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ABSTRACT

About 20 percent of countries employ multiple exchange rates. An important rationale for this practice is the creation of fiscal revenue. This paper develops a general equilibrium model with exchange controls. It shows that such controls can mobilize significant fiscal resources, but also cause dollar shortages, misallocation, and smuggling. The paper studies an optimal taxation problem where chronic fiscal deficits must be financed with money creation and exchange controls. Under plausible calibrations, the optimal policy favors multiple exchange rates, with stronger controls on exports than on imports. Both exchange controls and inflation finance significant portions of the deficit.

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1 Introduction

About 20 percent of all countries, especially in poor and emerging areas of the world, have in place dual, multiple, or parallel exchange rates (Ilzetzki, Reinhart, and Rogoff, 2019). This paper investigates the fiscal implications of exchange controls for countries that experience chronic fiscal deficits financed with money creation. Exchange controls are akin to a tax on international trade (Bhagwati, 1978). Therefore, they compete with the inflation tax as an alternative source of fiscal revenue. The question we pose is what is the optimal monetary and exchange control policy for a government that faces an exogenous stream of fiscal deficits.

To address this question we embed exchange controls in a general equilibrium model of an open economy with a tradable and a nontradable sector. Both sectors use imported materials as inputs of production. A demand for money is motivated by a transactions cost that is increasing in money velocity. The government runs an exogenous stream of primary fiscal deficits. In addition, the economy is financially isolated from the rest of the world but the government owes an external debt denominated in foreign currency on which it pays interest. We have in mind a situation in which regular taxes are already high, and the government has lost its political ability to raise them further to close the fiscal gap. As a result, the government must finance fiscal imbalances with revenues generated by money creation and exchange controls.

In the model economy, exchange controls work as follows. The government obliges exporters to surrender their foreign exchange earnings at the central bank in exchange for domestic currency at an exchange rate (the official exchange rate) that is disadvantageous relative to the market exchange rate. Thus, exchange rate controls act as a tax on exports with the tax rate being the gap between the market and the official exchange rate. The government also supplies foreign exchange to importers at the official exchange rate. Therefore, exchange-rate controls also represent a subsidy on imports. However, we show that to guarantee positive revenue from exchange controls, it can be in the interest of the government to limit the amount of foreign exchange it makes available to importers at the official exchange rate. When this limit becomes binding, exchange controls turn from an import subsidy to an import quota. This novel result is relevant for two reasons. First, it rationalizes the notion of "dollar shortage" characteristic of economies with exchange controls. Second, we find that dollar shortages induced by exchange controls are a major source of resource misallocation in all sectors of the economy.

Analyzing exchange controls in the context of a general equilibrium framework reveals an additional channel through which they can mobilize fiscal resources. Because government obligations have a nontradable and a tradable component, total government obligations measured in units of consumption depend on the real exchange rate. Thus, exchange controls can generate fiscal space by altering the real exchange rate. This effect implies that exchange controls can also create fiscal space through a reduction in the government's external debt burden. This channel has not been discussed in the related literature and turns out to be quantitatively relevant under certain forms of exchange controls.

Due to the arbitrage opportunities created by the difference between the market and the official exchange rates, exporters and importers have incentives to circumvent exchange controls by smuggling goods in and out of the country and by under invoicing exports and over invoicing imports. Engaging in smuggling, however, entails a cost, which limits the ability of firms to make arbitrage profits from the exchange-rate gap. We show analytically that if exchange controls are to affect fiscal revenue both legal and illegal trade must take place in equilibrium. In other words, when smuggling costs are so high that illegal trade is zero or when smuggling costs are so low that legal trade is zero, fiscal revenue ceases to be affected by the exchange rate gap. Thus, a government wishing to alter its fiscal space through variations in exchange controls must tolerate some contraband.

In the model, the government faces a tradeoff between financing the fiscal deficit with inflation or with exchange controls. We consider a benevolent government that maximizes the welfare of domestic households by choosing paths for inflation and exchange controls. We compare the outcome of the optimal policy with those of two alternative policy regimes. In one of these alternative regimes the government does not resort to exchange controls and finances the fiscal deficit entirely through inflation. In the other alternative regime, the government minimizes inflation and therefore maximizes fiscal revenues from exchange controls.

We calibrate the model to the Argentine economy. Over the past two decades, this country has experienced high inflation, persistent fiscal deficits and exchange controls. We find that under the welfare maximizing policy the government finances two thirds of the deficit with exchange controls and one third with seignorage revenue. The optimal exchange control policy favors multiple official exchange rates, with stronger controls on exports than on imports. If the government is constrained to set the same official exchange rate on exports and imports—perhaps with the intention to comply with the International Monetary Fund's (IMF) position against multiple currency practices—the optimal policy finances the majority of the fiscal deficit through money creation. In this regard, exchange-control regimes that do not permit the use of different official exchange rates on imports and exports are inflationary. The reason why the government makes less use of exchange controls in his case is that exchange controls on imports are highly distorting, as they create a dollar shortage that forces the economy to operate with an inefficiently low level of imported inputs of production.

The paper motivates the use of exchange controls as a way to raise fiscal revenue. It is therefore natural to discuss empirical evidence supporting this assumption. Dornbusch (1986) reviews macroeconomic aspects of exchange controls and lists their ability to generate fiscal revenue as the first motivation. Kamin (1994), in a case study of exchange controls in Argentina (the economy to which we calibrate the model), points out that governments—especially those with net foreign currency obligations to the rest of the world (an assumption maintained in our paper)—gain implicit tax revenues through exchange controls. The IMF has a "Policy on Multiple Currency Practices (MCPs)"—the official IMF term for exchange controls—according to which IMF program countries have to ask for approval from the IMF when implementing exchange controls. The 2022 report on Multiple Currency Practices (IMF, 2022) discusses conditions under which MCPs should be approved. In this context the report states that countries maintain MCPs to avoid balance of payments problems and to raise revenue by taxing exchange transactions. Both of these motivations concord with the role that exchange controls play in the present study. And when discussing reasons why countries are slow to remove exchange controls, the report states "...countries have faced difficulties in removing such MCPs, reflecting a lack of progress on domestic revenue mobilization and other fiscal reforms." Further, the 2019 IMF report on Multiple Currency Practices (IMF, 2019) contains a discussion of why countries impose exchange controls. The report cites expansionary fiscal policies, unsustainable macroeconomic policies, and revenue mobilization. Moreover, it discusses why exchange controls may be adopted instead of more conventional types of taxation. In this regard the report states that "The use of multiple rates is preferred over taxation for two main reasons. First, the administration of multiple rates is easier when compared to the administrative difficulties of direct taxation (export and import taxes) particularly when state capacity is weak... Second, revenue collection through multiple rates can be sizable, especially in the near term." Taken together these discussions in academic and official IMF policy papers provide compelling evidence that in practise countries are motivated to use exchange controls for fiscal reasons. Finally, the use of exchange controls as a fiscal instrument is not a recent phenomenon but goes back a long way. For example, Sherwood (1956) presents empirical evidence of fiscal aspects of multiple exchange rate systems for three developing countries, Cuba, the Philippines, and Venezuela, over the period 1951 to 1954 and finds that the fiscal revenue obtained from exchange controls ranged from 5 percent to 20 percent of total revenue.

To the best of our knowledge the present paper is the first attempt to frame the determination of exchange controls as the outcome of an optimal monetary and fiscal policy problem. The paper is related to several strands of literature. An early formulation of the functioning of a dual exchange-rate system using a non-optimizing framework and adaptive expectations is Argy and Porter (1972). Flood and Marion (1982) introduce rational expectations into the framework of Argy and Porter. These papers are primarily concerned with the ability of a dual exchange rate system vis-à-vis a single exchange rate arrangement to isolate the country from domestic and external disturbances.

Closer to the present analysis is Adams and Greenwood (1985) who incorporate a dual exchange-rate system in a two-period optimizing model with rational expectations. These authors show that the Ramsey optimal policy calls for the Friedman rule (i.e., a zero nominal interest rate and average inflation equal to minus the real interest rate) and no exchange rate controls. A key difference with the present study is that these authors assume that the government can set lump sum taxes endogenously to ensure fiscal solvency independently of the monetary or the exchange rate arrangement. In other words, unlike in the present study, these authors assume that the government need not rely on seignorage revenue or on revenues from exchange controls to balance the budget. It can be readily shown that their conclusion would also obtain in our framework were we to add lump-sum taxation as a policy instrument.

More recently, Mosquera and Sturzenegger (2021) analyze an optimizing model in which exchange controls act as a tax on exports. They show that because these types of taxes are distorting, exchange rate controls are welfare reducing. However, Mosquera and Sturzenegger do not explore the fiscal consequences of exchange controls nor their optimal determination, both of which are at the core of the present investigation. Espino, Gauna, and Neumeyer (2023) augment a Krugman-style balance of payment crisis model with dual exchange rates and capital controls to study how these frictions affect the timing of the balance of payments crisis and the transitional dynamics of expenditure, the exchange rate gap, and interest rates. Recently, there is work investigating the ability of exchange rate manipulation to achieve goals other than the collection of fiscal revenue. For example, Ottonello, Perez, and Witheridge (2024) present a model in which real exchange rate management can alter a country's speed of convergence to the technological frontier. Itskhoki and Mukhin (2023) show that different sanctions that give rise to the same real allocation can have different effects on the real exchange rate, so that the exchange rate is not always an appropriate gauge of the effectiveness of sanctions.

Another body of work to which this paper is related is one that studies optimal monetary and fiscal policy when the government has access to distortionary taxation in the form of labor or capital income taxes. One of the questions studied in this literature is under what conditions the Friedman rule is optimal (Lucas and Stokey, 1983; Chari, Christiano, and Kehoe, 1991; Correia, Nicolini, and Teles, 2008; Schmitt-Grohé and Uribe, 2004a,b). In the present paper, the fiscal instrument available to the government—exchange controls—is also distortionary, so the problem of the benevolent government can be framed in similar terms as in this literature. Thus, we contribute to this body of work by characterizing a realistic environment in which the Friedman rule is not supported as an optimal outcome.

Finally, there are a number of empirical studies that document episodes of dual and multiple exchange rate practices. Reinhart and Rogoff (2004) present empirical evidence on observed exchange rate gaps in monthly data for 153 countries from 1946 to 2001. In addition, they estimate the degree of underinvoicing of exports over this period and find that underinvoicing was sizeable in countries with dual and parallel exchange rates. Ilzetzki, Reinhart, and Rogoff (2019) provide the history of multiple exchange rate regimes for 194 countries from 1946 to 2016. Kiguel, Lizondo, and O'Connell (1997) contains a collection of case studies of exchange controls in developing countries.

