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The Capital Structure of Nations*

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Abstract

When a nation can finance its investments via foreign-currency denominated debt or domestic-currency claims, what is the optimal capital structure of the nation? Building on the functions of fiat money as both medium of exchange, and store of value like corporate equity, our model connects monetary economics, fiscal theory, and international finance under a unified corporate finance perspective. With frictionless capital markets both a Modigliani–Miller theorem for nations and the classical quantity theory of money hold. With capital market frictions, a nation's optimal capital structure trades off inflation dilution costs and expected default costs on foreign-currency debt. Our framing focuses on the process by which new money claims enter the economy and the potential wealth redistribution costs of inflation.

Keywords: Fiat Money, Inflation, Equity, Foreign-currency Debt, Foreign-currency reserves

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1. Introduction

When a nation can finance its investments via foreign-currency denominated debt or domestic-currency claims, what is the optimal capital structure of the nation? Can corporate finance theory shed light on this financing question for nations? The choice of capital structure for a firm is sometimes narrowly formulated as a choice of optimal leverage. How high should the ratio of debt to total assets be? For nations this question is typically formulated as a debt sustainability problem. What is a reasonable range for the debt-to-GDP

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ratio? However, even such a narrow framing around corporate leverage cannot entirely avoid addressing the issue of when and how much a firm should rely on *equity versus debt financing* for its investments. This is where an analogy between the financial structure of a corporation and the financial structure of a nation becomes problematic. For, what is the analog of corporate equity for a nation?

The idea we put forward in this paper is that the *fiat money* of a nation and other fiat claims may be seen as a close equivalent to the common stock of a corporation. At the simplest level, shares in a company just as units of fiat money entitle the owner to a *pro rata* share of output. For a company, the output is profits net of interest expenses and taxes. For a nation, the output is real production of goods and services net of any foreign debt obligations. The goal of this paper is to formally model this analogy and thereby inform the determination of the optimal capital structure of nations.

In finance textbooks corporate equity is defined as simply a financial claim entitling the holder to a pro rata share of residual cash-flows. Voting rights attached to common stock and the corporate control dimension of common stock instruments are typically ignored in both textbooks and most corporate finance models (see e.g., the survey by Harris and Raviv, 1991). The parallel of equity with fiat money is most compelling under such a stylized representation of equity, especially in a static model. Abstracting from control considerations of corporations is convenient as it allows us to also abstract from political considerations for nations. Still, there remain important differences, which mainly have to do with the fact that fiat money is not only a store of value but also a medium of exchange. That is, individuals store value by holding money balances from one period to the next and they obtain output by trading money for goods. The additional function of fiat money as medium of exchange is a key feature of our model.

Particularly relevant for nations is the pecking order theory of corporate financing of Myers and Majluf (1984) and Myers (1984), which pits the (informational) dilution cost advantages of debt against financial distress costs or debt-overhang costs (Myers, 1977). According to this theory, nations, like corporations, should fund their investments and other expenditures first with internal funds (or tax revenues), then with debt, and finally with equity.

The analog of dilution costs of equity for the owners of a firm is inflation costs for the holders of fiat money. If a company issues new shares to new shareholders at a price below their true value, then the value of the shares held by existing shareholders is *diluted*. Similarly, when a nation issues more money to new holders while adding less real output than the purchasing power of money, then existing holders of money are also diluted in proportion to the *transfer of value*. Hence, as in Myers and Majluf (1984) the optimal financial structure of a nation can be understood as pitting the inflation costs of money issuance against the default and debt-overhang costs of debt.

The basic model we consider has three periods. In period 0 the nation undertakes investments, which improve the production technology. We consider financing of these investments either through (foreign-currency) debt or through fiat money issuance. The nation is run by a representative risk-neutral agent, who maximizes the utility of consumers' life-time consumption. This representative agent thus issues claims in period 0 to finance investments against period-2 output. Production takes place in period 1 and requires a real consumption good as an input. This real good is purchased from a representative consumer with fiat money held by the representative firm. Thus, money in our model plays the dual role of means of exchange and store of value. Realized output in period 2 is stochastic and is sold to the representative consumer (after subtracting any foreign-currency debt obligations) against money saved by the representative consumer from period 1 to period 2.

We begin our analysis by considering a frictionless economy, and show that an analog of the Modigliani–Miller irrelevance theorem can be established for nations. In an ideal frictionless economy it does not matter how the nation funds its investments. It obtains the same final expected utility for the representative consumer by financing its investments by printing money or by issuing debt. In addition, under frictionless capital markets the classical quantity theory of money also holds. The Modigliani–Miller irrelevance theorem for nations combines in our reduced-form framework the ideas of *Ricardian Equivalence* (Barro, 1974) and the *Fiscal theory of the price level* (Leeper, 1991; Sims, 1994, 2001; Woodford, 1995; Cochrane, 2005).

As in all corporate finance theories, capital structure for the nation only matters in the presence of friction. We introduce two types of frictions. First, if the nation relies on foreign-currency financing, we introduce a classic willingness to repay problem. If realized output in period 2 is too low relative to the nation's debt burden, then the nation prefers to default on its debt obligations even if it incurs a deadweight output loss as a result of the default. Second, if the nation relies on equity financing (printing money), it may incur equity dilution or inflation costs. We model these costs by introducing differences of beliefs between international investors, who offer investment goods in exchange for money, and domestic residents regarding the nation's future monetary policy. The more the nation relies on printing money, the more investors worry about future inflation. When investors have an exaggerated fear of inflation they will undervalue the nation's currency and thus impose a funding cost on domestic residents. The representative consumer of the nation then trades off the dilution costs of money against the expected default cost of debt to determine an optimal capital structure of the nation.

Our theory of the capital structure of nations makes an explicit comparison between the benefits of printing money (what money buys) and the costs (higher inflation). Thus, if the benefits of printing money are substantial (e.g., financing a valuable investment or avoiding a buildup of unsustainable debts) then they may justify paying some inflation costs. As Myers and Majluf (1984) make clear, it may be optimal for a firm (or a nation) to issue new equity to fund a new valuable investment even at the cost of diluting ownership, and even if the new equity offering results in a stock price drop.

The classic quantity theory of money is a benchmark model in monetary economics. We contribute to this theory by describing more explicitly the process by which fiat money enters the economy. The stock of fiat money is not increased by dropping money from a helicopter (as is often assumed in textbook treatments), but by purchasing real goods and securities with the newly printed money. A key determinant of the effects of an increase in the money base on the price level then is the size of the increase in output resulting from the real investment that is financed with the new money issue.

By focusing on what money buys, our theory also emphasizes the tight link between the costs of inflation and redistribution of wealth. In our model there is no cost of inflation without redistribution. The cost of inflation (if there is any) is the transfer of wealth (if there is one) from existing holders of money to the new holders of money. As is the case in Myers and Majluf (1984), where a new equity issue involves no dilution of existing shareholders if it is a rights issue, if a nation issues new money to existing holders in proportion to their holdings then there is no cost of inflation.

After analyzing the optimal capital structure and characterizing different equilibria, we extend our analysis by considering the effects of debt overhang, when the nation's legacy debt is so large that it could distort the nation's efficient investment decisions. We find that under an equity-financed investment there is no debt overhang if and only if inherited debt is safe, while under a debt-financed investment there is no debt overhang if inherited debt is risky. We further proceed to analyze how monetary policy and debt monetization can help deal with debt overhang. We find that it is always possible to avoid default by monetizing domestic-currency debt. It is even possible to avoid default through monetization when debt is denominated in foreign-currency, provided that the nation's real output after suffering a bad shock is greater than its foreign-currency liabilities.

Some of the main model predictions on the optimal choice of financing are straightforward. This is true for example for the prediction that nations with a reputation for conservative monetary policy should not fund themselves with foreign-currency denominated debt. Other predictions are less obvious. For instance, nations that have not established a solid reputation for fiscal and monetary austerity, but that also face large deadweight costs of default are still better off financing their investments by issuing domestic-currency claims. If a nation is at risk of suffering a major banking crisis as a result of the default on its foreign-currency debt it may be preferable to finance its investments with domestic-currency debt.

Related Literature. An analogy between corporate equity and fiat money has first been made in the context of the fiscal theory of the price level (Sims, 2001; Cochrane, 2005).[1] But the implications of this analogy for the optimal financing of government expenditures are not systematically explored in this literature. Sims (2001) contrasts domestic-currency debt financing with dollarized debt financing and argues that full dollarization is inefficient, as it amounts to giving up a valuable option to inflate the debt.

Although our basic model borrows several elements of the pecking-order theory of Myers (1984), one important difference in our modeling of the costs of equity is that we do not impose rational expectations on investors and domestic residents. Instead, we follow Hong, Scheinkman, and Xiong (2006); Dittmar and Thakor (2007); and the "market-driven" corporate finance literature (Baker, 2009) by allowing for a more realistic, behavioral perspective on expectation formation, with differences of opinion between foreign investors and domestic consumers, as in Scheinkman and Xiong (2003).[2]

There is clearly a link between our analysis and the international finance literature on sovereign debt, especially the literature around the notion of the "original sin." This is a term introduced by Eichengreen, Hausmann, and Panizza (2003) to refer to the observation that until recently most emerging market nations would only issue foreign-currency denominated debt. They argue that it was impossible for most of these nations to borrow from international investors in the form of domestic-currency debt, as they had not established a credible monetary policy to control inflation. Relatedly, Eaton and Gersovitz (1981) and Bulow and Rogoff (1989) have argued that it could also be difficult for these

1 Cochrane (2005) identifies the connection when he writes: "The fiscal theory of the price level recognizes that nominal debt, including the monetary base, is a residual claim to government primary surpluses, just as Microsoft stock is a residual claim to Microsoft's earnings." (Cochrane, 2005, p. 502).

2 Malmendier and Nagel (2015) find evidence that individual inflation expectations are far from rational and are heavily influenced by individuals' personal past experiences with inflation.

nations to raise funds by issuing foreign-currency debt, as they had a limited ability to commit to repay.

Besides the limited commitment problem that constrains sovereign borrowing, another widely examined problem in the international finance literature following Calvo (1988) is self-fulfilling debt crises, which expose sovereigns who borrow in the form of foreign-currency debt to substantial financial risk (see Chang and Velasco, 2000; Cole and Kehoe, 2000; Burnside, Eichenbaum, and Rebelo, 2001; Jeanne and Wyplosz, 2003; Jeanne and Zettelmeyer, 2005; Jeanne, 2009a, 2009b).

The more recent studies on self-fulfilling debt crises extend the framework to include both domestic and foreign-currency debt. The central question addressed in these studies is whether the risk of self-fulfilling debt crises can be reduced or entirely avoided if the debt is denominated in domestic currency (see Aguiar *et al.*, 2013; Araujo, Leon, and Santos, 2013; Jeanne and Wang, 2013; Corsetti and Dedola, 2014; Bacchetta, Perrazi, and van Wincoop, 2015; Nuño and Thomas, 2015; Reis, 2017). To the extent that the monetization of domestic-currency debt can mitigate the risk of self-fulfilling debt crises, albeit at the cost of higher inflation, these studies explore a related tradeoff to ours: The benefit of domestic-currency debt is a lower risk of default but this comes at the expense of a higher cost of inflation.

Although the general tradeoff in these studies is similar to ours, the conception of inflation costs is entirely different. Taking a corporate finance perspective, we associate inflation costs with dilution costs. The cost of inflation is a wealth redistribution cost from domestic residents to foreign investors. The above studies on credibility and self-fulfilling debt crises, however, introduce inflation costs exogenously, or tie the cost of inflation to a loss in future monetary credibility. The higher is current inflation, the higher is expected future inflation. This, in turn, results in higher nominal debt yields, and thereby in higher future debt servicing costs, which invite further future monetization and therefore higher future inflation, etc. Our model can also accommodate concerns over monetary credibility and thereby allow for unsustainable domestic-currency debt. However, to focus on the more novel notion of dilution costs we downplay credibility issues for most of our analysis. Note also that our corporate finance perspective allows us to delink a monetary expansion (a new equity issue) with a mechanical increase in the price level. The monetary expansion may not necessarily result in an increase in the price level if it is used to fund a positive NPV investment.

