) | Max (%) | CV |
|---|---|---|---|---|---|---|
| **Period: 1990–2019** | | | | | | |
| Net flow of portfolio equity | 148 | 0.31 | 1.11 | -5.00 | 8.00 | 3.58 |
| Foreign direct investment | 174 | 3.15 | 2.37 | -3.00 | 12.00 | 0.76 |
| Net flow total external debt | 168 | 34.77 | 146.53 | -972.00 | 727.00 | 4.22 |
| Net flow short-term external debt | 168 | 17.08 | 121.21 | -912.00 | 624.00 | 7.10 |
| Net flow long-term external debt | 168 | 17.67 | 46.76 | -60.00 | 355.00 | 2.65 |
| Total external debt | 174 | 59.95 | 52.48 | 8.00 | 360.00 | 0.88 |
| Short-term external debt | 174 | 7.44 | 5.68 | 0.00 | 28.00 | 0.76 |
| Long-term external debt | 174 | 52.52 | 51.73 | 4.00 | 332.00 | 0.98 |
| **Sub Period 1: 1990–1996 (before the crisis)** | | | | | | |
| Net flow of portfolio equity | 29 | 0.41 | 0.73 | 0.00 | 3.00 | 1.77 |
| Foreign direct investment | 42 | 3.12 | 2.86 | 0.00 | 12.00 | 0.92 |
| Net flow total external debt | 36 | 14.19 | 16.87 | -2.00 | 75.00 | 1.19 |
| Net flow short-term external debt | 36 | 4.97 | 6.91 | -1.00 | 33.00 | 1.39 |
| Net flow long-term external debt | 36 | 9.25 | 11.83 | -4.00 | 43.00 | 1.28 |
| Total external debt | 42 | 90.71 | 75.55 | 15.00 | 360.00 | 0.83 |
| Short-term external debt | 42 | 10.43 | 8.03 | 0.00 | 28.00 | 0.77 |
| Long-term external debt | 42 | 80.29 | 73.61 | 12.00 | 332.00 | 0.92 |
| **Sub Period 2: 1998–2003 (after the crisis)** | | | | | | |
| Net flow of portfolio equity | 29 | 0.07 | 0.97 | -4.58 | 1.17 | 13.26 |
| Foreign direct investment | 36 | 2.53 | 2.21 | -2.76 | 6.43 | 0.87 |
| Net flow total external debt | 36 | 0.80 | 20.86 | -37.35 | 83.80 | 26.20 |
| Net flow short-term external debt | 36 | 0.56 | 20.47 | -30.88 | 94.51 | 36.52 |
| Net flow long-term external debt | 36 | 0.24 | 15.19 | -23.79 | 61.02 | 64.48 |
| Total external debt | 36 | 75.82 | 49.98 | 12.05 | 192.11 | 0.66 |
| Short-term external debt | 36 | 6.88 | 6.22 | 0.00 | 26.09 | 0.90 |
| Long-term external debt | 36 | 68.93 | 50.19 | 7.20 | 192.10 | 0.73 |
| **Sub Period 3: 1998–2019 (after the crisis)** | | | | | | |
| Net flow of portfolio equity | 119 | 0.29 | 1.19 | -5.00 | 8.00 | 4.15 |
| Foreign direct investment | 132 | 3.16 | 2.21 | -3.00 | 10.00 | 0.70 |
| Net flow total external debt | 132 | 40.39 | 164.77 | -972.00 | 727.00 | 4.08 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Net flow short-term external debt | 132 | 20.38 | 136.63 | -912.00 | 624.00 | 6.70 |
| Net flow long-term external debt | 132 | 19.97 | 52.20 | -60.00 | 355.00 | 2.61 |
| Total external debt | 132 | 50.16 | 38.08 | 8.00 | 192.00 | 0.76 |
| Short-term external debt | 132 | 6.49 | 4.31 | 0.00 | 26.00 | 0.66 |
| Long-term external debt | 132 | 43.68 | 38.88 | 4.00 | 192.00 | 0.89 |

## Appendix B: Proofs of Technical Results

**Proof of Proposition.** We consider a general one-period economy that captures a subgame Specifically, we consider the one-period economy indexed by dates $t$ and $t+1$. We write $\tau_t$ for the date $t$ tax on the exchange, which is effectively a tax on investment funds, and $r^*_{t+1} = e^{-1}_{t+1} r^r_{t+1} e_t$ for the date $t+1$ home currency gross return on date $t$ investments in the recipient country. The home currency gross return $r^*_{t+1}$ is dependent or the economic conditions in the recipient country. The tax rate $\tau_t$ on the exchange rate is influenced by the economic conditions in the recipient country. This implies that $\tau_t$ is a function of the gross return $r^*_{t+1}$. Thus, the derivative of the gross return $r^*_{t+1}$ with respect to $\tau_t$ is well defined.