The remainder of the paper proceeds as follows. Section 2 presents the model. Section 3 discusses the calibration and characterizes the equilibrium effects of changes in the exchange-rate gap on key macroeconomic indicators of interest. Section 4 analyzes optimal monetary and exchange control policy. Section 5 concludes.

2 The Model

We study a small economy open to international trade but isolated from international financial markets. The economy produces a nontradable good and an export good. Nontradables are produced with labor and imported materials, and export goods are produced with imported materials. Money is motivated by a transactions cost on consumption purchases. The government has a chronic fiscal deficit and owes an external debt on which it pays interest. It finances these outlays with a combination of seignorage revenue (money creation) and revenue from exchange controls.

2.1 Households

The economy is populated by a large number of identical households with preferences given by

$$\sum_{t=0}^{\infty} \beta^t U(c_t, h_t), \tag{1}$$

where c_t denotes consumption in period t, h_t denotes labor supplied in period t, $\beta \in (0, 1)$ is the subjective discount factor, and U is the period utility function. Labor income is $W_t h_t$, where W_t denotes the nominal wage rate. The household also receives in a lump-sum fashion a government transfer denoted τ_t and profits from the ownership of firms denoted ϕ_t, both measured in units of consumption. Consumption purchases are subject to a proportional transactions cost, denoted $s(v_t)$, that is increasing in money velocity, $v_t = P_t c_t / M_t$, where M_t denotes nominal money holdings and P_t is the price level. Households can trade a pure discount bond denominated in domestic currency, denoted B_t, that pays the interest rate i_t. Their sequential budget constraint is then given by

$$[1 + s(v_t)]P_t c_t + M_t + \frac{B_t}{1 + i_t} = W_t h_t + P_t(\tau_t + \phi_t) + M_{t-1} + B_{t-1}.$$

Letting $a_t \equiv (M_t + B_t)/P_t$ denote real private asset holdings, $m_t \equiv M_t/P_t$ denote real money balances, and $w_t \equiv W_t/P_t$ the real wage, the budget constraint of the household expressed in units of consumption is given by

$$[1 + s(v_t)]c_t + \frac{i_t}{1 + i_t} m_t + \frac{a_t}{1 + i_t} = w_t h_t + \tau_t + \phi_t + \frac{a_{t-1}}{1 + \pi_t}, \tag{2}$$

where $\pi_t \equiv P_t/P_{t-1} - 1$ denotes price inflation.

The household chooses paths of consumption, labor, money holdings, and asset holdings to maximize the lifetime utility function (1) subject to the budget constraint (2), the definition of money velocity

$$v_t = \frac{c_t}{m_t}, \tag{3}$$

and to some no-Ponzi-game constraint. The first-order conditions associated with this maximization problem give rise to a money demand function of the form

$$v_t^2 s'(v_t) = \frac{i_t}{1 + i_t}, \tag{4}$$

to the labor supply schedule

$$-\frac{U_2(c_t, h_t)}{U_1(c_t, h_t)} = \frac{w_t}{1 + s(v_t) + v_t s'(v_t)}, \tag{5}$$

and to the Euler equation

$$\lambda_t = \beta(1 + i_t)\frac{\lambda_{t+1}}{1 + \pi_{t+1}}, \tag{6}$$

where

$$\lambda_t = \frac{U_1(c_t, h_t)}{1 + s(v_t) + v_t s'(v_t)}$$

denotes the marginal utility of wealth. Under the assumption that $v^2 s'(v)$ is increasing in v, the optimality condition (4) implies that the demand for real money holdings, m_t, is decreasing in the interest rate and proportional to consumption. In addition to generating resource losses (shoe leather costs), the transactions cost distorts the marginal rate of substitution between consumption and leisure in favor of the latter (optimality condition (5)). This distortion is increasing in the nominal interest rate i_t. Changes in the interest rate also distort the intertemporal allocation of consumption (optimality condition (6)).

2.2 Firms

Suppose that there is a representative firm that produces a nontradable consumption good and an exportable good. Output of the nontradable consumption good is produced using as inputs labor, h_t, and imported materials, q_t^n. The production technology is of the form $F(h_t, q_t^n)$. The exportable good is produced with imported materials, denoted q_t^x, using the technology $X(q_t^x)$. Both production functions, $F(\cdot,\cdot)$ and $X(\cdot)$, are assumed to be positive, increasing, and concave.

The world price of imported materials is assumed to be constant and equal to one unit of the foreign currency, and the world price of the exported good in terms of imported materials (the external terms of trade), denoted p_t^x, is assumed to be exogenously given. Let $\mathcal{E}_t$ denote the market nominal exchange rate and $\mathcal{E}_t^o$ the official nominal exchange rate set by the government. Both exchange rates are defined as the domestic-currency price of one unit of foreign currency, so that an increase in $\mathcal{E}_t$ or $\mathcal{E}_t^o$ represents a depreciation of the domestic currency.

Firms are required to sell to the government the foreign currency generated by exports in exchange for domestic currency at the official exchange rate $\mathcal{E}_t^o$. We refer to this type of exports as official exports and denote them x_t^o. Similarly, firms are obliged to acquire from the government the foreign currency needed to buy imported materials. We refer to this type of imports as official imports and denote them q_t^o. The government sells foreign currency at the official exchange rate $\mathcal{E}_t^o$ to firms that wish to import. This exchange rate is in general cheaper than the market rate, $\mathcal{E}_t$, so the government rations its quantity at the level $\bar{q}_t^o$, which the firm takes as given. Here we focus on the case in which exchange controls are applied equally to imports and exports, that is, the case in which there is a single official exchange rate. Section 4.3 considers the case in which the government can apply different official exchange rates on imports and exports.

It is illegal to export or import goods outside of the official channel. However, firms can circumvent exchange rate controls by smuggling. This assumption is motivated by the fact that in countries with exchange controls contraband is typically observed. Section 3.1 provides some evidence from the economy to which the model is calibrated. Let x_t^s and q_t^s

denote the amount of smuggled exports and imports. Smuggling carries a cost $C(x_t^s, \kappa_x)$ and $C(q_t^s, \kappa_q)$ measured in units of consumption, where κ_x and κ_q are parameters representing the strength of barriers to smuggling such as the degree of enforcement of contraband laws. The function $C(\cdot, \cdot)$ is assumed to be positive, convex in its first argument, and to satisfy $C(0, \cdot) = 0$ and $C_2 > 0$.

Then, letting ϕ_t denote profits of the firm expressed in units of the consumption good, we have that

$$\phi_t = F(h_t, q_t^n) + \frac{\mathcal{E}_t^o}{P_t}(p_t^x x_t^o - q_t^o) + \frac{\mathcal{E}_t}{P_t}(p_t^x x_t^s - q_t^s) - w_t h_t - C(q_t^s, \kappa_q) - C(x_t^s, \kappa_x). \tag{7}$$

A positive value of x_t^s can be interpreted as under invoicing of exports to customs authorities. A negative value of x_t^s represents over invoicing of exports. Clearly, as long as $\mathcal{E}_t^o < \mathcal{E}_t$, it will not pay for the firm to over invoice exports as it would result in an avoidable loss. A positive value of q_t^s represents under invoicing of imports and a negative value represents over invoicing of imports. As we will see, both under and over invoicing of imports are possible in equilibrium. In particular, under invoicing of imports may arise in equilibrium even if $\mathcal{E}_t^o < \mathcal{E}_t$ because of rationing of foreign exchange at the official rate.

The firm chooses x_t^s, x_t^o, q_t^s, q_t^o, q_t^n, q_t^x, and h_t to maximize (7), subject to

$$q_t^n + q_t^x = q_t^o + q_t^s, \tag{8}$$

$$x_t^o + x_t^s = X(q_t^x), \tag{9}$$

$$q_t^o \leq \bar{q}_t^o, \tag{10}$$

and

$$x_t^o \geq 0. \tag{11}$$

The firm takes the upper bound $\bar{q}_t^o$ on official imports as given, but, as will be clear shortly, $\bar{q}_t^o$ is endogenously determined in equilibrium, which introduces an externality. The non-negativity constraint (11) states that the government does not allow firms to import the exportable good at the subsidized official exchange rate $\mathcal{E}_t^o$. Let

$$\gamma_t \equiv \frac{\mathcal{E}_t}{\mathcal{E}_t^o} - 1$$

denote the gap between the market exchange rate and the official exchange rate. We will refer to γ_t as the exchange rate gap.[1] Let

$$e_t = \frac{\mathcal{E}_t}{P_t}.$$

Absent exchange controls, e_t represents the real exchange rate, that is, the relative price of the imported good in terms of the nontraded good. However, as we will discuss in section 2.5, in the presence of exchange controls firms perceive a different real exchange rate.

Using these definitions to eliminate $\mathcal{E}_t$ and $\mathcal{E}_t^o$ and equations (8) and (9) to eliminate q_t^n and x_t^o from (7) and (11), the firm's problem consists in choosing h_t, q_t^x, q_t^s, x_t^s, and q_t^o to maximize

$$F(h_t, q_t^o + q_t^s - q_t^x) + \frac{e_t}{1+\gamma_t}[p_t^x(X(q_t^x) - x_t^s) - q_t^o] + e_t(p_t^x x_t^s - q_t^s) - w_t h_t - C(q_t^s, \kappa_q) - C(x_t^s, \kappa_x) \quad (12)$$

subject to (10) and

$$X(q_t^x) - x_t^s \geq 0. \quad (13)$$

Letting μ_t^q and μ_t^x denote the Lagrange multipliers associated with (10) and (13), the first-order conditions with respect to h_t, q_t^x, q_t^s, q_t^o, and x_t^s, respectively, are

$$F_1(h_t, q_t^o + q_t^s - q_t^x) = w_t, \quad (14)$$

$$F_2(h_t, q_t^o + q_t^s - q_t^x) = \left[\frac{e_t p_t^x}{1+\gamma_t} + \mu_t^x\right] X'(q_t^x), \quad (15)$$

$$F_2(h_t, q_t^o + q_t^s - q_t^x) = e_t + C'(q_t^s, \kappa_q), \quad (16)$$

$$F_2(h_t, q_t^o + q_t^s - q_t^x) = \frac{e_t}{1+\gamma_t} + \mu_t^q, \quad (17)$$

$$\frac{e_t p_t^x}{1+\gamma_t} + \mu_t^x = e_t p_t^x - C'(x_t^s, \kappa_x), \quad (18)$$

and the nonnegativity and complementary slackness conditions

$$\mu_t^q \geq 0, \quad (19)$$

$$\mu_t^x \geq 0, \quad (20)$$

$$\mu_t^q(\bar{q}_t^o - q_t^o) = 0, \quad (21)$$

and

$$\mu_t^x\left[X(q_t^x) - x_t^s\right] = 0. \quad (22)$$

[1] In the related literature, the exchange rate gap is also referred to as the "parallel market premium."