Another related international finance literature is that on sovereign debt overhang (Sachs, 1984; Krugman, 1988; who build on the corporate finance ideas of Myers, 1977). Our analysis of debt overhang relates in particular to the literature on sovereign debt sustainability and the question of what is a reasonable range for a sustainable debt-to-GDP ratio (see e.g., Huang and Xie, 2008). We address this issue from the perspective of the capital structure of nations and suggest a combination of policy tools, including monetary policy, debt monetization, and foreign exchange reserves management, to deal with sovereign debt overhang issues.

In policy discussions and scholarly writings on sovereign-debt restructuring, the analogy with corporate debt is taken for granted (see Bolton, 2003; Panizza, Sturzenegger, and Zettelmeyer, 2009). The latest, prolonged, Greek debt crisis, and the dramatic legal battles over Argentina's sovereign-debt restructuring following the 2012 ruling of the US Southern District Court in New York, have injected new life in the idea of creating a sovereign-debt restructuring scheme for nations akin to corporate bankruptcy.

Our paper also contributes to the growing literature on foreign exchange reserves, which distinguishes between two explanations for the recent build-up of reserves: beggar-thy-neighbor policies (Dooley, Folkerts-Landau, and Garber, 2004) and precautionary savings (Jeanne, 2007). We emphasize foreign exchange reserves management as a tool of monetary policy for an open economy, developed, or developing countries alike.

Finally, our paper is also related to the macroeconomics of public finance, and sheds new light on the fiscal theory of the price level and the relationship between fiscal constraints and monetization.

The remainder of the paper is structured as follows. Section 2 develops the basic model. Section 3 establishes the Modigliani–Miller theorem for nations and the quantity theory of money. Section 4 introduces the basic frictions of willingness to inflate and willingness to repay and derives the optimal capital structure of nations. Section 5 extends the analysis to debt overhang. Section 6 considers debt monetization and the interaction of fiscal and monetary policy. Section 7 analyzes a nation's foreign exchange reserves management. Section 8 discusses empirical predictions of the basic theory, and section 9 concludes. Proofs are presented in the Appendix.

2. Model

We consider a nation with an open economy, operating over three periods. In the initial period (date 0) the nation can undertake an investment of size $k > 0$, which improves its productivity. In the intermediate period (date 1) the nation allocates its initial endowment of goods w between consumption c_1 and inputs for production. In the final period (date 2), output is realized and consumed.

We begin by describing the economy at dates 1 and 2, assuming that no investment has been undertaken at date 0. We can think of these two dates as representing a short time window of the life-cycle of an infinitely lived nation. The economy comprises a continuum of identical consumers and firms operating in perfectly competitive markets. Consumers are assumed to be risk-neutral and to maximize total life-time consumption. Consumers require a minimum subsistence consumption in each period, which we normalize to equal 0, so that we must have $c_t \geq 0$, $t = 1, 2$. Their utility function is:

$$U(c_1, c_2) = \beta c_1 + c_2, \tag{1}$$

where $\beta \leq 1$, so that consumers have a preference for late rather than early consumption. Consumers' initial endowment of goods at date 1 is $w > 0$. They can store their initial endowment or sell it to firms. Storage, however, results in some depreciation: if the endowment w is stored from period 1 to period 2 it depreciates to dw, where $d < 1$. For most of our analysis we can set $d = \beta$ without loss of generality.

The representative competitive firm uses the consumption good as an input into production. Its production function is given by

$$y \equiv \theta f(x),$$

with $f' > 0$, $f'' < 0$, where θ is a productivity shock with p.d.f. $h(\cdot)$ and c.d.f. $H(\cdot)$ on the support $[\theta_L, \theta_H]$ (with $\theta_L > 0$), and x denotes the quantity of input used by the firm in production. Firms' initial endowment of fiat money is $m > 0$. They purchase consumers' initial endowment of inputs using cash at date 1, and consumers use the saved cash to purchase firms' output at date 2.

Firms are owned by entrepreneurs, whose objective is to maximize date 2 output, as their date 2 consumption is a fraction $\psi \in (0, 1)$ of final output. To minimize the number of parameters to keep track of, we let $\theta f(x) = \theta(1-\psi)F(x)$ denote the final output to be brought to the market, net of the entrepreneur's consumption (i.e., output gross of entrepreneurial consumption is $\theta F(x)$). Let m_2 denote the representative firm's holdings of cash at the end of period 2, then the continuation value for the firm is given by $V(m_2)$, which is strictly increasing in m_2. The value $V(m_2)$ can be thought of as the present discounted value of future entrepreneurial consumption streams.

To be able to consume, entrepreneurs must be able to produce. And to be able to produce they must be able to purchase inputs. They can only do this against fiat money. If m_2 represents the expected money holdings of the representative firm, then the value of money holdings m_i for an individual firm i is given by $\hat{V}(m_i; m_2)$. This value is clearly increasing in m_i, $\partial\hat{V}(m_i; m_2)/\partial m_i > 0$, as firm i is then able to purchase more inputs in the subsequent iteration. In equilibrium all firms end up holding the same amount of money m_2 and we have $\hat{V}(m_i; m_2) \equiv V(m_2)$. Moreover, we have $V'(m_2) \equiv \partial\hat{V}(m_i; m_2)/\partial m_i > 0$. This is a simple way of solving the Hahn (1965, 1982) problem that in a final period money has no value.

In the situation where this economy functions with no investment and no borrowing, the *central planner*'s intertemporal optimization problem is to solve:

$$\max[\beta(w-x) + \overline{\theta}f(x)],$$

where $\overline{\theta} = E(\theta)$.

We shall make the following assumption throughout our analysis:

Assumption A1. *$xf'(x) \geq f(x)$ for all $x \leq w$.*

Under this assumption it is optimal to set $x = w$, and period 1 is entirely a production period, while period 2 is a consumption period.

To set this outcome up as a competitive equilibrium we need firms to optimally give up all their cash m for the whole consumer endowment w in period 1, and we need consumers to optimally purchase the entire period 2 output of firms $\theta f(w)$. If we let the price of goods in period 1 be $p_1 = m/w$ and the price of goods in period 2 be $p_2(\theta) = m/[\theta f(w)]$, then the value of money in period 2 is:

$$\frac{1}{p_2(\theta)} = \frac{\theta f(w)}{m}.$$

We can verify that the representative consumer cannot do better than sell her entire endowment for a price p_1 in period 1, and that the representative firm cannot do better than sell its entire production for a price $p_2(\theta)$ in period 2 under Assumption A1.

Indeed, consider the possibility that the representative consumer only sells $x < w$ of her endowment in period 1 and consumes the remainder, $c_1 = w - x$. Then, her expected lifetime payoff is given by:

$$\beta(w-x) + E\left[\frac{1}{p_2(\theta)}\right]p_1 x = \beta(w-x) + \frac{\overline{\theta}f(w)x}{w} < \overline{\theta}f(w),$$

where the inequality follows immediately from Assumption A1.

Similarly, suppose that the representative firm holds on to some of its cash in period 1 and only purchases $x < w$ of inputs. It can then expect to produce and sell no more than $\overline{\theta}f(x)$ of output in period 2. Its total stock of cash at the end of period 2 is then:

$$(m - p_1 x) + E[\theta f(x) p_2(\theta)].$$

For any $x \leq w$, the firm can at the margin either hold p_1 in money or purchase one more unit of input and sell the incremental expected output $\overline{\theta}f'(x)$ at expected price $E[p_2(\theta)]$. It is optimal for the firm to use up all its money holdings m to purchase inputs if

$$E[\theta p_2(\theta)]f'(x) \geq p_1, \text{for all}\, x \leq w.$$

Or, substituting for $p_2(\theta)$ and p_1, if

$$E\left[\frac{m}{\theta f(x)}\theta\right]f'(x) \geq \frac{m}{w},$$

which is satisfied for all $x \leq w$ under Assumption A1.

Thus, the equilibrium in this simple economy reduces to the representative firm purchasing all the inputs for m in period 1 and the representative consumer purchasing all the firms' output for m in period 2.

The classical quantity theory of money holds in this simple situation of no investment, because a doubling of the stock of money m in the economy doubles the price of goods in period 1 and halves the value of money in period 2. We will show next that the classical quantity theory of money holds under more general conditions under which a Modigliani–Miller theorem for nations also holds.

3. The Modigliani–Miller Theorem for Nations

In this section, we derive the first key theorem of our model, an analog of the Modigliani–Miller irrelevance theorem for nations. We will show that the classical quantity theory of money is a corollary of this irrelevance theorem, which combines in a reduced-form framework the ideas of Ricardian equivalence and of the fiscal theory of the price level.

Consider the situation where the nation can make investments at date 0, which will enhance the representative firm's total output at date 2: By investing $k > 0$ at date 0, firm output in period 2 is increased by a factor $Q(k)$, where we assume that $Q(0) = 1,\ Q' > 0$ and $Q'' < 0$. To make the problem interesting, we assume that the investment is a positive net present value investment:

$$[Q(k) - 1]\overline{\theta}f(w) > k.$$

The nation raises k from international capital markets at a world price normalized to 1. In other words, following a standard assumption in analyses of open economies, we fix the world interest rate to zero, which amounts to setting the world price of capital to 1.[3] The nation can pay for this capital by either printing money $\delta_0 m$ in period 0 or by promising to repay k out of period 2 output.

We let $Q(k)f(w) = \Omega(k, w)$ to simplify notation, and suppress the dependence of Ω on k and w, whenever there is no ambiguity that Ω represents output when the nation has an endowment w and has undertaken the investment k in period 0.

We shall assume for now that the nation can issue default-free foreign-currency debt. Specifically, we assume:

Assumption A2. $\theta_L\Omega > k$.

3 One consequence of setting the world interest rate to zero is that Friedman's (1969) theory for the optimal money supply then results in an indeterminate rule for changes in *m*.

It is then feasible for the nation to always meet its foreign-currency debt obligations. We shall also assume that the nation can commit not to default and not to print more money after the increase in the money base of $\delta_0 m$.

Theorem 1 (Modigliani–Miller Theorem for Nations). *When there are no frictions in international capital markets it is equivalent to finance the investment k with either a domestic-currency debt or money issue, a foreign-currency debt issue, or any combination of foreign and domestic debt and money financing.*

Proof: See the Appendix. ■

When there are no frictions in capital markets, it is equivalent to finance the investment with a domestic-currency issue $\delta_0 m$, or with a foreign-currency denominated debt issue.

Note that when the Modigliani–Miller irrelevance theorem for nations holds, and the nation finances its investment k entirely with money issuance $\delta_0 m$ we have that:

$$\delta_0 = \frac{k}{\bar{\theta}\Omega - k}.$$

In other words, the increase in money supply at date 0 is given by the ratio of investment k, and $\bar{\theta}\Omega - k$, the total expected output net of investment. This expression for δ_0 suggests a simple rule for money supply akin to the monetarist prescription that the growth in the supply of money should be proportional to the growth in real output. The monetarist theory for money growth, however, does not say what the constant of proportionality should be, partly because it is silent on how money enters the real economy. Our analysis above proposes one way in which money can enter the economy, namely through purchases of capital goods and that the constant of proportionality is then given by the ratio above.

Upon closer examination, it also becomes apparent that the Modigliani–Miller irrelevance theorem for nations implies that the classical quantity theory of money must also hold. Since p_2 and $E[p_2]$ are linear functions of m, and since δ_0 is independent of m, a doubling of the stock of money m in the economy doubles the price of goods in period 1, or halves the value of money in period 2, and requires the nation to print $2\delta_0 m$ in period 0.[4]

Corollary 1. *When there are no frictions in capital markets, the classical quantity theory of money holds.*

A stock split just like a change in currency denomination should have neutral effects in a frictionless economic environment. A stock split could affect the market capitalization of a company in practice by improving secondary market liquidity. Similar effects can also be found for national economies following the re-denomination of the national currency.

Note also that since goods are invested productively in period 1, the value of money rises over time. The optimal quantity of money in periods 1 and 2 is indeterminate (assuming no transactions costs in printing money) given that the world interest rate is normalized to equal zero.

In sum, the Modigliani–Miller irrelevance theorem for nations implies that the quantity theory of money holds. As the proof highlights, it also combines in reduced-form Ricardian

4 In our model the link between the Modigliani–Miller theorem for nations and the classical quantity theory of money rests on the fact that money serves both as a store of value and a medium of exchange. This goes beyond the simple analogy between fiat money and equity in terms of equivalent stores of value, and highlights the key additional role money plays as a medium of exchange.