The first-order condition associated with Problem 1 is given by the equation

$$\frac{d\left(r^*_{t+1}(1-\tau_t)y_t\right)}{d\tau_t} = \left((1-\tau_t)\frac{dr^*_{t+1}}{d\tau_t} - r^*_{t+1}\right)y_t = 0$$

If the investment allocation $y_t$ is not zero, we get the first-order differential equation

$$(1-\tau_t)\frac{dr^*_{t+1}}{d\tau_t} - r^*_{t+1} = 0 \tag{B1}$$

This differential equation is separable, so we write it in the form

$$\frac{dr^*_{t+1}}{r^*_{t+1}} = \frac{d\tau_t}{1-\tau_t}$$

The general solution to this differential equation is given by the relation

$$\int \frac{dr^*_{t+1}}{r^*_{t+1}} = \int \frac{d\tau_t}{1-\tau_t} + a_t$$

The constant $a_t$ is the usual constant of integration. By carrying out the integration exercise, we obtain the general solution

$$\ln\left(r^*_{t+1}\right) = -\ln(1-\tau_t) + a_t \tag{B2}$$

We apply the exponential function to both sides of this equation and obtain $r^*_{t+1} = \frac{c_t}{1-\tau_t}$, where $c_t = \exp(a_t)$.

We now express the tax in terms of the investors' home currency gross return on investments in the recipient country and the constant of integration. This is given by the equation

$$\tau_t = 1 - \frac{c_t}{r^*_{t+1}} \tag{B3}$$

The constant $c_t$ will be completely determined when we solve the investor's problem.

We solve Problem 2 backwards, starting at date $T-1$. Given the government's choice of a tax on investment funds flowing into the recipient country, an investor chooses the amount $x_{T-1}$ to invest in the home country and the amount $y_{T-1}$ to invest in the foreign country and fraction $\alpha_{T-1}$ of the returns in the recipient country to repatriate to the home country to maximise the investor's expected utility of terminal wealth

$$E\left[U\left(W_T\right)\right]=\log\left(r_T x_{T-1}+\alpha_{T-1}r_T^{*}\left(1-\tau_{T-1}\right)y_{T-1}\right) \tag{B4}$$

Subject to $x_{T-1}+y_{T-1}\le r_{T-1}x_{T-2}+\alpha_{T-2}r_{T-1}^{*}\left(1-\tau_{T-1}\right)y_{T-2}$ (B5)

$$x_{T-1},y_{T-1}\ge 0 \tag{B6}$$

Condition (A3) says that short sales are not allowed.

In the period $T-1,$ expectation is taken based on date $T-1,$ that is, information at this date and earlier dates is known. Because there is nothing left on the table, the budget constraint (B2) is binding, that is, this inequality is an equality.

$$x_{T-1}+y_{T-1}=r_{T-1}x_{T-2}+\alpha_{T-2}r_{T-1}^{*}\left(1-\tau_{T-2}\right)y_{T-2} \tag{B7}$$

We substitute these values into the investor's utility function and get

$$E\left[U\left(W_T\right)\right]=\log\left(r_T r_{T-1}x_{T-2}+r_T\alpha_{T-2}r_{T-1}^{*}\left(1-\tau_{T-2}\right)y_{T-2}+\left(\alpha_{T-1}\left(1-\tau_{T-1}\right)r_T^{*}-r_T\right)y_{T-1}\right) \tag{B8}$$

Differentiating this objective function with respect to $y_{T-1}$ and setting the derivative to zero yields the equation $\dfrac{\alpha_{T-1}\left(1-\tau_{T-1}\right)r_T^{*}-r_T}{r_T r_{T-1}x_{T-2}+r_T\alpha_{T-2}r_{T-1}^{*}\left(1-\tau_{T-2}\right)y_{T-2}+\left(\alpha_{T-1}\left(1-\tau_{T-1}\right)r_T^{*}-r_T\right)y_{T-1}}=0.$ This equation implies that the numerator is zero. In other words, we have

$$\alpha_{T-1}\left(1-\tau_{T-1}\right)r_T^{*}-r_T \tag{B9}$$

If the fraction of returns in the recipient country that the investor repatriates to the home country is not zero, then the period $T-1$ tax regime is

$$\tau_{T-1}=1-\frac{r_T}{\alpha_{T-1}r_T^{*}} \tag{B10}$$

Differentiating the objective function (B8) and setting the derivative to zero yields the equation $\dfrac{\left(1-\tau_{T-1}\right)y_{T-1}}{r_T r_{T-1}x_{T-2}+r_T\alpha_{T-2}r_{T-1}^{*}\left(1-\tau_{T-2}\right)y_{T-2}+\left(\alpha_{T-1}\left(1-\tau_{T-1}\right)r_T^{*}-r_T\right)y_{T-1}}y_{T-1}=0.$ We conclude that the numerator is zero. In other words, we have the equation

$$\left(1-\tau_{T-1}\right)y_{T-1}=0 \tag{B11}$$

This suggests investors are left with zero after taxes funds for investment. Thus, we get a corner solution, $\alpha_{T-1}=0,1.$ From (B10) we rule out the corner solution $\alpha_{T-1}=0,$ allowing only the corner solution $\alpha_{T-1}=1.$ In other words, investors repatriate to their home country all the returns from investment in the recipient country. This is consistent with intuition, meaning investors repatriate to their home country all the investment returns from the recipient country to finance consumption of the domestic good in the last period.