Optimality condition (14) is a demand for labor. Equation (15) says that the value of the marginal product of imported materials must be the same in the nontraded sector and the export sector. Optimality condition (16) says that in producing nontradable goods the firm equates the marginal product of the imported input to the marginal cost of smuggling it, which is the sum of the market real exchange rate, e_t, and the marginal smuggling cost, $C'(q_t^s, \kappa_q)$. Condition (17) says that if the import constraint is not binding ($\mu_t^q = 0$), then the firm equates the marginal product of imported materials in producing nontradables to the marginal cost of imported materials through the legal market. When the firm's legal imports are rationed ($\mu_t^q > 0$), the shadow marginal cost of importing materials through the legal market is larger than the official marginal cost. Finally, when the nonnegativity constraint on official exports is not binding ($\mu_t^x = 0$), condition (18) says that at the margin, the firm is indifferent between exporting through the official market or through contraband.

2.3 The Government

The government prints money, M_t, issues discount bonds denominated in domestic currency, B_t, and in foreign currency, B_t^*, and makes transfers, τ_t. It also collects resources from the imposition of exchange controls. Its sequential budget constraint is then given by

$$M_t + \frac{B_t}{1+i_t} + \frac{\mathcal{E}_t B_t^*}{1+i_t^*} + (\mathcal{E}_t - \mathcal{E}_t^o)(p_t^x x_t^o - q_t^o) = P_t \tau_t + M_{t-1} + B_{t-1} + \mathcal{E}_t B_{t-1}^*,$$

where i_t^* denotes the interest rate paid by the government on its external debt and is assumed to be exogenously determined. The left-hand side represents the government's sources of funds and includes revenues from exchange rate controls. The right-hand side represents the government's uses of funds. Dividing the above expression through by the price level, P_t, and recalling the definition $a_t \equiv (M_t + B_t)/P_t$, the sequential budget constraint expressed in units of consumption is given by

$$\frac{i_t}{1+i_t} m_t + \frac{a_t}{1+i_t} + \frac{e_t B_t^*}{1+i_t^*} + \frac{e_t \gamma_t}{1+\gamma_t}(p_t^x x_t^o - q_t^o) = \tau_t + \frac{a_{t-1}}{1+\pi_t} + e_t B_{t-1}^*. \tag{23}$$

The last term on the left-hand side represents the fiscal surplus generated by taxing the official trade balance with the exchange-rate gap. We denote this source of fiscal revenue by s_t,

$$s_t \equiv \frac{\gamma_t}{1+\gamma_t} e_t (p_t^x x_t^o - q_t^o). \tag{24}$$

Given our focus on the case of a positive exchange-rate gap, $\gamma_t > 0$, it is clear from this expression that if the government is to generate any direct fiscal revenue from exchange controls, it must ensure a positive official trade balance, $p_t^x x_t^o - q_t^o > 0$. In equilibrium, exchange controls can also affect the government's finances indirectly through their effects on endogenous variables such as the external real exchange rate, e_t, and real balances, m_t.

For simplicity, we assume that the bond denominated in domestic currency trades only in the domestic market and that the bond denominated in foreign currency trades only in the international market. Furthermore, we have in mind a government that is financially isolated from the international capital market. The government makes interest payments to the rest of the world, but cannot change its external debt position endogenously—to smooth transitory disturbances, say. Specifically, we set $B_t^* = B^*$, where B^* is a positive constant. Thus, net international interest payments expressed in units of the imported good, $i_t^* B^*/(1+i_t^*)$, are exogenously given.

Iterating the government's budget constraint (23) forward, using (24) to replace $e_t\gamma_t/(1+\gamma_t)(p_t^x x_t^o - q_t^o)$, and using the household's transversality condition, we can write

$$\frac{a_{-1}}{1+\pi_0} = \sum_{t=0}^{\infty} \frac{\frac{i_t}{1+i_t} m_t + s_t - \tau_t - e_t \frac{i_t^* B^*}{1+i_t^*}}{\prod_{s=0}^{t-1} \frac{1+i_s}{1+\pi_{s+1}}}. \tag{25}$$

In the numerator on the right-hand side, the first term is seignorage revenue. The second term is the amount of resources the government extracts from the private sector through exchange controls. The third term is the primary fiscal deficit, and the last term is net international interest payments in units of consumption goods. Thus, equation (25) says that the government's initial domestic real liabilities, $a_{-1}/(1+\pi_0)$, must be backed by the present discounted value of primary fiscal surpluses plus seignorage revenue and resources from exchange controls, net of international interest payments. We assume that the government starts with a liability position, $a_{-1} > 0$.

As explained earlier, we assume that the government provides foreign exchange to importers at the official exchange rate $\mathcal{E}_t^o$. However, the government limits the amount of foreign exchange importers can buy at the official exchange rate, which may necessitate rationing. We make this assumption because rationing is an ubiquitous feature of exchange control regimes in general (Dornbusch, 1986) and in particular of the existing arrangement in Argentina, the economy on which we base the calibration of the model. Since direct fiscal revenue from a positive exchange-rate gap, s_t, is positive only if the official trade balance, $p_t^x x_t^o - q_t^o$, is in surplus, we assume that the amount of foreign exchange the government offers to importers must be smaller than official exports. Specifically, we assume that the government imposes the following upper bound on purchases of foreign exchange at the official rate:

$$\bar{q}_t^o = (1-\rho_t)p_t^x x_t^o, \tag{26}$$

with $0 < 1-\rho_t < 1$. The higher ρ_t is, the more restricted legal imports will be. Absent restriction (26), there are no guarantees that the official trade balance, $p_t^x x_t^o - q_t^o$, will be positive. In other words, constraint (26) ensures that the government, if it wishes, will be able to collect resources from taxing official net exports when the exchange-rate gap is positive.

The government uses ρ_t as a policy instrument. Note that firms take $\bar{q}_t^o$ as exogenously given, but that in equilibrium it is endogenously determined. This feature introduces an externality into the model because firms do not internalize that by exporting more they could relax the import restrictions and buy more foreign exchange at the subsidized rate $\mathcal{E}_t^o$. Firms understand that their collective exports raise the import limit $\bar{q}_t^o$, but they also understand that individually they are too small to affect it.

Finally, we have in mind a situation of a country that is unable or unwilling to eliminate chronic primary fiscal deficits. Thus, we will assume that the path of primary fiscal deficits, τ_t, is exogenously given. It follows that the government has three policy instruments at hand: the domestic interest rate i_t, the exchange rate gap γ_t, and import restrictions ρ_t. Because of its intertemporal budget constraint, the government can pick freely the paths of only two of these three instruments.

2.4 Equilibrium

In equilibrium the market for nontradable goods must clear. Formally,

$$[1+s(v_t)]c_t + C(q_t^s, \kappa_q) + C(x_t^s, \kappa_x) = F(h_t, q_t^n). \tag{27}$$

Combining the budget constraint of the household (equation (2)), the budget constraint of the government (equation (23)), the definition of profits (equation (12)), and the market clearing condition in the nontraded sector (equation (27)) yields

$$p_t^x(x_t^o + x_t^s) - (q_t^o + q_t^s) - \frac{i_t^* B^*}{1+i_t^*} = 0, \tag{28}$$

which says that because the country is financially isolated from the rest of the world, its current account is nil up to changes in the external interest rate i_t^*.[2]

Conditions (3)-(5), (8)-(11), (14)-(22), (24), and (26)-(28) represent a static system of 16

[2] The current account is given by $[1/(1+i_{t-1}^*) - 1/(1+i_t^*)]B^*$, which vanishes only when $i_t^* = i_{t-1}^*$.

equations and 4 inequalities in the 16 endogenous variables v_t, c_t, m_t, h_t, w_t, q_t^n, q_t^x, q_t^o, q_t^s, x_t^o, x_t^s, $\bar{q}_t^o$, s_t, μ_t^q, μ_t^x, and e_t, given policy variables γ_t, ρ_t, and i_t, and exogenous variables p_t^x, i_t^*, and τ_t. This static system can be solved for the equilibrium values of the 16 endogenous variables as functions of the policy variables and the exogenous shocks. We summarize this result in the following proposition:

Proposition 1 (Partial Equilibrium) *Letting*

$$\eta_t = \left[\begin{array}{ccc} \gamma_t & \rho_t & i_t \end{array} \right]$$

be the policy vector and

$$\eta_t^* = \left[\begin{array}{ccc} p_t^x & i_t^* & \tau_t \end{array} \right]$$

the vector of exogenous shocks, then in equilibrium the 16 endogenous variables v_t, c_t, m_t, h_t, w_t, q_t^n, q_t^x, q_t^o, q_t^s, x_t^o, x_t^s, $\bar{q}_t^o$, s_t, μ_t^q, μ_t^x, and e_t are the solution to the static system of 16 equations and 4 inequalities given by (3)-(5), (8)-(11), (14)-(22), (24), *and* (26)-(28) *and can be expressed as functions of η_t and η_t^*. Thus, if x_t is any of the aforementioned endogenous variables, then one can write*

$$x_t = x(\eta_t, \eta_t^*).$$

The policy variables γ_t, ρ_t, and i_t in the policy vector η_t are not independent of one another in equilibrium because the intertemporal equilibrium conditions of the model must also be satisfied. Specifically, the intertemporal budget constraint of the government (equation (25)) and the Euler equation (6) introduce a restriction on the equilibrium path of the policy vector η_t. Combining these two equations and letting $\theta_t \equiv 1 + s(v_t) + v_t s'(v_t)$ denote the distortion in the consumption leisure decision of the household introduced by inflation, a competitive equilibrium can be defined as follows:

Definition 1 (Competitive Equilibrium) *A competitive equilibrium is a scalar π_0 and a sequence of policy variables $\eta_t \equiv [\gamma_t \, \rho_t \, i_t]'$ for $t \geq 0$ satisfying*

$$\frac{a_{-1}}{1+\pi_0} = \sum_{t=0}^{\infty} \beta^t \frac{U_1(c(\eta_t, \eta_t^*), h(\eta_t, \eta_t^*))\theta(\eta_0, \eta_0^*)}{U_1(c(\eta_0, \eta_0^*), h(\eta_0, \eta_0^*))\theta(\eta_t, \eta_t^*)} \left[\frac{i_t m(\eta_t, \eta_t^*)}{1+i_t} + s(\eta_t, \eta_t^*) - \tau_t - e(\eta_t, \eta_t^*) \frac{i_t^* B^*}{1+i_t^*} \right], \tag{29}$$

and

$$i_t \geq 0,$$

given the initial stock of real government liabilities $a_{-1} > 0$ and the sequence of exogenous shocks $\eta_t^* \equiv [p_t^x \, i_t^* \, \tau_t]'$, for $t \geq 0$.