Equivalence, in the sense that the issuance of government debt does not create any value *per se* in frictionless capital markets.

4. Optimal Capital Structure for Nations

In this section, we enrich the model by introducing two frictions in international capital markets and derive the optimal capital structure for an open economy facing these frictions. For most of our analysis we consider the situation where the nation is able to raise financing to fund the investment k, and therefore generates expected output $\overline{\theta}\Omega$ in period 2.

A first imperfection that is commonly mentioned in the international finance literature is the sovereign's limited willingness to repay debts owed to international investors. As a result of the sovereign's limited commitment to repay debt obligations, the nation's cost of issuing debt claims to foreign investors is higher and its ability to raise funds via international debt issues is constrained. As Eaton and Gersovitz (1981) and Bulow and Rogoff (1989) emphasize, a sovereign will repay only if the cost of default is higher than the cost of servicing the debt.

The second friction we introduce is what we refer to as a nation's willingness to inflate problem. Just as a nation cannot commit to honor its debts, it cannot pledge to limit inflation. Investors may therefore be concerned about the risk of debasement of the currency and require compensation for holding claims denominated in the domestic currency. This imperfection is also commonly mentioned in general terms in the international finance literature. It is the premise of the notion of original sin of Eichengreen, Hausmann, and Panizza (2003). Equally, Jeanne (2009a) along with others invokes the lack of an emerging market nation's monetary credibility as a key reason why private sector lending in emerging markets is in the form of foreign-currency debt. However, the particular manifestation of this problem we capture below is more closely related to the corporate finance notion of dilution costs. If international investors' perceived risk of currency debasement is excessive, then the nation may incur a dilution cost by issuing undervalued domestic-currency claims to these investors. In its choice of mode of financing the nation then trades off the costs of debt stemming from the willingness to repay problem against the costs of dilution caused by an exaggerated perceived risk of money debasement.

We consider first the case where the nation funds k by printing money (or issuing domestic-currency debt), and second the case where the nation issues foreign-currency debt to finance k.

4.1 Equity Financing and Inflation Costs

Foreign investors will demand more or less money depending on how inflation prone the nation is. Following Myers and Majluf (1984), we assume that in period 0 it is not known for sure whether the future government in period 2 will be a monetary-dove or a monetary-hawk. A monetary-dove government will expand the money supply in period 2 by $\delta_1(1+\delta_0)m$ to fund domestic residents' consumption. This future expansion in the money base is a pure transfer to domestic residents that results in a higher nominal price level. In contrast, a monetary-hawk government will not expand the money supply in period 2 at all, so that $\delta_1 = 0$.

Myers and Majluf (1984) assume that investors have rational expectations. Later analyses of firm equity issuance (e.g., Hong, Scheinkman, and Xiong, 2006; Dittmar and

Thakor, 2007) depart from this assumption and instead assume that investors' beliefs are not fully rational. Investors may have different beliefs and may bet against each other. There is mounting evidence of the existence of differences of opinion among investors and of firms' equity issuance decisions being influenced by episodes of equity-market buoyancy (see Baker, 2009). Although our analysis could be carried out under the assumption of rational expectations, we shall allow for the possibility that investors' beliefs about inflation risk may differ. Specifically, we assume that domestic residents' and foreign investors' beliefs about future inflation risk may differ. This is to be expected given that domestic residents are likely to be much more familiar with local politics than foreign investors, and the latter are likely better equipped to identify global trends than local residents. The assumption of differences of beliefs is not only more realistic, but also allows for a more tractable analysis.

Thus, suppose that domestic residents expect to have a monetary-dove government in period 2 with probability $\lambda \in (0, 1)$ but that international investors' beliefs do not generally coincide with those of domestic residents. Let $\mu(\delta_0) \in (0, 1)$ denote the conditional probability that international investors assign to a monetary-dove government in period 1. When the nation increases its money supply $\delta_0 > 0$ at date 0, international investors put more weight on the possibility that they may face a monetary-dove government. We therefore assume that $\mu' \geq 0$. However, domestic and international investors' conditional beliefs $\mu(\delta_0)$ may be imperfectly revised in response to the financing choices of the government in period 0. We assume for simplicity and without much loss of generality that domestic residents' beliefs are unresponsive to changes in money supply.[5] For much of our analysis we shall restrict attention to the situation where $\mu(0) = \underline{\mu} < \lambda$ and $\mu(\delta_0) > \lambda$ for a sufficiently large δ_0.

Unresponsive investor beliefs. We begin our analysis by considering the simplest possible setup, the special case where neither international investors' nor domestic residents' beliefs are responsive to changes in the money supply: $\mu' = \lambda' = 0$. In this special case it is straightforward to derive the costs or benefits from monetary financing from the perspective of domestic residents. Basically, when $\mu > \lambda$ domestic residents incur an abnormal cost of monetary financing, given that international investors demand a higher compensation for inflation risk than is warranted from domestic residents' perspective. And vice versa, when $\mu < \lambda$ domestic residents perceive a benefit from monetary financing obtained at the expense of overly optimistic international investors. The following lemma states domestic residents' expected loss in purchasing power from monetary financing of the investment k.

Lemma 1. *When $\mu > \lambda$, domestic residents perceive a loss in expected purchasing power from financing the investment k with a money issue of:*

$$\frac{(\mu - \lambda)\delta_1 k}{1 + (1 - \mu)\delta_1}.$$

Proof: See the Appendix. ■

Note that if $\delta_1 = 0$ domestic residents' perceived loss in purchasing power is simply 0. And when μ is close to 1 the perceived loss in purchasing power reaches its highest level at $(1 - \lambda)\delta_1 k$. It is this perceived loss in purchasing power that domestic residents pit against the costs of debt financing in their choice of financial structure for the nation.

5 All our qualitative results hold if we assume instead that $\lambda(\delta_0) \neq \mu(\delta_0)$, and that $\lambda' \geq 0$.

4.2 Debt Financing and Deadweight Costs of Default

Consider next the situation where the nation funds k by borrowing in foreign-currency denominated debt. That is, the nation promises to repay D in output in period 2 to foreign investors against an investment of k in period 0. The nation may default on its debt if it is in its interest *ex post*. When the nation defaults, it will suffer a deadweight output loss due to, say (unmodeled), trade sanctions and other economic disruptions. Suppose that this cost is a percentage loss in final output $\phi > 0$, so that after default the nation can only produce and consume $(1-\phi)\theta\Omega$. Then, the nation will choose to default on its debt obligation D if and only if

$$\theta\Omega - D < (1-\phi)\theta\Omega,$$

or $D > \phi\theta\Omega$. Let $\theta_D \in [\theta_L, \theta_H]$ denote the cutoff

$$\theta_D = \frac{D}{\phi\Omega},$$

at which the nation defaults, and let D be the promised debt repayment such that the nation is just able to raise k to fund its investment:

$$\Pr(\theta \geq \theta_D)D = k.$$

Then, the expected deadweight cost of foreign-currency denominated debt financing is given by:

$$\Pr(\theta < \theta_D)E[\theta|\theta < \theta_D]\phi\Omega.$$

We summarize the above discussion in the following lemma.

Lemma 2. *When the nation finances its investment k by issuing foreign-currency debt D it incurs expected deadweight default costs*

$$\Pr(\theta < \theta_D)E[\theta|\theta < \theta_D]\phi\Omega,$$

where

$$\theta_D = \frac{k}{\Pr(\theta \geq \theta_D)\phi\Omega}.$$

Proof: See the discussion above. ■

Although the nation can raise debt at fair terms, doing so involves a deadweight cost of default as the nation cannot be sure that it will be able, or willing, to repay its debts in the future. Note that the nation's default decision is independent of whether the government is a monetary-dove or monetary-hawk, since the representative resident obtains the same real output in both cases. An expansion in the money supply of $\delta_1 m$ in this situation involves no inflation costs, as there is no redistribution of wealth from domestic residents to foreign investors as a result of the monetary expansion. In other words, such an increase in money supply is equivalent to a rights issue, preserving the *per-capita* output share each resident can buy.

4.3 Debt versus Equity Financing

When expected deadweight costs of default are large the nation may prefer to fund its investment by issuing domestic-currency liabilities that can always be monetized, even if it thereby incurs inflation costs. To compare inflation and default costs in the most tractable way we specialize the model to the case where θ can take only two values, $\theta \in \{\theta_L, \theta_H\}$ and denote by π the probability that θ_H is realized: $\Pr(\theta = \theta_H) = \pi \in (0,1)$; we let $\overline{\theta} \equiv \pi\theta_H + (1-\pi)\theta_L$.[6]

Consider first the decision for the nation whether to finance the investment k with either 100% foreign-currency debt or 100% equity. Then, comparing expected costs of default with expected inflation costs we obtain the following condition for the optimality of equity financing.

Theorem 2 (Optimal Financing). *Equity is the only feasible source of financing when* $\pi\theta_H\phi\Omega < k$. *When* $\pi\theta_H\phi\Omega \geq k$ *equity financing is always better than debt financing when* $\lambda > \mu$. *When* $\lambda \leq \mu$ *and*

$$\pi\theta_H\phi\Omega \geq k > \theta_L\phi\Omega, \tag{2}$$

equity financing dominates debt financing if:

$$\frac{(\mu-\lambda)\delta_1 k}{1+(1-\mu)\delta_1} < (1-\pi)\theta_L\phi\Omega. \tag{3}$$

Proof: See the Appendix. ■

Some simple comparative statics observations follow from Condition (3) in Theorem 2, which we summarize in the following corollaries.

Corollary 2. *(a) Nations that have an undeserved reputation for being monetary-doves—that is, nations for which* $(\mu-\lambda)$ *is large and* δ_1 *is large—are better off financing investments through foreign-currency denominated debt; (b) nations that face larger deadweight costs of default* ϕ*, or high investment return* Ω*, are better off financing their investments by printing money or by issuing domestic-currency claims; (c) the lower is the productivity* θ_L *in a crisis, the less the nation has to lose from a default; the higher is the probability of a good state,* π*, the more likely it is that the nation will be able to service its foreign debt.*

One reason why a nation may have a high deadweight cost of default ϕ is that it may suffer a banking crisis as a result of the default on its sovereign debt. The collapse of the banking system, which is inevitable if banks hold a significant fraction of the sovereign debt issued by the nation, would result in a serious contraction in output. Such a loss in output can be captured in reduced form in our model with the parameter ϕ. It then follows from Corollary 2 that nations that are concerned about such a possible banking collapse will limit their foreign-currency debt issuance. Note also that when θ_L is low the issuance of risky debt may be attractive for the issuing nation to achieve some consumption smoothing by, in effect, issuing a state contingent claim at relatively low deadweight default cost. Risky debt in this situation implements similar allocations as *GDP-indexed debt*.

When $\mu < \lambda$, the nation may not only strictly prefer to fund itself entirely through money issuance, but also want to issue even more ‘equity’ than it needs to fund its

6 As in Bolton and Jeanne (2007), we can obtain closed-form solutions under the assumption that θ is uniformly distributed on the interval $[\theta_L, \theta_H]$. The algebra is then more involved and less transparent, as the expected default cost is then given by the following expression:

$$\left[\theta_H - \left(\theta_H^2 - \frac{4k}{\phi\Omega}\right)^{\frac{1}{2}}\right]\frac{\theta_H\phi\Omega}{4} - \frac{k}{2} - \frac{\theta_L^2\phi\Omega}{2}.$$

investment outlays, and build foreign exchange reserves. We return to a discussion of foreign exchange reserves in section 7.

4.4 The Optimal Debt–Equity Ratio

Henceforth, we will focus on the most interesting case where $\mu > \lambda$ and ask what is then the optimal mix of finance for the investment k. How much should the nation rely on foreign-currency denominated debt, and how much should it rely on the issuance of domestic-currency liabilities?

Unresponsive beliefs. We begin by considering the special case where beliefs are unresponsive: $\mu' = \lambda' = 0$. Given that $\mu > \lambda$, it is strictly optimal for the nation to issue as much default-free foreign-currency debt as possible. The maximum amount of default-free foreign-currency debt that the nation can issue is given by $D_L = \theta_L \phi \Omega$. Whether the nation should issue more foreign-currency debt and take the risk of defaulting on its debt depends on the expected deadweight costs of default relative to the dilution costs incurred when the nation issues domestic-currency debt. The next proposition characterizes the optimal debt–equity ratio for situations where Condition (2) holds.