Continuing working backward, we consider the period $T-t$ economy. An investor chooses the investment funds $x_{T-t}$ and $y_{T-t}$ together with the fraction $\alpha_{T-t}$ of returns on investment repatriated to the home county to maximise utility of terminal wealth

$$E\left[U\left(W_T\right)\right]=\log\left(r_T r_{T-1}...r_{T-t+1}x_{T-t}+r_T r_{T-1}...r_{T-t+2}\alpha_{T-t}r^*_{T-t+1}\left(1-\tau_{T-t}\right)y_{T-t}\right) \quad \text{(B12)}$$

Subject to $x_{T-t}+y_{T-t}\le r_{T-t}x_{T-t-1}+\alpha_{T-t-1}r^*_{T-t}\left(1-\tau_{T-t-1}\right)y_{T-t-1}$ (B13)

$$x_{T-t},y_{T-t}\ge 0 \quad \text{(B14)}$$

There is nothing left on the table, so budget constraint (B12) holds with equality. In other words,

$$x_{T-t}+y_{T-t}=r_{T-t}x_{T-t-1}+\alpha_{T-t-1}r^*_{T-t}\left(1-\tau_{T-t-1}\right)y_{T-t-1} \quad \text{(B15)}$$

We express $x_{T-i}$ in terms of $y_{T-i}$ and substitute into the objective function (B11) and get

$$E\left[U\left(W_T\right)\right]=\log\begin{pmatrix} r_T r_{T-1}...r_{T-t}x_{T-t-1}+r_T r_{T-1}...r_{T-t+1}\alpha_{T-t-1}r^*_{T-t}\left(1-\tau_{T-t-1}\right)y_{T-t-1} \\ +r_T r_{T-1}...r_{T-t+2}\left(\alpha_{T-t}\left(1-\tau_{T-t}\right)r^*_{T-t+1}-r_{T-t+1}\right)y_{T-t}\end{pmatrix} \quad \text{(B16)}$$

Differentiating this objective function with respect to $y_{T-i}$ and setting the derivative to zero yields the equation

$$\frac{r_T r_{T-1}...r_{T-t+2}\left(\alpha_{T-t}\left(1-\tau_{T-t}\right)r^*_{T-t+1}-r_{T-t+1}\right)}{\begin{matrix}r_T r_{T-1}...r_{T-t}x_{T-t-1}+r_T r_{T-1}...r_{T-t+1}\alpha_{T-t-1}r^*_{T-t}\left(1-\tau_{T-t-1}\right)y_{T-t-1}\\ +r_T r_{T-1}...r_{T-t+2}\left(\alpha_{T-t}\left(1-\tau_{T-t}\right)r^*_{T-t+1}-r_{T-t+1}\right)y_{T-t}\end{matrix}}=0.$$ This equation implies that the numerator is zero, that is, we have equation

$$\alpha_{T-t}\left(1-\tau_{T-t}\right)r^*_{T-t+1}-r_{T-t+1}=0 \quad \text{(B17)}$$

The period $T-t$ tax regime is

$$\tau_{T-t}=1-\frac{r_{T-t+1}}{\alpha_{T-t}r^*_{T-t+1}} \quad \text{(B18)}$$

Differentiating the objective function (B16) with respect to $\alpha_{T-t}$ and setting the derivative to zero yields the equation $\frac{r_T r_{T-1}...r_{T-t+2}\left(1-\tau_{T-t}\right)r^*_{T-t+1}y_{T-t-1}}{\begin{matrix}r_T r_{T-1}...r_{T-t}x_{T-t-1}+r_T r_{T-1}...r_{T-t+1}\alpha_{T-t-1}r^*_{T-t}\left(1-\tau_{T-t-1}\right)y_{T-t-1}\\ +r_T r_{T-1}...r_{T-t+2}\left(\alpha_{T-t}\left(1-\tau_{T-t}\right)r^*_{T-t+1}-r_{T-t+1}\right)y_{T-t}\end{matrix}}=0.$ We conclude that the numerator is zero. In other words, we have

$$\left(1-\tau_{T-t}\right)y_{T-t-1}=0 \quad \text{(B19)}$$

This suggests investors are left with zero after taxes funds for investment. Thus, we get a corner solution, $\alpha_{T-t}=0,1.$ From (B18) we rule out the corner solution $\alpha_{T-t}=0,$ and we only allow the corner solution $\alpha_{T-t}=1.$ The conclusion is that investors repatriate to their home country all the investment returns in the recipient country. This we set $c_t=r_{t+1}$ in (B3), proving the optimal tax (6) in the proposition.