2.5 Exchange Controls and Competitiveness: Internal and External Relative Prices

In the presence of exchange controls, there are two real exchange rates, an external one and an internal one. The external real exchange rate, $e_t \equiv \mathcal{E}_t/P_t$, is the relative price of the imported good in terms of the nontraded good using the market exchange rate to convert foreign currency prices into domestic currency prices (recall that the foreign currency price of the imported good is assumed to be one). The external real exchange rate is economically relevant because it affects the cost of servicing the government's external debt in terms of nontradables, $e_t i_t^* B^*/(1+i_t^*)$, see equilibrium condition (29). However, the external real exchange rate is not economically relevant for domestic firms in the presence of exchange controls. The reason is that firms cannot purchase the imported good at the price $\mathcal{E}_t$ without having to pay a smuggling cost. The internal real exchange rate takes this distortion into account. It is defined as the relative price of the import good in terms of the nontraded good in the domestic market. The price of imports inside the country is $\mathcal{E}_t + P_t C'(q_t^s, \kappa_q)$. This is so because the imported good is not always available for purchase at the official exchange rate ($\mathcal{E}_t^o$), but is always available through smuggling, which requires paying the market exchange rate ($\mathcal{E}_t$) plus the marginal cost of smuggling ($P_t C'(q_t^s, \kappa_q)$). Thus the internal real exchange rate is given by $[\mathcal{E}_t + P_t C'(q_t^s, \kappa_q)]/P_t$, which can be written as

$$\text{internal real exchange rate} = e_t + C'(q_t^s, \kappa_q). \tag{30}$$

In words, the internal real exchange rate equals the external real exchange rate adjusted by the marginal contraband cost. The economic relevance of the internal real exchange rate for the firm is reflected in optimality condition (16), which says that firms equate the marginal product of imported materials in the production of nontradable goods to the internal real exchange rate.

Exchange rate controls distort not only the real exchange rate but also the terms of trade. The external terms of trade, p_t^x, is the relative price of the exported good in terms of the imported good in world markets. The small open economy takes the external terms of trade as exogenously given. However, internally, producers of export goods perceive a different relative price. The internal nominal price of the exported good is $\mathcal{E}_t^o p_t^x$ and the internal nominal price of the imported good is $\mathcal{E}_t + P_t C'(q_t^s, \kappa_q)$. Taking the ratio of these two prices, the internal terms of trade can be written as

$$\text{internal terms of trade } = p_t^x \frac{e_t}{(1+\gamma_t)(e_t + C'(q_t^s, \kappa_q))}.$$

In the absence of exchange controls ($\gamma_t = \rho_t = 0$) the internal terms of trade are equal to the external terms of trade because smuggling and hence marginal smuggling costs are zero ($q_t^s = C'(q_t^s, \kappa_q) = 0$). Consider now the case of exchange controls ($\gamma_t > 0$). Using optimality conditions (16) and (17) to eliminate $e_t + C'(q_t^s, \kappa_q)$ from the definition of the internal terms of trade given above, we can write

$$\text{internal terms of trade} = p_t^x \frac{\frac{e_t}{1+\gamma_t}}{\frac{e_t}{1+\gamma_t} + \mu_t^q}.$$

It is clear from this expression that the internal and external terms of trade are equal to each other if the import constraint (10) is slack ($\mu_t^q = 0$). On the other hand, when this constraint binds ($\mu_t^q > 0$), exchange controls deteriorate the internal terms of trade.

We conclude that exchange controls worsen the perceived competitiveness of the economy from the point of view of both the producers of nontradable goods (the internal real exchange rate depreciates) and the producers of export goods (the internal terms of trade deteriorate).

2.6 The Necessity of Legal and Illegal Trade

In this section we show that for exchange-rate controls to matter as a fiscal instrument (i.e., to be a useful vehicle to generate income for the government) it is essential that smuggling be costly but not prohibitively so. In other words, if the government is to affect the fiscal space through changes in the exchange-rate gap, contraband laws must be strict enough to guarantee some legal trade but also weak enough to guarantee some illegal trade. To show that both legal and illegal trade are necessary for the exchange-rate gap to be fiscally relevant, we consider two polar cases. In one case, contraband laws are so strict that all international trade occurs through the legal channel. In the other case, contraband laws are so lax that all international trade occurs through the illegal channel. We show that in both cases changes in the exchange-rate gap do not affect the fiscal space in equilibrium.

2.6.1 The Necessity of Illegal Trade

Consider first the case of strict enforcement of contraband laws. Specifically, assume that $C(x, \kappa) = \infty, \forall x \neq 0$. In this case, the firm chooses not to smuggle goods in or out of the country, that is,

$$x_t^s = q_t^s = 0.$$

The resource constraint for tradable goods (28) then implies that the official trade balance, which now equals the overall trade balance, must satisfy

$$p_t^x x_t^o - q_t^o = \frac{i_t^* B^*}{1+i_t^*}.$$

Using this expression and the definition of s_t given in (24) to eliminate the official trade balance from the equilibrium intertemporal budget constraint of the government (29) yields

$$\frac{a_{-1}}{1+\pi_0} = \sum_{t=0}^{\infty} \beta^t \left\{ \frac{U_1(c(\eta_t,\eta_t^*), h(\eta_t,\eta_t^*))\theta(\eta_0,\eta_0^*)}{U_1(c(\eta_0,\eta_0^*), h(\eta_0,\eta_0^*))\theta(\eta_t,\eta_t^*)} \left[\frac{i_t m(\eta_t,\eta_t^*)}{1+i_t} - \tau_t - \frac{e(\eta_t,\eta_t^*)}{1+\gamma_t}\frac{i_t^* B^*}{1+i_t^*} \right] \right\}.$$

This expression says that the exchange-rate gap, γ_t, has fiscal consequences only if it affects the equilibrium values of $e_t/(1+\gamma_t)$, m_t, c_t, h_t, or v_t. However, it turns out that, when exchange controls are strictly enforced, these variables are independent of γ_t. To see this, note that in this case the objective function of the firm, given in (12), becomes

$$F(h_t, q_t^o - q_t^x) + \frac{e_t}{1+\gamma_t}[p_t^x X(q_t^x) - q_t^o] - w_t h_t, \tag{31}$$

which depends on $e_t/(1+\gamma_t)$ but not on γ_t or e_t separately. The constraints of the firm—which under strict enforcement of contraband laws become $q_t^o \le \bar{q}_t^o$ and $X(q_t^x) \ge 0$—feature neither e_t nor γ_t. Thus, the optimality conditions of the firm depend on $e_t/(1+\gamma_t)$, w_t, and $\bar{q}_t^o$, but, again, not on e_t or γ_t separately. Further, neither e_t nor γ_t appear in the resource constraint for tradables (28), the resource constraint for nontradables (27), the demand for money (4), the supply of labor (5), or the definition of $\bar{q}_t^o$ given in (26). It follows that the equilibrium values of v_t, c_t, m_t, h_t, w_t, q_t^n, q_t^x, x_t^o, $\bar{q}_t^o$, and $e_t/(1+\gamma_t)$ are independent of the exchange-rate gap γ_t. This implies that when exchange controls are strictly enforced, changes in the exchange-rate gap, γ_t, do not affect the fiscal space. We summarize this result in the following proposition:

Proposition 2 (Necessity of Illegal Trade) *If anti-contraband laws are strictly enforced ($C(x,\kappa)=\infty$ for all $x \neq 0$), then in equilibrium government revenue, $i_t/(1+i_t)m_t + s_t - \tau_t - e_t i_t^* B^*/(1+i_t^*)$, and the real allocation, c_t, h_t, and v_t, are independent of the exchange-rate gap γ_t.*

The intuition behind Proposition 2 is that if contraband costs are prohibitively high, then there is no black market in which the government could sell the foreign currency it confiscates from exporters. As a result, the government cannot profit from exchange controls.

2.6.2 The Necessity of Legal Trade

Suppose that $C(x, \kappa) = 0$ for all x. Then, if $\gamma_t > 0$, no exports will be channeled through the legal market,

$$x_t^o = 0.$$

On the other hand, the firm will desire to channel all imports through the official market, where the exchange rate is subsidized. However, because the upper bound on official imports imposed by the government, $\bar{q}_t^o = (1 - \rho_t) p_t^x x_t^o$, is proportional to official exports (equation (26)), we have that official imports must be nonpositive, $q_t^o \leq 0$. But official imports can never be negative when $\gamma_t > 0$, because it would imply that the firm buys imported materials in the illegal market at e_t and sells them in the legal market at $e_t/(1 + \gamma_t) < e_t$, making an avoidable loss. Formally, this can be seen by combining optimality conditions (16) and (17), which implies that $\mu_t^q > 0$ when $\gamma_t \geq 0$ and $C'(\cdot, \cdot) = 0$. In turn, by the slackness condition (21), $\mu_t^q > 0$ and the fact that $\bar{q}_t^o = 0$ imply that

$$q_t^o = 0.$$

Since the official trade balance, $p_t^x x_t^o - q_t^o$, is zero, so is the amount of direct revenue from exchange controls collected by the government, s_t (see equation (24)). It remains to show that by changing γ_t the government cannot collect resources indirectly by altering the equilibrium values of the variables that enter in its equilibrium intertemporal budget constraint (29), namely, c_t, h_t, v_t, m_t, and e_t. By optimality conditions (15), (16), and (18), we have that $p_t^x X'(q_t^x) = 1$, which pins down q_t^x independently of γ_t. In turn, the resource constraint for tradables (28) determines q_t^n also independently of γ_t. Now, by (4), v_t depends only on the policy variable i_t. Then, equilibrium conditions (5), (14), and (27) represent a system of three equations in three unknowns, c_t, h_t, and w_t, that is independent of γ_t. Finally, optimality condition (16) determines e_t, again, independently of γ_t. This completes the demonstration that if the government fails to enforce contraband laws, then exchange-rate controls do not serve as a fiscal instrument. We summarize this result in the following proposition:

Proposition 3 (Necessity of Legal Trade) *If anti-contraband laws are not enforced ($C(x, \kappa) = 0$ for all x), then in equilibrium government revenue, $i_t/(1+i_t)m_t + s_t - \tau_t - e_t i_t^* B^*/(1+i_t^*)$, and the real allocation, c_t, h_t, and v_t, are independent of the exchange-rate gap γ_t.*

The intuition behind Proposition 3 is that if smuggling is costless, then no trade occurs at the official exchange rate, so, the government cannot confiscate any foreign currency.