Proposition 1. *When $\mu > \lambda$ and Condition (2) holds, it is optimal to issue a combination of safe foreign-currency debt $D_L = \theta_L \phi \Omega$ and domestic-currency debt $[(1+\delta_0)(k-\theta_L\phi\Omega)-1]m$, where*

$$\delta_0 = \frac{(k-\theta_L\phi\Omega)(1+\delta_1)}{[1+(1-\mu)\delta_1]\overline{\theta}\Omega-(k-\theta_L\phi\Omega)(1+\delta_1)}, \tag{4}$$

if

$$\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1} \leq (1-\pi)\theta_L\phi\Omega. \tag{5}$$

Otherwise, it is optimal to finance the investment entirely with a foreign-currency debt issue of $D_H = k/\pi$.

Proof: See the Appendix. ■

The nation may not always be able to entirely finance its investment with risky foreign-currency debt. This is the case when $k > \pi\theta_H\phi\Omega$. When the latter condition holds the nation cannot avoid incurring some dilution costs. The condition under which the nation then prefers safe over risky foreign-currency debt is modified as follows.

Proposition 2. *When $\mu > \lambda$ and $k > \pi\theta_H\phi\Omega$, it is optimal to issue a combination of safe foreign-currency debt $D_L = \theta_L\phi\Omega$ and domestic-currency debt $[(1+\delta_0)(k-\theta_L\phi\Omega)-1]m$, where δ_0 is given by Equation (4) if*

$$\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1} \leq (1-\pi)\theta_L\phi\Omega. \tag{6}$$

Otherwise, it is optimal to finance the investment with a foreign-currency debt issue of $D_H = \theta_H\phi\Omega$ and domestic-currency debt $[(1+\delta_0)(k-\theta_H\phi\Omega)-1]m$, where

$$\delta_0 = \frac{(k-\pi\theta_H\phi\Omega)(1+\delta_1)}{[1+(1-\mu)\delta_1]\overline{\theta}\Omega-(k-\theta_H\phi\Omega)(1+\delta_1)}, \tag{7}$$

if

$$\frac{(\mu-\lambda)(k-\pi\theta_H\phi\Omega)\delta_1}{1+(1-\mu)\delta_1} \le (1-\pi)\theta_H\phi\Omega. \tag{8}$$

Proof: See the Appendix. ■

From Conditions (5) and (6) we observe that a nation's decision to avoid the risk of default by issuing no more than D_L in foreign-currency debt depends not only on the probability of default $(1-\pi)$ when issuing $D_H = \min\{k/\pi; \theta_H\phi\Omega\}$, or on the unit cost of dilution $(\mu-\lambda)$, but also on the nation's foreign-currency debt capacity, $\pi\theta_H\phi\Omega$. When the nation has a limited debt capacity, so that $k > \pi\theta_H\phi\Omega$, it cannot avoid incurring dilution costs, in which case it has a stronger preference to avoid default by limiting its reliance on foreign-currency debt.

Responsive beliefs. The nation's ability to fund itself with domestic-currency debt depends on the credibility of its monetary policy. This observation is the leitmotif of much of the international finance literature. The monetary credibility problem associated with domestic-currency debt can be captured in our model through responsive investor beliefs. Accordingly, suppose now that $\mu(\delta_0)$ has the following affine function specification:

$$\mu(\delta_0) = \underline{\mu} + \gamma\delta_0,$$

with $\gamma > 0$. This specification captures in a simple way the idea that the more domestic-currency liabilities $\delta_0 m$ the nation issues to foreign investors in period 0 the more investors believe that the nation will have a monetary-dove government in period 1. Investors have reasons to believe that a more monetary profligate government in period 0 is more likely to be followed by a monetary-dove government in period 1, since the more domestic-currency liabilities are in the hands of foreign investors the greater is the incentive for the nation to dilute their claims by printing more money in period 1. But, to the extent that investors anticipate the risk of a future monetary expansion in period 1 the cost of domestic-currency debt financing will be borne by the nation. This all the more so if investors' beliefs are excessively responsive to a monetary expansion in period 0. The next proposition establishes that if the sensitivity of beliefs to a monetary expansion is sufficiently high then it is optimal for the nation to finance its investment through foreign-currency debt.

Proposition 3. *When foreign investors have responsive beliefs $\mu(\delta_0) = \underline{\mu} + \gamma\delta_0$ such that $\underline{\mu} \ge \lambda$ and condition (2) holds, it is optimal to issue risky foreign-currency debt $D = k/\pi$ when $\gamma \ge \hat{\gamma}$, where $\hat{\gamma}$ is given by:*

$$\frac{(\underline{\mu}+\hat{\gamma}\delta_0-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\underline{\mu}-\hat{\gamma}\delta_0)\delta_1} = (1-\pi)\theta_L\phi\Omega.$$

Proof: See the Appendix. ■

In Proposition 3 we have assumed that foreign investors' beliefs are responsive but domestic residents' beliefs are unresponsive. The effect of a monetary expansion in period 0 is then to widen the differences in beliefs between foreign and domestic investors. In other words, the effect of a monetary expansion is to increase the perceived dilution costs for domestic residents. But, what if domestic residents' and foreign investors' beliefs are equally responsive, so that:

$$\mu(\delta_0) = \underline{\mu} + \gamma\delta_0 \text{ and } \lambda(\delta_0) = \underline{\lambda} + \gamma\delta_0,$$

with $\underline{\mu} > \underline{\lambda}$? In this case, it is straightforward to observe that differences in beliefs remain constant

$$\mu(\delta_0) - \lambda(\delta_0) = \underline{\mu} - \underline{\lambda},$$

so that Proposition 1 essentially applies with $(\mu - \lambda)$ replaced by $(\underline{\mu} - \underline{\lambda})$.

There is one important difference, however, with the situation of unresponsive beliefs. Namely that domestic-currency debt financing may not be feasible if beliefs are too responsive. To see this, suppose that beliefs are so responsive that $\mu(\delta_0) = 1$ for a sufficiently high $\delta_0 m$. It may then no longer be possible for the nation to finance $(k - \theta_L\phi\Omega)$ with domestic-currency debt. Indeed, setting $\mu(\delta_0) = 1$, this requires that the nation be able to issue sufficient domestic-currency claims $\delta_0 m$ to foreign investors to be able to raise $(k - \theta_L\phi\Omega)$:

$$E\left[\frac{1}{\hat{p}_2(\theta)}\right]\delta_0 m \geq k - \theta_L\phi\Omega,$$

where

$$E[\hat{p}_2(\theta)] = \frac{m(1+\delta_0)(1+\delta_1)}{\Omega(\overline{\theta} - \theta_L\phi)},$$

or, substituting for $\hat{p}_2(\theta)$:

$$\Omega(\overline{\theta} - \theta_L\phi)\frac{\delta_0}{1+\delta_0} \geq (k - \theta_L\phi\Omega)(1+\delta_1).$$

But, if δ_1 is too large this condition cannot be satisfied. We summarize this discussion in the proposition below.

Proposition 4. *When foreign investors have responsive beliefs such that $\mu(\delta_0) = 1$ for a finite δ_0, it is not possible to issue sufficient domestic-currency liabilities to fund $k - \theta_L\phi\Omega$, when δ_1 is sufficiently large.*

Proof: See the discussion above. ■

Proposition 4 is, in essence, the original sin observation of Eichengreen, Hausmann, and Panizza (2003). When a nation faces a major monetary credibility problem it may not be able to use domestic-currency liabilities to finance its investments even if expected costs of inflation are lower than expected default costs. The international finance literature on the currency composition of sovereign debt commingles credibility ideas with inflation cost ideas (see e.g., Aguiar *et al.*, 2013). However, as our analysis above illustrates, these are separate economic forces. Inflation costs are linked to dilution costs and wealth transfers from domestic residents to foreign investors. Credibility issues are linked to financial constraints and the nation's ability to maintain the real value of its monetary claims, whether they are held by foreign investors or domestic residents.

5. Debt Overhang

Suppose the nation is already indebted at time $t=0$ and has an outstanding stock of foreign-currency denominated debt of D_0, under what conditions is it worthwhile to invest in k? Consider in turn equity and debt financing.

Equity Financing. When the inherited stock of debt D_0 is low enough that it is always in the nation's interest to fully repay it, then under equity financing the choice whether to invest in k or not is unaffected by the presence of the debt D_0. To see this, observe that the expected payoff under no investment is

$$\overline{\theta}\Omega(0,w) - D_0.$$

And under equity financed investment the expected payoff is

$$[1-\alpha(\mu)]\overline{\theta}\Omega - D_0,$$

where

$$\alpha(\mu) = \frac{\delta_0}{1+\delta_0}\left(1 - \frac{\mu\delta_1}{1+\delta_1}\right) = \frac{k}{\overline{\theta}\Omega}.$$

The nation thus prefers an equity-financed investment to no investment if and only if:

$$[1-\alpha(\mu)]\overline{\theta}\Omega(k,w) \geq \overline{\theta}\Omega(0,w),$$

a condition that is independent of D_0.

However, when D_0 is so large that the nation may default in the crisis state, the legacy debt D_0 may overhang the nation's investment decision as the next lemma establishes.

Lemma 3 (Debt Overhang). *Suppose that* $\phi\theta_H\Omega(0,w) > D_0 > \phi\theta_L\Omega(0,w)$, *and that* $D_0 \leq \phi\theta_L\Omega(k,w)$. *Then* D_0 *is so large that the nation may prefer not to invest in* k *for some parameter values.*

Proof: See the Appendix. ■

Note that the situation where $D_0 > \phi\theta_H\Omega(0,w)$ is not interesting. It would mean that the nation inherits such a large stock of debt that it would default no matter what.

Debt Financing. Suppose first that $D_0 < \phi\theta_L\Omega(0,w)$, so that the expected payoff under no investment is:

$$\overline{\theta}\Omega(0,w) - D_0.$$

If the nation adds D_1 to its inherited debt to fund the investment, so that $(D_1+D_0) > \phi\theta_L\Omega(k,w)$, then its expected payoff becomes:

$$\pi[\theta_H\Omega(k,w) - D_1 - D_0] + (1-\pi)(1-\phi)\theta_L\Omega(k,w),$$

where $D_1 = k/\pi$. The nation thus prefers a debt-financed investment to no investment if and only if:

$$\pi\left[\theta_H\Omega(k,w) - \frac{k}{\pi} - D_0\right] + (1-\pi)(1-\phi)\theta_L\Omega(k,w) \geq \overline{\theta}\Omega(0,w) - D_0,$$

or rearranging:

$$\overline{\theta}[\Omega(k,w) - \Omega(0,w)] - k \geq (1-\pi)[\phi\theta_L\Omega(k,w) - D_0].$$

Given that $\phi\theta_L\Omega(k,w) > \phi\theta_L\Omega(0,w) > D_0$, an amount of safe inherited debt D_0 such that

$$D_0 > \phi\theta_L\Omega(k,w) - \frac{k}{\pi}$$

can potentially overhang a debt-financed investment.

In contrast to equity financing, for which there is no debt overhang problem as long as inherited debt D_0 is "safe," under debt financing any inherited "safe" debt that is sufficiently high to force the nation into risky debt territory when it funds its investment via additional debt D_1 can result in a debt overhang problem. By adding new debt D_1 to old debt D_0, the nation incurs an expected deadweight cost of default that acts like a tax on investment. More generally, every time the nation is in a situation where an increase in indebtedness raises the risk of default, it may face a debt overhang problem if it funds its investments via debt.

Suppose next that $D_0 > \phi\theta_L\Omega(0,w)$. The nation then prefers a debt-financed investment to no investment if and only if:

$$\pi[\theta_H\Omega(k,w) - \frac{k}{\pi} - D_0] + (1-\pi)(1-\phi)\theta_L\Omega(k,w) \geq$$

$$\pi[\theta_H\Omega(0,w) - D_0] + (1-\pi)(1-\phi)\theta_L\Omega(0,w),$$

or rearranging:

$$[\pi\theta_H + (1-\pi)(1-\phi)\theta_L][\Omega(k,w) - \Omega(0,w)] \geq k.$$

Note that in this case there is no debt overhang as the condition above is independent of the size of D_0.

We summarize the above discussion in the following proposition.