3 Quantitative Analysis

Section 2.6 shows that in the extreme cases of strict enforcement of contraband laws and no enforcement of such laws, changes in the exchange-rate gap γ_t do not affect fiscal revenue. In fact, in those extreme cases the entire real allocation is independent of γ_t. In this section, we consider the intermediate case in which there is some enforcement of contraband laws that results in an equilibrium in which international trade occurs both through the legal and illegal markets. We discipline the cost of smuggling by requiring that the model replicate aspects of international trade observed in an actual economy with exchange controls.

3.1 Calibration

Table 1 displays the calibrated parameters. The time unit is a quarter. Variables without a time subscript denote steady-state values.

We calibrate the policy parameters of the model to the Argentine economy during the period 2007 to 2021. This period includes two episodes of exchange controls, known as cepos cambiarios. The first cepo cambiario lasted from October 2011 to December 2015 and had an average exchange rate gap of 45 percent. The second cepo cambiario started in September 2019 and was still in effect at the end of the sample, with an average exchange-rate gap of 72 percent. We start the calibration period in 2007 because this year marks the beginning of the administration during which the first spell of exchange rate controls was implemented. During much of the calibration sample, the cepos cambiarios specified a single official exchange rate for imports and exports, which coexisted with a market-determined parallel exchange rate. The domestic currency was always more depreciated in the parallel market than in the official market, $\mathcal{E}_t > \mathcal{E}_t^o$, implying a non-zero exchange-rate gap, $\gamma_t > 0$.

We set the steady-state value of the exchange-rate gap at 23 percent, $\gamma = 0.23$. This value is the average exchange rate gap observed in Argentina during the calibration period (January 2007 to December 2021). Drawing on the empirical estimate of the interest rate faced by Argentina in international capital markets presented in Schmitt-Grohé and Uribe (2016), we set i^* to 13 percent per year ($i^* = 1.13^{1/4} - 1$).

We assume that the production technologies of nontradable and exportable goods are of the form

$$F(h, q^n) = A_n h^{\alpha_h} (q^n)^{\alpha_n}$$

and

$$X(q^x) = A_x (q^x)^{\alpha_x}.$$

We normalize A_n and A_x to unity. Following Uribe (1997), we set α_h to 0.75. This value

Table 1: Calibration

Calibrated Parameters		
γ	0.23	Exchange-rate gap, $\gamma = \mathcal{E}/\mathcal{E}^o - 1$
β	$1.04^{-1/4}$	Subjective discount factor
A_x, A_n	1	Level of technology in the nontraded and export sectors
α_x, α_n	0.15	Import elasticity of output in the nontradable and export sectors
α_h	0.75	Labor elasticity of nontraded output
σ	2	Inverse of the intertemporal elasticity of substitution
χ_1	0.5	Inverse of the Frisch elasticity of labor supply
i^*	$1.13^{1/4} - 1$	External interest rate
p^x	1	External terms of trade
Estimated Parameters		
A	0.80	Parameter of transactions cost function
B	1.95	Parameter of transactions cost function
D	1.77	Parameter of transactions cost function
Implied Parameters		
ρ	0.088	Import limit at the official exchange rate, $q^o \leq (1-\rho)p^x x^o$
κ_q, κ_x	0.71	Parameter of the smuggling cost function, $C(x,\kappa) = (\kappa/2)x^2$
χ_0	0.82	Preference parameter
B^*	3.29	External public debt
a	1.81	Total domestic government liabilities, $a = m + b$
τ	0.0183	Primary fiscal deficit
δ	0.03	Off-the-books government revenue
Targeted Moments		
$\frac{ep^x x^o}{y}$	0.17	Recorded exports to output ratio
$\frac{eB^*/(1+i^*)}{4y}$	0.22	Share of foreign government liabilities in output
$\frac{e(p^x x^o - q^o)}{y}$	0.015	Recorded trade balance to output ratio
$\frac{\tau}{y}$	0.02	Fiscal deficit to output ratio
π	$1.31^{1/4} - 1$	CPI inflation rate
$\frac{b}{4y(1+i)}$	0.38	Ratio of domestic government debt to annual output
h	1	Steady state value of hours

Notes. The time unit is a quarter. The variable $y \equiv (1+s(v))c + e(p^x x^o - q^o)$ denotes steady-state recorded real output.

implies a share of labor in nontraded gross output of 75 percent. Based on the cross-country evidence on the average share of imported inputs in domestic production presented in Gopinath, Itskhoki, and Rigobon (2007), we set $\alpha_n = \alpha_x = 0.15$. We normalize the steady state of the external terms of trade to one, $p^x = 1$.

We assume a period utility function of the form

$$U(c,h) = \frac{c^{1-\sigma} - 1}{1-\sigma} - \chi_0 \frac{h^{1+\chi_1}}{1+\chi_1}.$$

We set $\sigma = 2$, which is a standard value for the inverse of the intertemporal elasticity of consumption substitution in business-cycle analysis. We set χ_1 equal to 1/2. This value implies a Frisch elasticity of labor supply of 2, which is commonly used in the calibration of open-economy business-cycle models (Mendoza, 1991). The parameter χ_0 is a scaler, which determines the steady-state value of hours worked. As explained below, we set it to ensure that in the steady state hours are normalized to 1. The implied value is 0.82. The subjective discount rate is assumed to be 4 percent per year, $\beta = 1.04^{-1/4}$.

We propose a transactions cost function of the form

$$s(v) = \frac{\left(A - \frac{D}{v}\right)^{1+B}}{1+B}. \tag{32}$$

This functional form ensures that the demand for money has the following three properties: (i) a satiation point (i.e., a finite demand for money at a zero nominal interest rate); (ii) a Laffer curve for the inflation tax (i.e., an inverse-U shape for the relationship between inflation and seignorage income); and (iii) a unit income elasticity. These features are desirable because we estimate the demand for money over a period in which Argentina experienced wildly different inflation outcomes ranging from hyperinflation (1989 to 1991) to deflation (1998 to 2001). If the demand for money does not satisfy (i), then seignorage revenue could grow unboundedly as the interest rate approaches zero ($\frac{i}{1+i}m \to \infty$ as $i \to 0$). Similarly, if the demand for money does not satisfy (ii), then seignorage revenue could become arbitrarily large as the interest rate becomes large ($\frac{i}{1+i}m \to \infty$ as $i \to \infty$).

The transactions cost function (32) implies a demand for money of the form

$$m = c\left[\frac{A}{D} - \frac{1}{D}\left(\frac{i}{D(1+i)}\right)^{\frac{1}{B}}\right], \tag{33}$$

which is essentially a power function with an intercept. This demand for money gives rise to a Laffer curve for seignorage revenue, $i/(1+i)m$, with a peak at $i/(1+i) = D\left(\frac{AB}{1+B}\right)^B$. At the Friedman rule, $i = 0$, the demand for money is finite and equal to cA/D.

We estimate the parameters A, B, and D on Argentine data over the period 1960 to 2021 using nonlinear least squares. The estimation includes a dummy for the period 1991 to 2001 during which the Argentine peso was convertible to dollars at a one-to-one rate. During the convertibility period the money-to-output ratio experienced a significant discrete fall of about 45 percent in spite of the inflation rate being at the lowest level in the sample.[3] The reason why real balances were low during this period is that the government lifted restrictions on the use of the dollar as a medium of exchange, as a store of value, and as a unit of account, which led to widespread currency substitution. These restrictions were later reinstituted.

There is no reliable quarterly data on consumption and nominal interest rates for Argentina over long time spans. For this reason, we use annual data, GDP as a proxy for consumption, and CPI inflation as a proxy for the nominal interest rate. Specifically, the proxy for the nominal interest rate is inflation plus a constant riskless annual real interest rate of 4 percent. Data on the money base is taken from the Central Bank of Argentina. The source for nominal GDP is Kehoe and Nicolini (2021) for the period 1960 to 2017 and the Ministry of the Economy of Argentina for the period 2017 to 2021. The source for CPI inflation is the price index produced by Instituto Nacional de Estadística y Censos (INDEC), the government statistical office in charge of producing the Argentine consumer price index, except for the period 2007 to 2016, for which the source is Cavallo and Bertolotto (2016). The Cavallo-Bertolotto CPI index controls for the fact that for much of the period 2007 to 2016 INDEC underreported inflation figures.[4] The parameter estimates are $A = 0.80$, $B = 1.95$, and $D = 1.77$.[5]

Figure 1 displays the implied money demand function and the associated Laffer curve for seignorage income. At the average inflation rate of 31 percent per year observed over the calibration period, the money demand function implies a money-to-output ratio of 8.6 percent per year. The peak of the Laffer curve occurs at a quarterly interest rate of 106 percent. Given the assumed discount rate of 4 percent per annum, at the peak of the Laffer curve the monthly inflation rate is 27 percent. With this inflation rate, the government collects 7.9 percent of GDP in seignorage revenue.

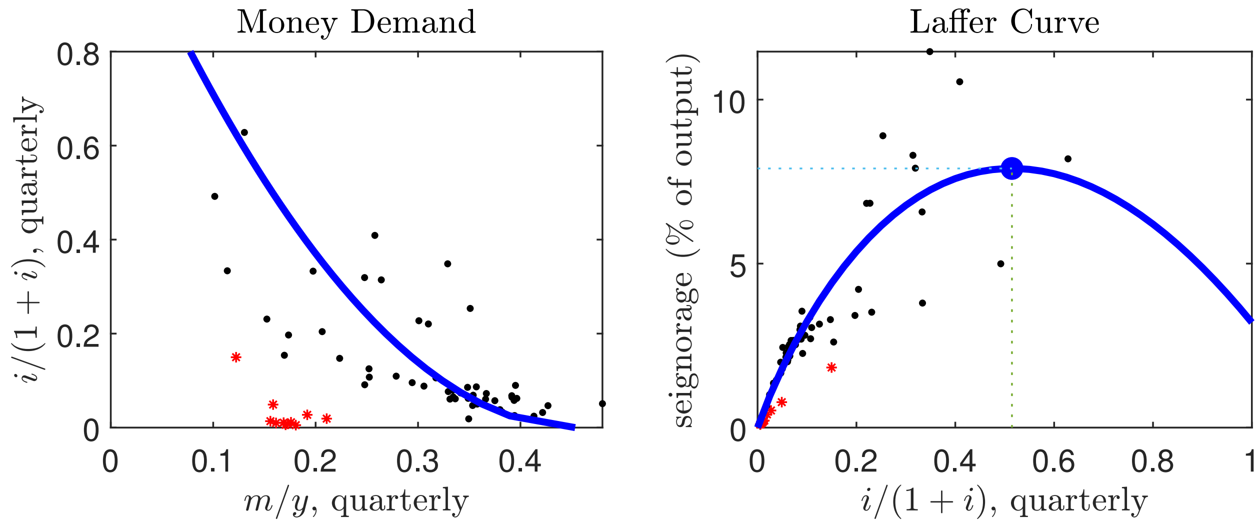
We assume that in the steady state the inflation rate is 31 percent per year, $\pi = 1.31^{1/4} - 1$. This value corresponds to average CPI inflation observed in Argentina over the calibration period for policy variables, 2007 to 2021. By the Euler equation (6), the steady-state domestic nominal interest rate, i, satisfies $i = (1 + \pi)/\beta - 1$. Given the assumed values of β and π,

[3] Controlling for inflation, the fall in real money holdings during the convertibility period was 72 percent.

[4] We thank Emilio Zaratiegui for sharing this data.

[5] These parameter values are expressed in a form compatible with a demand for money observed at a quarterly frequency, so they can be used directly in the calibration of the model.

Figure 1: Estimated Money Demand Function and Laffer Curve: Argentina 1960 to 2021



Notes. The notation is m = real money balances, y = real quarterly GDP, and i = quarterly nominal interest rate. Dots and stars represent, respectively, data outside and during the convertibility period (1991 to 2001). Solid lines represent the estimated money demand function (left) and the Laffer curve (right). Seignorage is defined as $i/(1+i)m/y$. The money demand function has the form given in equation (33). The estimated parameter values are shown in Table 1.

the implied steady-state nominal interest rate is 36 percent per year, or $i = 0.08$.

We assume that the smuggling cost function is the same in the export and import sectors, $\kappa_q = \kappa_x = \kappa$, and adopt a quadratic functional form

$$C(z, \kappa) = \frac{\kappa}{2} z^2, \tag{34}$$

for $z = q^s, x^s$. Government detection and sanctioning of smuggling activity is regularly reported in the press during spells of exchange controls.[6] We adopt an indirect inference approach to estimate the parameter κ. In essence, the strategy to identify κ consists in comparing the recorded trade balance and the country's observed interest payments on ex-

[6]For example, on February 12, 2023, Clarín, one of the main newspapers of Argentina, reported the government's uncovering of an export under invoicing scheme involving 20 slaughterhouses. The strategy consisted in channeling meat exports through traders located in a third country (Cyprus, Uruguay, and the United States). These middlemen added no value added, but would simply buy meat from the slaughterhouses at a below-market price and then re-export it to other countries (including China, Chile, and Brazil) with a markup of about 30 percent. The profit, denominated in hard currency, would then be deposited in banks outside Argentina in accounts owned by the involved slaughterhouses, thereby avoiding having to render the foreign exchange at the central bank. In the same article, Clarín reports another under invoicing strategy consisting in exporting regular beef (class C) as canner beef (class D or E). The price difference is again deposited outside Argentina, avoiding conversion to domestic currency at the official exchange rate by the central bank.

ternal debt. The difference between these two figures is the smuggling trade balance. The value of κ is picked to induce the required smuggling trade balance as an equilibrium outcome. Formally, we jointly calibrate κ, B^*, ρ, and χ_0 by simulated method of moments. The targeted moments are: (a) An official trade balance to output ratio of 1.5 percent, $e(p^x x^o - q^o)/y = 0.015$, where $y \equiv c[1 + s(v)] + e[p^x x^o - q^o]$ denotes output. This matches the recorded average value observed in Argentina over the calibration period. The data source is the IMF's International Financial Statistics (IFS). (b) A net external debt of the government of 22 percent of annual GDP, $eB^*/(1 + i^*)/(4y) = 0.22$. This figure represents the average value of the Argentine government's debt with external creditors as a fraction of GDP over the calibration period. The data source is the Argentine Ministry of the Economy. (c) Official exports equal 17 percent of output, $ep^x x^o/y = 0.17$. This figure matches the corresponding observed value in Argentina over the calibration period. The source is IFS. And (d) an average level of hours of 1, $h = 1$.

Over the calibration period, the average primary fiscal deficit in Argentina was 2 percent of GDP, $\tau/y = 0.02$, and the average domestic government debt was 38 percent of GDP, $[(a - m)/(1 + i)]/(4y) = 0.38$. The data sources are IMF Fiscal Monitor and Argentine Ministry of the Economy, respectively.

The above calibration of the model provides values for all components of the government's budget constraint (29) in the steady state: seignorage $(i/(1 + i)m)$, revenue from exchange controls (s), the primary fiscal deficit (τ), interest payments on external debt $(ei^*B^*/(1+i^*))$, and total domestic government liabilities (a). As discussed in Kehoe, Nicolini, and Sargent (2021), in general, these numbers need not exactly satisfy the government budget constraint. The reasons why in general the government budget constraint will not be satisfied at the calibrated values include: (a) Argentina may not have been at exactly a steady state during the calibration period; (b) the different components of the budget constraint were taken from independent sources; and (c) the model does not allow for default or confiscation of financial assets, which is a recurrent phenomenon in Argentina. To circumvent this issue, we follow Kehoe, Nicolini, and Sargent and introduce a residual, denoted δ, to ensure that the government budget constraint is satisfied in the steady state. Thus, the steady-state government budget constraint becomes

$$a\frac{\beta^{-1} - 1}{1 + i} = \frac{i}{1 + i}m(\eta, \eta^*) + s(\eta, \eta^*) - \tau - e(\eta, \eta^*)\frac{i^*B^*}{1 + i^*} + \delta, \tag{35}$$

where we used the Euler equation (6) evaluated at the steady state to replace π_0 by $\beta(1+i)-1$. The resulting value of δ is 0.03. We keep this value constant for the remainder of the paper.

Table 2: Exchange Controls and Changes in the Fiscal Space

	ρ		
γ	0	0.5	1
0	0	1.4	2.3
1	0.3	3.1	3.9
2	0.4	3.2	4.5
3	0.4	3.2	4.8
4	0.4	3.0	4.9
5	0.3	2.8	4.8

Notes. Changes in the fiscal space are measured in percent of GDP and relative to the case $\gamma = \rho = 0$. The interest rate is kept constant at its baseline value.

3.2 Fiscal Effects of Exchange Controls

Exchange controls affect the fiscal deficit through two channels. First, the exchange-rate gap γ represents a tax on official net exports $p^x x^o - q^o$. Second, if the government has obligations denominated in units of tradables and in units of nontradables, then by affecting the real exchange rate e, exchange controls can alter the real value of the fiscal deficit. In the present model the primary deficit τ is a stream of nontradable goods, whereas interest on the external debt $i^* B^*/(1+i^*)$ and revenues from the exchange rate gap $\gamma/(1+\gamma)(p^x x^o - q^o)$ are streams of tradable goods. Movements in the real exchange rate change the relative importance of these components of the fiscal deficit. Thus, exchange controls are not just a tax on net exports but may also create fiscal space if they reduce the government's external debt burden measured in units of consumption.

To gauge the ability of exchange controls to generate fiscal revenue, Table 2 displays the change in the fiscal space,

$$\text{fiscal space} = s(\eta, \eta^*) - e(\eta, \eta^*) \frac{i^* B^*}{1 + i^*} - \tau,$$

as a fraction of output for selected values of γ and ρ, holding the nominal interest rate i_t and the exogenous shock vector η_t^* constant at their baseline values. Changes in the fiscal space are measured relative to a situation with no exchange controls ($\gamma = \rho = 0$). The analysis is in partial equilibrium because the fact that the nominal interest rate i is kept constant implies that the intertemporal government budget constraint (29) need not be satisfied.

Table 2 shows that exchange controls can raise significant revenue for the government. The maximum revenue is close to 5 percentage points of GDP. This is a big number. It is two and a half times as large as the primary fiscal deficit observed in Argentina over the calibration period (2007 to 2021). The government generates this outcome by setting the exchange rate gap at 400 percent and by not providing any foreign exchange to importers at the official exchange rate ($\rho = 1$). The table further shows that a government that seeks to maximize fiscal revenue from exchange controls does not sell any foreign currency to importers at the official exchange rate regardless of the value of the exchange rate gap γ. Finally, given ρ, there is an exchange-rate gap Laffer curve, in the sense that there is a value of γ below which fiscal revenue is increasing in γ and above which fiscal revenue is decreasing in γ.

Having established that exchange controls can be a powerful fiscal tool, a natural question that arises is what are the macroeconomic effects and welfare costs of using exchange controls to generate fiscal revenue. This will be the focus of the discussion that follows. For the remainder of the paper, the analysis will be performed in general equilibrium, that is, the path of the policy triplet $\eta_t = [\gamma_t \, \rho_t \, i_t]$ will always be required to ensure the satisfaction of the equilibrium intertemporal budget constraint (29).