Proposition 5. *Under a debt-financed investment there is no debt overhang if inherited debt is risky, while under an equity-financed investment there is no debt overhang if and only if inherited debt is safe.*

Proof: See the discussion above. ■

This result is not entirely robust. If there is a positive recovery value of debt after default then whether inherited debt D_0 overhangs the nation's investment decision is less clear, as all the nation's foreign-currency denominated debt is *pari passu*. Adding new debt D_1 to the debt stock D_0 will then involve diluting the holders of the inherited debt and thus could result in a transfer to the nation. This transfer is a form of subsidy, which could encourage the nation to invest even if the net present value of the investment is negative.

When inherited debt is risky, one might expect that a nation would go out of its way to reduce its indebtedness in an effort to avoid any deadweight costs of default. But, this turns out not to be in domestic residents' best interests, as the main beneficiaries in any reduction in the risk of default are the holders of the inherited debt. When inherited debt is risky, it could actually be in the interest of domestic residents to increase the nation's indebtedness and risk of default in order to fund valuable investments. Indeed, the main losers from such an increase in the nation's indebtedness are the holders of the existing debt. Thus, debt overhang considerations in a sovereign debt context can give rise to debt dynamics where debt begets debt, to use an expression coined by Admati *et al.* (2014).

6. Monetary Policy and Debt Monetization

In this section, we extend the model to distinguish fiscal and monetary policy. We introduce a monetary authority that runs monetary policy separately from a fiscal authority. However, the two policies are interlinked through both debt monetization and the price level.

Thus, suppose that the representative agent delegates fiscal and monetary policy to two separate government agencies, an independent central bank charged with the conduct of monetary policy and a treasury department charged with fiscal policy. To keep the analysis simple, we shall assume that the fiscal authorities incur exogenously fixed public good expenditures, g, at time 0 that are financed by issuing debt b. This debt is repaid later through a combination of tax revenues and monetization of the debt by the central bank. Again for simplicity we will set the maximum tax rate $\overline{\tau} > 0$ exogenously, and we assume that taxes must be paid in fiat money.

The fiscal authorities can issue debt in either domestic or foreign currency. We show that if the debt is in domestic currency the government can always avoid a costly default by monetizing the debt. Avoiding default is not always possible if the debt is in foreign currency. However, even when the debt is in foreign currency, default can sometimes be avoided through monetization.

We begin by considering the case of domestic-currency debt financing of fiscal deficits. The timing is now as follows: In period 0 the fiscal authorities issue domestic-currency debt promises b to be repaid in period 2 in order to raise g units of endowment from the representative consumer toward public good expenditures. The representative consumer is willing to give up g units of endowment against a domestic-currency debt claim b as long as:

$$E\left[\frac{b}{p_2(\theta)}\right] \geq g, \tag{9}$$

and against a foreign-currency debt claim b_f as long as $b_f q(b_f) \geq g$, where $q(b_f)$ denotes the probability that the government does not default on its debt obligations in period 2.[7]

In period 1, the consumer then holds $(w-g)$ units of endowment and trades these against firms' money holdings at price $p_1 = m/(w-g)$. Period 2 begins with the realization of the productivity state $\theta \in \{\theta_L, \theta_H\}$ and real output $\theta f(w-g)$. The fiscal authorities move first by taxing household nominal wealth at rate $0 < \tau \leq \overline{\tau}$, and raising nominal tax revenues $\tau m \leq \overline{\tau} m$.[8] The tax proceeds go toward servicing the government's debt obligations b. The central bank can also monetize part of the debt b by printing money $\delta_2 m$ and making this quantity available to the fiscal authorities toward the repayment of the debt.

7 We assume for simplicity that when the government defaults debt-holders get no debt recovery at all.

8 Alternatively we could let the fiscal authorities tax nominal income $p_2(\theta)\theta f(w-g)$. The analysis of this formulation of the model is somewhat more involved but the results on debt monetization are unchanged.

Thus, given a tax rate τ and monetization $\delta_2 m$, the fiscal authorities' budget constraint is given by:

$$\tau m + \delta_2 m \geq b.$$

The consumer's budget constraint, in turn, is:

$$(1-\tau)m + b \geq p_2(\theta)\theta f(w-g),$$

as long as there is no default. That is, consumers start period 2 with their after-tax money holdings $(1-\tau)m$ plus the debt claims b they get repaid by the fiscal authorities, so that the total nominal income consumers have to spend is $(1-\tau)m + b$ and the total amount they must spend in purchasing firms' output is $p_2(\theta)\theta f(w-g)$.

There is no point for the fiscal authorities to run a surplus (net of debt repayments) in period 2. We shall therefore assume that the fiscal authorities will always set $\tau \leq \bar{\tau}$ so as to exactly balance their budget. More precisely, when $\bar{\tau}m \geq b$ the tax rate τ is set so that $\tau m = b$. When $\bar{\tau}m < b$, δ_2 is set so that

$$\bar{\tau}m + \delta_2 m = b. \tag{10}$$

Equilibrium prices $p_2(\theta)$ in period 2 are then obtained from the following consumer budget equation:

$$(1-\tau)m + \tau m + \delta_2 m = (1+\delta_2)m = p_2(\theta)\theta f(w-g),$$

so that, as expected, the equilibrium price level is given by:

$$p_2(\theta) = \frac{(1+\delta_2)m}{\theta f(w-g)}.$$

Note that any debt monetization $\delta_2 m > 0$ results in an increase in the price level.[9]

If the government issues domestic-currency debt b in period 0 that is bounded above, there exists a finite δ_2 given by the government budget Equation (10), so that it is always possible to avoid a costly default *ex post* by monetizing the debt. The debt claim b issued in period 0 such that

$$bE\left[\frac{1}{p_2(\theta)}\right] = g$$

in turn is bounded above as long as $\bar{\theta}f(w-g) > g$. To see this, observe that after substituting for $p_2(\theta)$ and substituting for δ_2 in Equation (10), we have:

$$bE\left[\frac{1}{p_2(\theta)}\right] = \frac{b\bar{\theta}f(w-g)}{(1+\delta_2)m} = \frac{b\bar{\theta}f(w-g)}{m(1-\bar{\tau})+b} = g.$$

For $\bar{\theta}f(w-g) > g$, it is always possible to find a finite b to support the last equation.

Unlike for domestic-currency debt, when the government issues foreign-currency debt, it may not always be possible to avoid a costly default. To see this, suppose that the government issues foreign-currency debt in period 0, and, by contradiction, that this debt is

9 As under the fiscal theory of the price level, government debt is repaid in period 2 through a combination of a primary fiscal surplus and an increase in the price level caused by the partial monetization of the debt b.

believed to be default-free. The representative consumer is then indifferent between holding on to g units of endowment or trading them against the debt claim b_f if $b_f = g$. The government's budget constraint in period 2 now becomes:

$$\tau m + \delta_2 m \geq p_2(\theta) g. \tag{11}$$

The fiscal authorities are always solvent without monetization if for all θ:

$$\bar{\tau} m \geq p_2(\theta) g,$$

where

$$p_2(\theta) = \frac{m}{\theta f(w-g)}.$$

Substituting for $p_2(\theta)$ this condition reduces to:

$$\bar{\tau} \theta f(w-g) \geq g.$$

In other words, the fiscal authorities can dispense with monetization only if maximum real tax revenues are always greater than or equal to the real liabilities $b_f = g$ for all θ.

Suppose now that $\bar{\tau}\theta_L f(w-g) < g$, then the fiscal authorities cannot always avoid default through monetization of the foreign-currency denominated debt g.

Theorem 3. *Suppose that*

$$\bar{\tau}\theta_L f(w-g) < g < \bar{\tau}\theta_H f(w-g),$$

then the government can avoid default in state θ_L through monetization if and only if

$$\theta_L f(w-g) > g.$$

Proof: See the Appendix. ■

The condition, $\theta_L f(w-g) > g$, is intuitive. As long as the nation's real output is greater than the government's real (foreign-currency) liabilities it is always possible to monetize this debt, essentially by purchasing all the real output that is necessary to service the real liabilities. But when $\theta_L f(w-g) \leq g$ the government is insolvent in real terms and is therefore forced into a default in state θ_L. The reason why monetization of foreign-currency debt is not always possible is well understood: monetization while providing the fiscal authorities with extra liquidity also results in depreciation of the domestic currency, thereby increasing debt liabilities in domestic currency. When the increase in debt liabilities is larger than the increase in liquidity, foreign-currency debt monetization is not possible. Still, when

$$\bar{\tau}\theta_L f(w-g) < g < \theta_L f(w-g),$$

debt monetization is critical to avoid default, and can be an effective response to avoid a costly default when $\theta_L f(w-g) \geq g$. In other words, debt monetization should not just be seen as an appropriate response when the government issues domestic-currency debt. It can also be an effective response to an adverse output shock (albeit to a limited extent) when the government has issued foreign-currency debt, provided of course that the size of the debt relative to GDP is not so large that the nation is insolvent in real terms.

7. Foreign-Exchange Reserves Management

In this section, we return to the general model with responsive beliefs, where

$$\mu(\delta_0) = \underline{\mu} + \gamma\delta_0,$$

with $\gamma > 0$. As we have shown, most of our analysis on the choice of financing of investment extends straightforwardly to this more general setup. However, another facet of the nation's optimal financial policy that we have not yet discussed is the nation's optimal foreign exchange reserve management. Just as the stock of fiat money can be changed via purchases of investment goods, it can also be changed through trades in the foreign exchange market. By building or drawing down foreign exchange reserves, an open economy can sterilize shocks to the supply of the global reserve currency. If there is an increase in the supply of the global reserve currency, which could result in higher inflation or an exchange rate appreciation, this can be offset by increasing foreign exchange reserves. And *vice versa* if there is a decrease in the supply of foreign money.

We can capture in a simple way how the nation should manage its foreign-exchange reserves in response to international monetary conditions. Although we do not explicitly model the supply of foreign money, foreign investors' beliefs can be interpreted as reflecting more or less tight international monetary conditions. Thus, we can interpret international monetary conditions to be relatively loose in situations where $\mu(0) < \lambda$, and relatively tight in situations where $\mu(0) > \lambda$.

Consider the nation's decision at time 0_- to increase or decrease its foreign-currency reserves by intervening in foreign currency markets through currency swaps, before it faces the decision of how to finance the investment k. Suppose to begin with that international monetary conditions are relatively loose, so that $\mu(0) = \underline{\mu} < \lambda$. It is then optimal for the nation to accumulate foreign-currency reserves by increasing its money supply δ_0. More precisely, the following proposition about the nation's reserve management holds.

Proposition 6. *Suppose that $\mu(0) = \underline{\mu} < \lambda$. Then, it is optimal to build foreign-currency reserves of $\overline{R}$ by issuing δ_R of domestic currency, where δ_R and $\overline{R}$ are, respectively, given by:*

$$\delta_R = \frac{\lambda - \underline{\mu}}{\gamma},$$

and

$$\overline{R} = \overline{\theta}\Omega \frac{\lambda - \underline{\mu}}{\gamma + \lambda - \underline{\mu}} \frac{1 + (1-\lambda)\delta_1}{1 + \delta_1}.$$

Proof: See the Appendix. ■

An immediate corollary of Proposition 6 is:

Corollary 3. *Suppose that $\underline{\mu} > \lambda$. It is then optimal for the nation to draw down foreign-currency reserves by at least $\underline{R}$ and shrink the money base by δ_D, where δ_D and $\underline{R}$ are given by:*

$$\delta_D = \frac{\lambda - \underline{\mu}}{\gamma} < 0,$$

and

$$\underline{R} = \overline{\theta}\Omega \frac{\lambda - \underline{\mu}}{\gamma + \lambda - \underline{\mu}} \frac{1 + (1 - \lambda)\delta_1}{1 + \delta_1} < 0.$$

In other words, the nation then repurchases some of its domestic-currency liabilities by drawing down its foreign-currency reserves.

In sum, the nation's reserve management can be understood like a corporation's decision to issue additional shares or buy back equity. When the corporation's stock is overvalued it is time to issue more shares and when it is undervalued it is time to buy back shares. As the "market-driven" corporate finance literature (Baker, 2009) has emphasized corporate capital structures and liquidity buffers can be explained to a significant extent by corporations' decisions to time equity markets in this way. Similarly, our analysis suggests that developing and developed countries' alike can benefit by actively managing their foreign exchange reserves to time international monetary conditions.