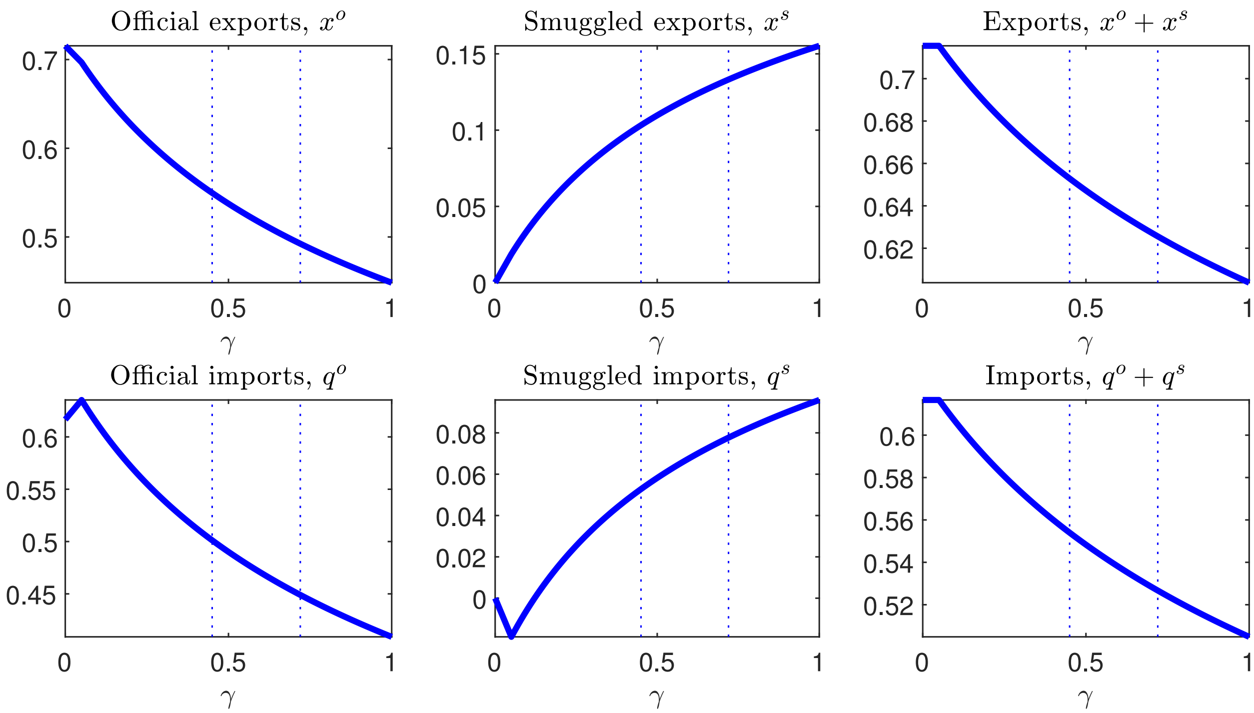
3.3 Macroeconomic Effects of Exchange Controls

In this section we study the general equilibrium effects of varying the exchange-rate gap γ_t. To this end, we consider equilibria in which the policy vector $\eta_t = [\gamma_t \, \rho_t \, i_t]$ is constant over time. We keep the import restriction ρ_t fixed at its baseline value ($\rho_t = \rho = 0.088$). We also keep fixed at their baseline values the vector of exogenous shocks and the real value of total government liabilities ($\eta_t^* = \eta^*$ and $a_t = a$). The assumption that a_t is fixed implies that the government does not use a one-time jump in the price level to inflate away part of its domestic liabilities to cover changes in the present discounted value of fiscal revenues induced by changes in the exchange-rate gap γ. Instead, the government finances these imbalances by adjusting the flow of seignorage revenue. Thus, although the nominal interest rate is constant across time, it is different for different values of γ. Specifically, for every value of γ, i adjusts to satisfy the intertemporal budget constraint of the government, equation (35).

Figure 2 displays the general equilibrium effects of changing the exchange rate gap γ on exports and imports. The exchange rate gap is akin to a tax on legal exports. Consequently, when γ increases, firms move away from legal exports and toward smuggling or under invoicing of exports (x^o falls and x^s increases). The figure shows, however, that the increase in illegal exports does not fully offset the fall in legal exports. As a result, total exports, $x^o + x^s$, decline.

At the same time, the exchange rate gap γ represents a subsidy on legal imports. The larger the exchange rate gap is, the larger the incentive to over invoice legal imports will be

Figure 2: Exports and Imports as Functions of the Exchange Rate Gap



Notes. The vertical dotted lines mark the average value of γ during each of the two spells of exchange-rate controls that took place during the calibration period, 45 percent in the first episode and 72 percent in the second. The economy is in steady state. The policy variable ρ, the exogenous variables τ, i^* and p^x, and total domestic government liabilities, a, take their baseline steady-state values shown in Table 1. The nominal interest rate, i, adjusts with γ to guarantee that the economy is in general equilibrium, that is, to guarantee that equation (35) is satisfied.

($q^o > q^n + q^x$ or, equivalently, $q^s < 0$). Firms have an incentive to over invoice imports, that is, to exaggerate their foreign exchange needs to the central bank to profit from the difference between the official and the market exchange rates. The positive relation between γ and q^o occurs for values of γ below 5 percent. For values of γ greater than 5 percent, the relation between γ and q^o turns negative (bottom left panel of Figure 2). This is because the incentive to import through the official channel and the disincentive to export through the official channel are so large that the import constraint becomes binding, $q^o = \bar{q}^o = (1-\rho)p^x x^o$. That is, the government starts to ration the provision of foreign exchange at the official exchange rate to importers. At this point, exchange controls turn from an import subsidy to an import quota. The larger is the exchange rate gap γ, the smaller legal exports will be and therefore the more stringent the import quota $(1-\rho)p^x x^o$ will be. Thus, paradoxically, as the subsidy on official imports increases (i.e., as γ increases), official imports decline. In the mainstream press, this effect is sometimes described as a "shortage of dollars." Deriving the shortage-of-dollar effect as an equilibrium outcome is a contribution of this paper. The figure suggests that dollar shortage begins to plague the economy at relatively low values of the exchange-rate gap ($\gamma > 0.05$), and, in particular, that it was a feature of the two spells of exchange controls observed in Argentina during the calibration period (vertical broken lines).

For exchange rate gaps larger than 12 percent ($\gamma > 0.12$), the supply of foreign exchange at the official rate is so scarce that importers stop over invoicing (q^s ceases to be negative) and begin to smuggle intermediate materials into the country (q^s becomes positive). In other words, for $\gamma > 0.12$ the amount of imported materials used in production exceeds the amount of official imports ($q^n + q^x > q^o$), or illegal imports are positive. The larger γ is, the larger the amount of smuggled imports will be. However, as the figure shows, the increase in illegal imports as γ goes up is not large enough to offset the fall in legal imports. As a result, as γ increases, total imports, $q^o + q^s$, fall.

In sum, Figure 2 shows that both total imports and total exports are decreasing functions of γ.[7] Thus, as the exchange rate gap widens, the economy becomes more closed to international trade.[8] Both the traded and nontraded sectors are forced to operate with less

[7]For values of the exchange-rate gap $0 < \gamma < 0.05$, total exports, $X(q^x)$, and total imports, $q^x + q^n$, are independent of γ. For this range of values of γ, both the import restriction and the nonnegativity constraint on official exports are slack ($q^o < (1-\rho)p^x x^o$ and $x^o > 0$). The production of export goods is efficient and determined by the condition $p^x X'(q^x) = 1$, so q^x is independent of γ. The amount of imports used in the production of nontradables, q^n, is also independent of γ and determined by the condition $p^x X(q^x) = q^x + q^n + i^* B^*/(1+i^*)$.

[8]The intuitive discussion of Figure 2 abstracts from the fact that the interest rate, i, which changes with γ because the analysis is in general equilibrium, does affect imports and exports. Changes in the nominal interest rate distort the labor-consumption decision (optimality condition (5)). In turn, changes in employment affect the production of tradable and nontradable goods, and thus also exports and imports.

imported inputs of production, which represents a misallocation of resources.

The appendix analyzes the effects of changes in the exchange rate gap on other macroeconomic indicators of interest. It shows that as the exchange rate gap increases, the economy becomes less competitive (firms face an increase in the cost of imported materials, which deteriorates their terms of trade) and more reliant on domestic factors of production (employment becomes inefficiently high). This misallocation of imports and employment drives consumption down. The appendix also shows that an increase in the exchange rate gap generates fiscal space, which allows the government to curb money creation and thus reduce inflation. The increase of fiscal space originates from two sources: first, a higher exchange-rate gap represents a higher tax on the official trade balance. Second, a higher exchange-rate gap appreciates the external real exchange rate (e_t falls), which reduces the cost of servicing the foreign debt in terms of domestic consumption.

Next, we characterize optimal policy when a benevolent government chooses the exchange-rate gap γ, the nominal interest rate i, and the degree of import restrictions ρ.

4 Optimal Exchange Controls

This section presents the optimization problem of a benevolent government and characterizes its solution. It considers two exchange-rate arrangements: In the first one, the Ramsey planner is constrained to set the same official exchange rate on imports and exports, so there are two possible exchange rates, the official exchange rate and the parallel market-determined exchange rate. In the second regime, the Ramsey planner can choose different official exchange rates on imports and exports. Under this regime, there are three exchange rates, the official exchange rate on imports, the official exchange rate on exports, and the parallel market-determined exchange rate. Both arrangements are frequently observed in practice (Ilzetzki, Reinhart, and Rogoff, 2019).

4.1 The Ramsey Problem

We present the Ramsey problem for the case of a single official exchange rate. The Ramsey problem for the case of multiple official exchange rates is similar.

We assume that the government chooses the path of the policy instruments i_t, γ_t, and ρ_t in a benevolent fashion, that is, aiming to maximize the lifetime welfare of the representative household. We also assume that the government can commit to its policy announcements.

However, these effects happen to be small, so that movements in exports and imports are dominated by changes in γ.

Further, we assume that policy is optimal from the timeless perspective in the following sense. We assume that the fundamentals p_t^x, i_t^* and τ_t are constant over time. Then, we define optimality from the timeless perspective as a policy that supports a steady state in which the stock of real domestic government liabilities, a_t, is constant over time at a value, a, determined in the indefinite past. Thus, the Ramsey optimal equilibrium is defined as follows:

Definition 2 (Ramsey Policy from the Timeless Perspective) *A Ramsey optimal equilibrium from the timeless perspective is a policy triplet* (γ, ρ, i) *that maximizes*

$$U(c(\eta, \eta^*), h(\eta, \eta^*))$$

subject to the intertemporal restriction (35) *and the nonnegativity constraint on nominal rates*

$$i \geq 0, \tag{36}$$

given a*, where* $\eta \equiv [\gamma\, \rho\, i]$ *and* $\eta^* \equiv [p^x\, i^*\, \tau]$*.*

The Ramsey problem does not admit a closed form solution. It is a complex maximization problem because both the objective function and the constraints feature functions of the policy triplet (γ, ρ, i) that are themselves the solution to a system of a relatively large number of equalities and inequalities (see Proposition 1). Accordingly, we solve the Ramsey problem numerically. All structural parameters as well as the real value of domestic government liabilities a and the exogenous fundamentals p^x, i^*, and τ take the values shown in Table 1.