Foreign-currency reserves $\underline{R}$ can be used to directly cover investment outlays k. But, more interestingly, they can also allow the nation to become more creditworthy, enhancing its debt capacity. A critical condition for enhancing a nation's debt capacity by relying on foreign-currency reserves however is that these reserves be placed in escrow at an offshore custodian bank, as for example Venezuela has done to finance its Petrolera Zuata oil-field project (see Esty and Millet, 1998). When this is the case, the nation stands to lose all reserves placed in escrow in the event of default on its debts. By placing foreign-currency reserves in escrow, the nation is then able to increase its safe debt capacity as follows.

Lemma 4. *Suppose that the nation places its entire foreign-currency reserves R in escrow, then it is able to issue an amount of safe foreign-currency denominated debt*

$$D_L = \theta_L \phi \Omega + R.$$

The nation will refrain from defaulting on any foreign-currency debt obligation D in the event of a bad productivity shock θ_L as long as:

$$\theta_L \Omega + R - D \geq \theta_L (1 - \phi)\Omega.$$

The right-hand side of this incentive constraint is the output the nation's residents would be able to consume following a default. Note that default now involves not only a lower output but also the loss of foreign-currency reserves. By pledging its foreign-currency reserves nation is thus able to expand its debt capacity and relax its financial constraints.

8. Model Predictions and Empirical Observations

Our main comparative statics predictions follow from Condition (3) in Theorem 2 and Corollaries 2 and 3. A first prediction is that nations which are in the fortunate situation where international investors believe the central bank to be more hawkish than domestic residents ($\mu \leq \lambda$) will not fund themselves with foreign-currency denominated debt. These nations are able to fund their investments by issuing domestic-currency liabilities, which from the perspective of domestic residents are overvalued. We relate this basic prediction with some stylized macroeconomic regularities of four nations that have had virtually no foreign-currency debt outstanding for the past quarter century.

Figure 1. Foreign–currency debt securities as a percentage of GDP.
Note: This figure plots the foreign–currency debt securities to GDP ratio for, respectively, the USA, UK, Japan, and China from 1993 to 2014.

Financing through domestic-currency liabilities: The USA, UK, China, and Japan compared. A basic premise of the "original sin" view of international finance is that only advanced countries can issue domestic-currency debt. However, the recent evidence suggests that reliance on domestic-currency debt is by no means confined to advanced economies.[10] If economic development is not the determining factor to explain the currency composition of a nation, what other considerations bear on the capital structure of a nation? By comparing the capital structures of four major economies, three advanced ones, and one developing economy, the USA, the UK, Japan, and China from 1993 to 2013, we shall illustrate how other stylized macroeconomic facts common to these economies are consistent with our broad theoretical predictions, namely that these nations almost exclusively relied on domestic-currency liabilities because they were not expected to be facing any significant costs of inflation and were taking advantage of favorable international investor beliefs concerning their monetary stance.

The ratio of foreign-currency debt to GDP in the USA, the UK, Japan, and China was negligible throughout this period for all four nations: respectively, no larger than 0.05%, 1.1%, 0.14%, and 0.5% (see Figure 1). These four nations also look very similar in terms of their ratios of M2+ domestic-currency debt-to-GDP ratios, as Figure 2 illustrates. The M2+ domestic-currency debt measure of the money stock is closest in our view to the m,

10 Du and Schreger (2015) study the currency composition of sovereign debt of thirteen emerging market countries and find that over the past decade the share of domestic-currency debt for these countries has increased from 15% to 60% on average.

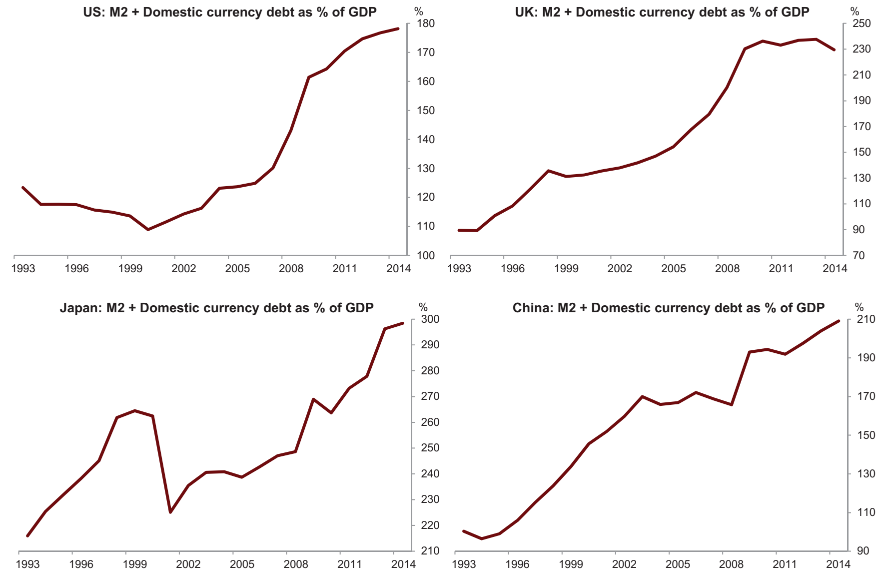

Figure 2. M2+ domestic–currency debt as a percentage of GDP.
Note: This figure plots the sum of M2 and domestic–currency debt as a percentage of GDP for, respectively, the USA, UK, Japan, and China from 1993 to 2014.

that is $m(1+\delta_0)$ and $m(1+\delta_0)(1+\delta_1)$, variable in the model. This ratio has increased from 120% in 1993 to 180% in 2014 for the USA, from under 100% in 1993 to nearly 250% in 2014 for the UK, from 215% in 1993 to 300% in 2014 for Japan, and from 100% in 1993 to nearly 210% in 2014 for China. Remarkably, despite what appear to be large increases in the money stock-to-GDP ratio in these nations, there has been subdued inflation over this 20-year period in each of these nations, as Figure 3 shows. Except for the financial crisis of 2008–9, the inflation rate in the USA from 1993 to 2014 has hovered around 2% and never exceeded 4%. The inflation experience of the UK is very similar, with inflation peaking at just under 4.5% in 2011. As for Japan, its rate of inflation has, if anything, been in deflation territory over this period, hovering around 0%, with the very recent exception of a peak inflation of 2.7% in 2014. Finally, China's inflation rate over this period has come down from a peak of 24% in 1994 to hover around 3% over the remainder of this period, with another peak at 5.8% in 2008. China was able to bring down its high inflation rate in 1995 and did contract its M2+ domestic-currency debt in 1994 and 1995. This was a key step to reaffirm its reputation as a low-inflation emerging-market nation, and thus preserve its ability to finance its high rate of growth and investment with domestic currency at favorable terms.

The four nations' macroeconomic experience, however, differs significantly in two respects. First, and most obviously the rate of GDP growth, which was around 3% in the USA and UK (with the exception of the financial crisis when it dropped to, respectively, -2.8% and -4.3% in the USA and UK and thereafter averaged around 2%), and around 1.5% for Japan (with a drop in 2009 to –5.5%). In contrast, China's GDP growth over this period started at a peak of 14% in 1993, continued at an average rate of 10% to reach a

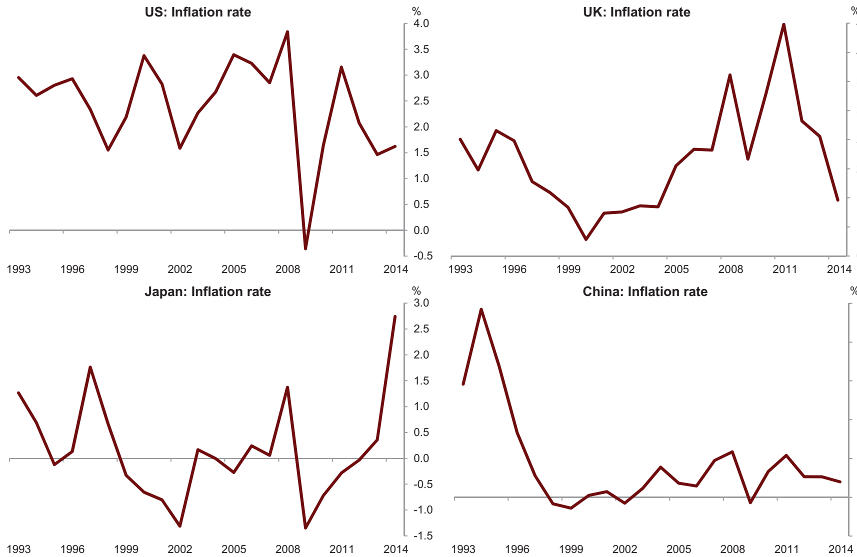

Figure 3. Inflation.
Note: This figure plots the inflation rate for, respectively, the USA, UK, Japan, and China from 1993 to 2014.

trough of 7.3% in 2014 (and, remarkably, with a growth rate of 9.2% in 2009). Second, China's foreign-currency reserves were at 3.3% of GDP in 1993 and ended at just under 40% in 2014. Similarly, Japan's foreign-currency reserves to GDP ratio shot up from 7.3% in 2000 to 26% in 2014. Meanwhile, the US foreign-currency reserves never exceeded 0.35% over this period and the UK's reserves peaked at just under 1% in 2003.

Part of the change in foreign-currency reserves reflects the fact that China and Japan ran large current account surpluses (and the USA and UK large current account deficits). As Figure 4 highlights, China's current account over this period was in surplus, rising from 1.3% of GDP in 1994 to a peak of 10.5% in 2007 and then declining back to a surplus of 2.1% in 2014. Similarly, Japan's current account surplus was 3% of GDP in 1993, peaked at 5.1% in 2007, and subsequently declined to 0.5% in 2014. In contrast, the current accounts of the USA and the UK are almost mirror images of those of China and Japan, with the USA running a deficit during this entire period, starting with –1.7% of GDP in 1994, peaking at −5.8% in 2006, and declining back to –2.4% in 2014 (the UK had a deficit of –0.35% in 1994, –3.7% in 2008, and –5.5% in 2014). While contributing substantially to the accumulation of foreign-currency reserves (roughly around two-third), these current account surpluses alone cannot entirely explain the sharp increase in reserves in China. Indeed, China's experience resembles in many ways the financing patterns of a growth firm, which keeps its leverage low so as to preserve its financing capacity to pursue future investment opportunities, and which regularly returns to equity markets to raise new funds for investment. In contrast, the USA, and UK experience resembles more the financing pattern of a mature, blue-chip, company that times the equity market to raise new funding on the cheap.

Figure 4. GDP growth.

Note: This figure plots the GDP growth rate for, respectively, the USA, UK, Japan, and China from 1993 to 2014.

Foreign-currency debt overhang and default risk: the example of Argentina. If there is one nation that comes to mind as an example for the "original sin" view it is Argentina. The fear of inflation led Argentina to adopt a currency board, which, in effect, institutionalized reliance on foreign-currency debt. As can be seen in Figure 5, Panel A, Argentina had a ratio of foreign-currency debt to GDP of just under 10% in 1993. This ratio steadily increased and peaked at 70% in 2002, the year in which Argentina defaulted on this debt and plunged the nation in a severe recession, with a GDP contraction of –11% (see Panel D). Although Argentina subsequently reached a debt restructuring agreement with a large majority of its debt holders in 2005, thus lowering its foreign-currency debt to GDP ratio to 23.5%, its continuing legal battles with hold-out creditors in effect shut it out from international foreign-currency debt markets, so much so that its foreign-currency-debt-to-GDP ratio continued to decline to 7.8% until 2014.[11]

Being unable to issue foreign-currency debt, Argentina inevitably had to rely on domestic-currency financing, as can be seen in Panel B of Figure 5, which plots Argentina's M2+ domestic-currency debt-to-GDP ratio. This ratio was at 20% in 2001 and thereafter jumped to hover 38%. By defaulting on its foreign-currency debt, and thereby removing its debt-overhang, Argentina, however, was able to clock up a relatively high GDP growth performance after 2002, as Panel D of Figure 5 reveals. But, it also suffered about of

11 The District Court for the Southern District of New York enjoined Argentina on November 21, 2012 to stop servicing the 2005 restructured bonds unless Argentina also paid in full all past principal and interest payments due to hold-out investors. As a result of this injunction Argentina eventually capitulated and agreed to repay the hold-out investors (see "Argentina clears way for repayment of 'holdout' creditors", *Financial Times*, March 31, 2016). See CEIC for data source.

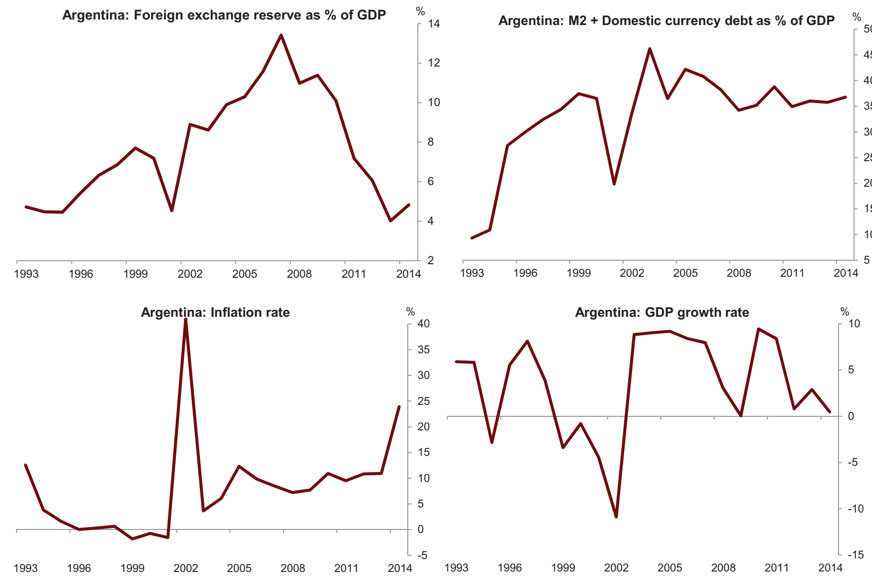

Figure 5. Argentina.

Notes: This figure plots the foreign exchange reserve as a percentage of GDP, sum of M2, and domestic–currency debt as a percentage of GDP, inflation rate, and GDP growth rate for Argentina from 1993 to 2014.

remarkably high inflation in a global context of low inflation: Panel C of Figure 5 shows that Argentina's inflation went from 8% in 2006 to 39% in 2014! Argentina's experience with domestic-currency financing and high inflation sharply contrasts with the experience of China and suggests that its choice of capital structure was constrained. Given the high inflation, Argentina would probably have chosen foreign-currency debt financing had it been able to do so.

Foreign-exchange reserves management: the example of Switzerland. It is only recently that Switzerland has engaged in large-scale foreign-exchange reserve operations. Almost all examples of nations that had accumulated large reserves until 2007 were Asian nations. The conventional wisdom is that these nations all belonged to a "dollar block": their reserve accumulation policy was a reaction to the Asian financial crisis of 1997 and an effort on their part to self-insure against dollar risk through precautionary savings (McKinnon, 2000). Switzerland does not belong to a "dollar block," nor is it in need of precautionary savings. Yet, Switzerland has rapidly built huge foreign-currency reserves in a period of 5 years, from 2007 to 2012. It increased its reserves-to-GDP ratio from under 10% to over 70%, as can be seen in Panel A of Figure 6.

Switzerland's reserve management can be understood in terms of our analysis in Section 7. It engaged in a large accumulation of reserves under special circumstances when its currency was overvalued by international investors. Over a 5-year period Switzerland increased its M2+ domestic currency debt-to-GDP ratio from 170% to 220% through its foreign exchange operations (see Panel B). Yet, inflation dropped from a rate of 2.5% in 2007 to deflation territory by 2014, as can be seen in Panel C. Finally, although

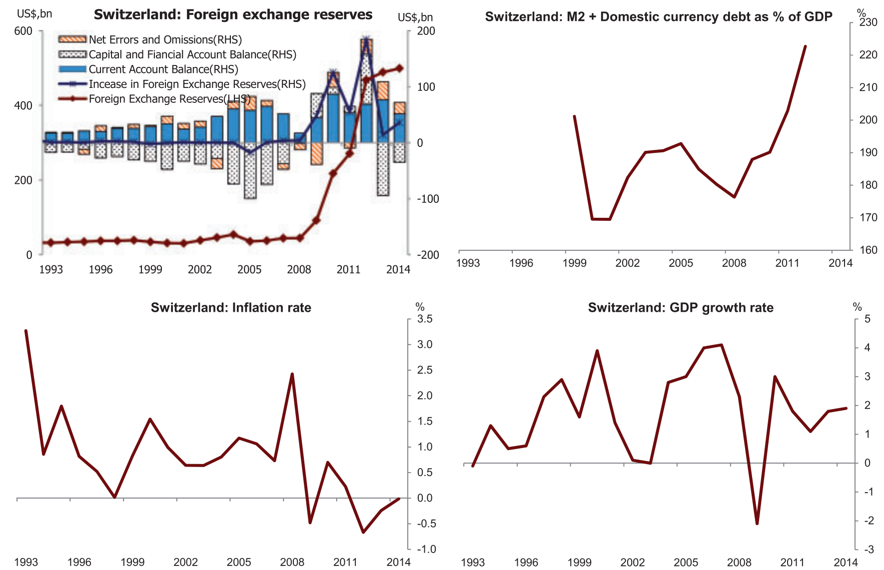

Figure 6. Switzerland.

Notes: This figure plots the foreign exchange reserve as a percentage of GDP, sum of M2, and domestic–currency debt as a percentage of GDP, inflation rate, and GDP growth rate for Switzerland from 1993 to 2014.

Switzerland's GDP-growth rate collapsed from 4% in 2007 to –2% in 2009, mainly as a result of the global financial crisis, thereafter it has largely recovered to pre-crisis levels, as Panel D illustrates. This experience of Switzerland reflects in the sharpest terms how a nation with an overvalued currency can benefit by increasing its foreign-currency reserves and responding to the increased global demand for Swiss-franc denominated liabilities with an increase in the supply of Swiss francs.

9. Conclusion

In this paper, we take a corporate finance approach to the question of debt and monetary financing of a nation's investments. We propose an analogy between a nation's fiat money and corporate equity. Both serve as a store of value. Moreover, a nation's currency is a claim on the nation's residual output just as a firm's equity is a claim on the firm's residual cash flow. However, unlike equity, a nation's currency also serves as a medium of exchange for domestic purchases.

The main advantage of such a perspective is that it helps unify parallel economic literatures that have developed independently of each other. For example, it allows us to connect the insight of Modigliani and Miller on the equivalence of debt and equity financing for a firm to the Ricardian equivalence result for a fiscal authority. By drawing out such connections each literature is enriched by the fundamental ideas of the other literatures. Thus, we show that when a Modigliani–Miller theorem for nations holds in a frictionless economy, this implies that the classical quantity theory of money also holds. We further show how the notions of price inflation and equity dilution are closely related, thus allowing us to link the costs of inflation to wealth redistribution. By framing the financing problem of nations as a problem similar to the financing choices of corporations we are able to make explicit the costs and benefits of printing money for a nation. In particular, if printing money is for the purposes of financing valuable investments this may justify paying some inflation costs. This is a fundamental result in Myers and Majluf (1984) that has far-reaching implications when applied to fiscal and monetary policy.

We have only taken a first step in our formal analysis by specifying an extremely simple static model. One important aspect we have oversimplified and which deserves further research is the fact that a nation is not quite like a company. The non-tradable sector of a nation's economy is a closed system, which responds to monetary and fiscal stimulus when depressed. Macroeconomic stimulus involves other funding considerations, which we have abstracted from entirely. Equally, we have consolidated the private and public sectors of the nation's economy for analytical simplicity, thereby suppressing important questions relating to the uncoordinated financing of government and corporate sectors. Another area worth exploring is the dynamics of a nation's capital structure. Finally, a fundamental area which requires further analysis are the governance and moral hazard issues related to how nations finance themselves. We leave these questions for future research.

Appendix

Proof ofTheorem 1: Suppose first that the nation raises k from risk-neutral foreign investors against domestic-currency claims. For example, a payment in domestic currency of $\delta_0 m$ in period 0. The increase $\delta_0 m$ must then be at least equal to $E[p_2(\theta)]k$. In other words, the foreign sellers of capital in period 0 must be able to purchase a fraction of period 2 output that is expected to be equal to k. Equivalently, the nation could raise k by issuing a domestic-currency debt promise of $\delta_0 m$ to be paid at the beginning of period 2, or any combination of domestic-currency payment in period 0 and domestic-currency debt payment in period 2 that in total add up to $\delta_0 m$. By investing k, the nation's expected period 2 output is given by $Q(k)\overline{\theta}f(w) = \overline{\theta}\Omega$, and for any realization θ the period 1 price level is given by:

$$p_2(\theta) = \frac{m(1+\delta_0)}{\theta\Omega}.$$

The representative consumer's problem in period 1, after the investment k is made, is then given by:

$$\max_{x\geq 0}\left\{\beta(w-x) + p_1 x E\left[\frac{1}{p_2(\theta)}\right]\right\} = \max_{x\geq 0}\left\{\beta(w-x) + x\left[\frac{\Omega}{f(w)(1+\delta_0)}\right]\frac{\overline{\theta}f(w)}{w}\right\}.$$

Suppose that, as we later verify:

$$\frac{\Omega}{f(w)(1+\delta_0)} \geq 1,$$

then it is again optimal to set $x = w$ and the representative consumer's payoff is given by

$$\frac{\overline{\theta}\Omega}{1+\delta_0}.$$

Second, suppose that the nation borrows k from risk-neutral foreign investors against a promise to repay $D=k$ in period 1 output, which is equivalent to financing the investment with (risk-free) foreign-currency debt. Under assumption A1, the period 1 price level for any realization θ is then:

$$p_2(\theta) = \frac{m}{[\theta\Omega - k]},$$

and the representative consumer's problem is:

$$\max_{x\geq 0}\left\{\beta(w-x) + x\frac{m}{w}E\left[\frac{\theta\Omega - k}{m}\right]\right\} = \max_{x\geq 0}\left\{\beta(w-x) + x\frac{\overline{\theta}\Omega - k}{w}\right\}.$$

Since $Q(k) > 1$ it is *a fortiori* optimal to set $x=w$, so that the representative consumer's payoff is: $\overline{\theta}\Omega - k$. Equivalence between the first and second form of financing k then requires that:

$$\frac{\overline{\theta}\Omega}{1+\delta_0} = \overline{\theta}\Omega - k$$

or

$$\delta_0 = \frac{k}{\overline{\theta}\Omega - k}.$$

Now, $\delta_0 m$ is set so that:

$$\frac{\delta_0 m}{E[p_2(\theta)]} = k.$$

Substituting for

$$E[p_2(\theta)] = \frac{m(1+\delta_0)}{\overline{\theta}\Omega},$$

we then indeed obtain:

$$\delta_0 = \frac{k}{\overline{\theta}\Omega - k}.$$

Finally, we verify that the condition

$$\frac{\Omega}{f(w)(1+\delta_0)} \geq 1$$

is equivalent to the positive NPV condition, $(Q(k)-1)\overline{\theta}f(w) > k$.

It is straightforward to adapt this argument to any combination of foreign-currency debt and money financing and to extend the logic to the case of risky foreign-currency debt with no deadweight costs of default. ■

Proof of Lemma 1: If the nation funds investment k by issuing money $\delta_0 m$ in period 0, the price level for any realization of θ in period 2 will then be

$$\hat{p}_2(\theta) = \frac{m(1+\delta_0)(1+\delta_1)}{\theta\Omega}$$

under a monetary-dove government, and

$$p_2(\theta) = \frac{m(1+\delta_0)}{\theta\Omega}$$

under a monetary-hawk government.[12]

Accordingly, foreign investors will demand a payment in money $\delta_0 m$ in exchange for the investment k such that:

$$\left[\frac{\mu}{E[\hat{p}_2(\theta)]} + \frac{1-\mu}{E[p_2(\theta)]}\right]\delta_0 m = k,$$

where

$$E[\hat{p}_2(\theta)] = \frac{m(1+\delta_0)(1+\delta_1)}{\overline{\theta}\Omega}$$

and

$$E[p_2(\theta)] = \frac{m(1+\delta_0)}{\overline{\theta}\Omega}.$$

Substituting for $\hat{p}_2(\theta)$ and $p_2(\theta)$ and rearranging we obtain that:

$$\overline{\theta}\Omega\frac{\delta_0}{1+\delta_0}\left(1-\mu+\frac{\mu}{1+\delta_1}\right) = k.$$

So that:

$$\delta_0 = \frac{k(1+\delta_1)}{[1+(1-\mu)\delta_1]\overline{\theta}\Omega - k(1+\delta_1)}. \tag{12}$$

Note that δ_0 is an increasing function in δ_1. Thus, at $\delta_1 = 0$, δ_0 reaches its lower bound:

$$\delta_0 = \frac{k}{\overline{\theta}\Omega - k}, \tag{13}$$

which is the same as in Theorem 1, when the Modigliani–Miller irrelevance theorem for nations holds.

While foreign investors assign a present value of k to $\delta_0 m$, domestic residents value $\delta_0 m$ at:

$$\left[\frac{\lambda}{E[\hat{p}_2(\theta)]} + \frac{1-\lambda}{E[p_2(\theta)]}\right]\delta_0 m,$$

or substituting for $\hat{p}_2(\theta)$ and $p_2(\theta)$ at:

$$\overline{\theta}\Omega\frac{\delta_0}{1+\delta_0}\left(1-\lambda+\frac{\lambda}{1+\delta_1}\right).$$

12 Note that we assume implicitly here that domestic consumers sell all their endowment to firms in period 1 so that $x = w$. It is optimal for domestic consumers to do so if β is low enough, which we assume in the remainder of the analysis.

When $\mu > \lambda$ domestic residents therefore perceive a loss in expected purchasing power from financing the investment k with a money issue of:

$$(\mu - \lambda)\frac{\overline{\theta}\Omega\delta_0}{1+\delta_0}\frac{\delta_1}{1+\delta_1}.$$

Substituting δ_0 as in Equation (12), we have

$$\frac{(\mu - \lambda)\delta_1 k}{1+(1-\mu)\delta_1}. \blacksquare$$

Proof of Theorem 2: There are two possible outcomes when the nation relies on foreign-currency debt financing. Either the nation limits its indebtedness so as to always be willing to service its debt obligations, or the nation issues so much debt that it defaults if the low productivity shock θ_L is realized. In the former situation, the maximum debt promise the nation can credibly make is given by $D = \theta_L\phi\Omega(k, w)$, so that a necessary and sufficient condition for safe debt is:

$$\theta_L\phi\Omega \geq k. \tag{14}$$

Suppose that this condition is violated, then the debt promise the nation must make to be able to raise k through an external debt issue is given by $D = k/\pi$, and a necessary condition for *risky debt* financing is

$$\theta_H\phi\Omega \geq \frac{k}{\pi}. \tag{15}$$

When Condition (15) holds but Condition (14) is violated, the nation can fund itself with risky debt and incurs an expected deadweight cost of default given by:

$$(1-\pi)\theta_L\phi\Omega.$$

When $\mu \geq \lambda$, equity financing involves the following expected dilution cost:

$$(\mu - \lambda)\frac{\overline{\theta}\Omega\delta_0}{1+\delta_0}\frac{\delta_1}{1+\delta_1}.$$

Comparing expected deadweight costs of default to expected dilution costs, substituting for δ_0 and rearranging we obtain Condition (3).

Note finally that when

$$\theta_H\phi\Omega < \frac{k}{\pi},$$

foreign-currency debt financing is not feasible as the nation would then default with probability one. $\blacksquare$

Proof of Proposition 1: The nation can entirely avoid default for any foreign-currency debt it issues $D \leq \theta_L\phi\Omega$. Given that issuing domestic-currency liabilities involves a strictly positive dilution cost when $\mu > \lambda$ it is optimal for the nation to issue at least $D_L = \theta_L\phi\Omega$. Since $D_L < k$ the nation must then also issue domestic-currency claims of $(1+\delta_0)(k - \theta_L\phi\Omega)$ given in Equation (16) if it wants to issue only safe debt. Proceeding as in the proof of Lemma 1, we find that

$$\delta_0 = \frac{(k-\theta_L\phi\Omega)(1+\delta_1)}{[1+(1-\mu)\delta_1]\overline{\theta}\Omega - (k-\theta_L\phi\Omega)(1+\delta_1)}, \tag{16}$$

and the nation then incurs expected dilution costs of

$$\overline{\theta}\Omega\frac{\delta_0}{1+\delta_0}\frac{(\mu-\lambda)\delta_1}{1+\delta_1}=\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}$$

on the portion of the investment $k-\theta_L\phi\Omega$ it finances with domestic-currency debt.

If the nation entirely finances k with foreign-currency debt it incurs expected default costs of $(1-\pi)\theta_L\phi\Omega$. Therefore, it is optimal to issue a combination of safe foreign-currency debt $D_L=\theta_L\phi\Omega$ and domestic-currency debt $[(1+\delta_0)(k-\theta_L\phi\Omega)-1]m$, when

$$\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}\leq(1-\pi)\theta_L\phi\Omega,$$

which is Condition 5. ■

Proof of Proposition 2: Given that $\mu>\lambda$ it is optimal for the nation to issue at least $D_L=\theta_L\phi\Omega$. When the nation issues D_L it must also issue domestic-currency claims of $(1+\delta_0)(k-\theta_L\phi\Omega)$ given in Equation (16). The nation then incurs expected dilution costs of

$$\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}$$

on the portion of the investment $k-\theta_L\phi\Omega$ it finances with domestic-currency debt.

If the nation issues $D_H=\pi\theta_H\phi\Omega$ of foreign-currency debt it incurs expected default costs of $(1-\pi)\theta_L\phi\Omega$. It then also incurs expected dilution costs of

$$\frac{(\mu-\lambda)(k-\pi\theta_H\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}.$$

It is then optimal to issue foreign-currency debt $D_H=\theta_H\phi\Omega$ and domestic-currency debt $[(1+\delta_0)(k-\pi\theta_H\phi\Omega)-1]m$, when:

$$\frac{(\mu-\lambda)(k-\pi\theta_H\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}\leq(1-\pi)\theta_H\phi\Omega,$$

where

$$\delta_0=\frac{(k-\pi\theta_H\phi\Omega)(1+\delta_1)}{[1+(1-\mu)\delta_1]\overline{\theta}\Omega-(k-\pi\theta_H\phi\Omega)(1+\delta_1)}. \tag{17}$$

Note that $\theta_L<\theta_H$. Therefore, if

$$\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}\leq(1-\pi)\theta_L\phi\Omega,$$

the nation issues $D_L=\theta_L\phi\Omega$ of foreign-currency debt; if

$$\frac{(\mu-\lambda)\left(\frac{k}{\theta_L\phi\Omega}-1\right)\delta_1}{1+(1-\mu)\delta_1}>1-\pi\geq\frac{(\mu-\lambda)\left(\frac{k}{\pi\theta_H\phi\Omega}-1\right)\delta_1}{1+(1-\mu)\delta_1},$$

the nation issues $D_H=\pi\theta_H\phi\Omega$ foreign-currency debt. ■

Proof of Proposition 3: When Condition (2) holds it is optimal for the nation to either issue foreign-currency debt $D_L=\theta_L\phi\Omega$ or $D_H=k/\pi$. When foreign investors have responsive beliefs $\mu(\delta_0)=\underline{\mu}+\gamma\delta_0$ the nation faces dilution costs

$$\frac{(\mu-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\mu)\delta_1}=\frac{(\underline{\mu}+\gamma\delta_0-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\underline{\mu}+\gamma\delta_0)\delta_1}, \tag{18}$$

where

$$\overline{\theta}\Omega\frac{\delta_0}{1+\delta_0}\left(1-\underline{\mu}-\gamma\delta_0+\frac{\underline{\mu}+\gamma\delta_0}{1+\delta_1}\right)=(k-\theta_L\phi\Omega), \tag{19}$$

when it issues safe foreign-currency debt $D_L=\theta_L\phi\Omega$. It faces expected default costs $(1-\pi)$ $\theta_L\phi\Omega$ when it issues risky foreign-currency debt $D_H=k/\pi$. The nation is indifferent between D_L and D_H when $\gamma=\hat{\gamma}$, where

$$\frac{(\underline{\mu}+\hat{\gamma}\delta_0-\lambda)(k-\theta_L\phi\Omega)\delta_1}{1+(1-\underline{\mu}-\hat{\gamma}\delta_0)\delta_1}=(1-\pi)\theta_L\phi\Omega, \tag{20}$$

and it strictly prefers D_H when $\gamma>\hat{\gamma}$. ■

Proof of Lemma 3: Suppose that $\phi\theta_H\Omega(0,w)>D_0>\phi\theta_L\Omega(0,w)$. The expected payoff under no investment is then:

$$\pi(\theta_H\Omega(0,w)-D_0)+(1-\pi)\theta_L(1-\phi)\Omega(0,w).$$

In addition, when $D_0\leq\phi\theta_L\Omega$ the nation's expected payoff under an equity-financed investment is as before:

$$(1-\alpha(\mu))\overline{\theta}\Omega-D_0.$$

Whether the nation decides to invest or not then depends on the following condition:

$$(1-\alpha(\mu))\overline{\theta}\Omega\geq\overline{\theta}\Omega(0,w)+(1-\pi)(D_0-\theta_L\phi\Omega(0,w)).$$

By assumption, $D_0>\phi\theta_L\Omega(0,w)$, so that for some parameter values we may have:

$$(1-\alpha(\mu))\overline{\theta}\Omega\geq\overline{\theta}\Omega(0,w)$$

and

$$(1-\alpha(\mu))\overline{\theta}\Omega<\overline{\theta}\Omega(0,w)+(1-\pi)(D_0-\theta_L\phi\Omega(0,w)).$$

In such situations, D_0 is so large that it overhangs the nation's efficient investment decision. ■

Proof ofTheorem 3: Default can be avoided with no monetization if

$$\overline{\tau}m\geq p_2(\theta)g,$$

where

$$p_2(\theta)=\frac{m}{\theta f(w-g)}.$$

Substituting for $p_2(\theta)$ we obtain the condition

$$\overline{\tau}\theta f(w-g)\geq g.$$

When

$$\overline{\tau}\theta f(w-g)<g,$$

monetization is needed to avoid default, and default can be avoided with monetization $\delta_2 m$ if

$$\overline{\tau}m+\delta_2 m\geq p_2(\theta)g,$$

where

$$p_2(\theta) = \frac{m(1+\delta_2)}{\theta f(w-g)}.$$

Substituting for $p_2(\theta)$ we obtain the following condition

$$\delta_2 \geq \frac{g - \overline{\tau}\theta f(w-g)}{\theta f(w-g) - g}. \tag{21}$$

Now, as long as $\theta f(w-g) > g$ there exists a $\delta_2 > 0$ such that inequality (21) is satisfied.

When (1) $\overline{\tau}\theta f(w-g) < g$, (2) $\theta f(w-g) > g$, and (3) inequality (21) holds, the central bank sets δ_2 such that the fiscal authority's budget constraint is binding

$$\overline{\tau}m + \delta_2 m = p_2(\theta)g.$$

Consumers' budget constraint in period 2 after balancing the government budget is then

$$(1-\overline{\tau})m + \overline{\tau}m + \delta_2 m = p_2(\theta)\theta f(w-g)$$

or

$$m(1+\delta_2) = p_2(\theta)\theta f(w-g).$$

When $\theta f(w-g) \leq g$ there does not exist a $\delta_2 > 0$ such that inequality (21) is satisfied, so that foreign-currency debt cannot be monetized. ■

Proof of Proposition 6: By issuing an amount δ_0 of domestic currency less than or equal to δ_R the nation is able to obtain foreign-currency reserves by incurring no inflation costs. These reserves can be used later to help finance the nation's investment k, either through direct purchases of investment goods from international markets or by using the reserves as collateral. A maximum stock of reserves $\overline{R}$ equal to

$$\overline{R} = \left[\frac{\lambda}{E[\hat{p}_2(\theta)]} + \frac{1-\lambda}{E[p_2(\theta)]}\right]\delta_R m$$

can then be accumulated without any inflation cost since for $\delta_0 \leq \delta_R$ we have $\mu(\delta_0) \leq \lambda$.

Note furthermore that

$$E[\hat{p}_2(\theta)] = \frac{m(1+\delta_R)(1+\delta_1)}{\overline{\theta}\Omega}$$

and

$$E[p_2(\theta)] = \frac{m(1+\delta_R)}{\overline{\theta}\Omega}.$$

Substituting for $\hat{p}_2(\theta)$ and $p_2(\theta)$ and rearranging we then obtain the desired expressions. ■

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