We compare the Ramsey optimal policy with two alternative policies. One is a policy without exchange-rate controls or import restrictions ($\gamma = \rho = 0$).[9] Under this policy, the government collects no revenue from exchange controls, and fiscal solvency is attained solely through seignorage revenue. The second alternative policy we consider is one in which the objective of the government is to minimize inflation instead of to maximize the welfare of the representative household. This policy seeks to gauge the ability of exchange controls to generate fiscal revenue in general equilibrium (recall that the analysis around Table 2 is in partial equilibrium). This policy regime is formally defined as follows:

Definition 3 (Minimum-Inflation Equilibrium from the Timeless Perspective) *The minimum-inflation equilibrium from the timeless perspective is a policy triplet* (γ, ρ, i) *that solves the problem*

$$\min \pi$$

[9]Strictly speaking, the regime without exchange-rate controls or import restrictions is $\gamma = 0$ and $\rho = -\infty$. However, because in equilibrium the economy must generate a trade surplus to service the interest on the external debt, $i^* B^*/(1 + i^*)$, the policy $\gamma = \rho = 0$ delivers the same equilibrium.

Table 3: Optimal Policy with a Single Official Exchange Rate

Variable	No Exchange Controls	Optimal Exchange Controls	Minimum Inflation
exchange-rate gap γ	0	0.03	0.87
import restrictions ρ	–	0.15	0.52
interest rate (%/yr)	45.2	41.1	0
inflation (%/yr)	39.6	35.6	-3.8
seignorage (% GDP)	2.9	2.7	0
revenue from FX controls (% GDP)	0	0.2	3.0
welfare cost (% consumption)	0.02	0	4.57

Notes. FX controls stands for exchange controls. Revenue from FX controls is defined as follows. Let $z \equiv s - ei^*B^*/(1+i^*)$ and z^0 be the value of z in the absence of FX controls ($\gamma = \rho = 0$). Similarly, let y^0 be the value of y in the absence of FX controls. Then revenue from FX controls as a percent of GDP is defined as $100(z - z^0)/y^0$. The welfare cost of a given policy is computed as the percentage increase in consumption each period required to make households as well off under the given policy as under the optimal one.

subject to the intertemporal restriction (35)*, the nonnegativity constraint on nominal rates* (36)*, and the Fisher equation*

$$1 + \pi = \beta(1 + i), \tag{37}$$

given a*, where* $\eta \equiv [\gamma\, \rho\, i]$ *and* $\eta^* \equiv [p^x\, i^*\, \tau]$.

The inflation-minimizing government described in Definition 3 is assumed to proceed as follows: Given a value of π, constraint (37) determines the nominal interest rate, i. If this value of i satisfies the nonnegativity constraint (36), then the government has two instruments, γ and ρ, to satisfy the equilibrium intertemporal budget constraint (35). In general, there can be multiple pairs (γ, ρ) consistent with the satisfaction of this constraint. Among all such pairs, the government picks the one associated with the highest level of lifetime utility of the representative household.

4.2 Optimal Policy Under a Single Official Exchange Rate

Table 3 displays the predictions of the model under a single official exchange rate. The main result is that the optimal policy (column 2) calls for virtually no exchange controls. The optimal exchange rate gap is only 3 percent ($\gamma = 0.03$) and import restrictions are low ($\rho = 0.15$). Consequently, total revenue from exchange controls is virtually nil (0.2 percent of GDP). The benevolent government relies almost exclusively on inflation to finance the budget. Under the optimal policy the annual inflation rate is 35.6 percent and seignorage revenue is 2.7 percent of GDP. Quantitatively, the optimal policy looks much like the policy without exchange controls (column 1 of Table 3).

The reason why the social planner does not rely on exchange controls to finance the budget is not that this instrument is incapable of collecting significant amounts of resources, but that it is a highly inefficient way of doing so. The third column of Table 3 shows the policy that minimizes inflation (see Definition 3). The inflation-minimizing government follows the Friedman rule ($i = 0$) and therefore collects no seignorage revenue. Instead, it collects 3 percent of GDP from exchange controls. It does so by increasing the exchange rate gap from 3 percent to 87 percent (γ increases from 0.03 to 0.87) and by reducing exchange-rate-based import subsidies (ρ increases from 0.15 to 0.52). About 60 percent of the increase in fiscal revenue from exchange controls stems from an increase in s (the tax on the official trade balance induced by a positive exchange-rate gap). The remaining 40 percent comes from a reduction in the debt burden, that is, from a decline in the value of net external interest payments in terms of consumption ($ei^*B^*/(1+i^*)$), caused by an appreciation of the external real exchange rate (a fall in e).

The significant widening of the exchange-rate gap, γ, and tightening of import restrictions, ρ, necessary to generate the required fiscal space in the minimum-inflation regime cause substantial misallocation. The reason is that when γ and ρ increase, the dollar shortage is exacerbated, and firms must rely more heavily on smuggled materials, which are more expensive than materials imported at the official exchange rate, since they are priced at the market exchange rate plus the contraband cost. The economy as a whole is forced to operate with an inefficiently low level of imported materials, which has a large negative effect on aggregate activity and domestic absorption. Consequently, financing a sizable part of the budget through exchange controls is highly welfare reducing. The bottom row of Table 3 shows that households require a 4.57 percent increase in consumption each period to be as well off under the minimum-inflation policy as under the optimal policy.

Next, we turn to an exchange-rate arrangement with multiple official exchange rates in which imports and exports receive differential exchange-rate treatments. Under this more flexible—and arguably no less realistic—arrangement, the Ramsey government finds it optimal to finance a substantial fraction of the fiscal deficit with exchange controls.

4.3 Optimal Policy Under Multiple Official Exchange Rates

Consider now the existence of separate official exchange rates for exports and imports. Let's denote these two exchange rates $\mathcal{E}_t^{ox}$ and $\mathcal{E}_t^{oq}$, respectively. This policy arrangement nests the regime with a single official exchange rate as a special case when $\mathcal{E}_t^{ox} = \mathcal{E}_t^{oq}$.

Table 4: Optimal Policy With Multiple Official Exchange Rates

Variable	Single official exchange rate	Multiple official exchange rates
export exchange-rate gap γ^x	0.03	0.12
import exchange-rate gap γ^q	0.03	0
import restrictions ρ	0.15	$-\infty$
interest rate (%/yr)	41.1	10.9
inflation (%/yr)	35.6	6.6
seignorage (% GDP)	2.7	1.0
revenue FX controls (% GDP)	0.2	2.0
welfare cost (% consumption)	0	-0.22

Notes. See notes to Table 3. The variables γ^x and γ^q denote the exchange-rate gaps on exports and imports. The entry $\rho = -\infty$ means that importers have unrestricted access to foreign exchange at the official rate $\mathcal{E}_t^{oq}$.

Direct government revenues from exchange controls on exports and imports, s_t, which under a single official exchange rate are given in equation (24), now take the form

$$s_t = e_t \left[\frac{\gamma_t^x}{1+\gamma_t^x} p_t^x x_t^o - \frac{\gamma_t^q}{1+\gamma_t^q} q_t^o \right],$$

where $\gamma_t^x \equiv \mathcal{E}_t/\mathcal{E}_t^{ox} - 1$ and $\gamma_t^q \equiv \mathcal{E}_t/\mathcal{E}_t^{oq} - 1$ denote the exchange-rate gaps on official exports and imports. With multiple official exchange controls, firm profits, previously given in equation (12), become

$$F(h_t, q_t^o + q_t^s - q_t^x) + \frac{e_t}{1+\gamma_t^x} p_t^x [X(q_t^x) - x_t^s] - \frac{e_t}{1+\gamma_t^q} q_t^o + e_t (p_t^x x_t^s - q_t^s) - w_t h_t - C(q_t^s, \kappa_q) - C(x_t^s, \kappa_x).$$

All other aspects of the model are as in the economy with a single official exchange rate.

The government now has four policy instruments, namely, two exchange rate gaps (γ_t^x and γ_t^q), import restrictions (ρ_t), and the nominal interest rate (i_t). When $\gamma_t^q < \gamma_t^x$, the implicit subsidy on imports is smaller in absolute value than the implicit tax on exports. The case $\gamma_t^q = 0$ and $\rho_t = -\infty$ corresponds to a liberalization of the exchange market for imports, because private agents can import unrestrictedly at the market exchange rate without having to pay smuggling costs.[10]

Table 4 displays the predictions of the model under the Ramsey optimal monetary and exchange-control policy. The benevolent government finds it optimal not to subsidize imports

[10]Note that now ρ_t is allowed to take negative values. The reason is that a negative value of ρ_t need no longer imply negative values of s_t.

($\gamma_t^q = 0$) and to allow unrestricted access to foreign currency at the market exchange rate ($\rho_t = -\infty$). Thus, liberalizing the foreign exchange market for imports is Ramsey optimal. The intuition behind this result is as follows. If the foreign exchange market for imports is liberalized, importers have no incentive to engage in smuggling, which is a wasteful activity. Also, the elimination of the exchange-rate gap on imports reduces the government's drain of foreign currency, boosting fiscal revenue. In turn, the improvement in the fiscal space allows the government to reduce the inflation tax. The optimal inflation rate is now 6.6 percent per year, compared to 35.6 percent per year under a single official exchange rate.

The exchange control regime with multiple official exchange rates welfare dominates the one with a single official exchange rate. Table 4 shows that the welfare gain relative to the optimal policy with a single official exchange rate is equivalent to a permanent increase of 0.22 percent in consumption. This is a large number as welfare measures go in macroeconomics.

Because the government does not subsidize imports, exchange controls now represent a tax on exports instead of a tax on the trade balance. Thus, exchange controls become a more powerful fiscal tool, as its tax base is larger: For example, in Argentina over the calibration period, exports represented 17 percent of GDP, whereas the trade balance represented only 1.5 percent of GDP. Consequently a relatively modest exchange-rate gap on exports ($\gamma_t^x = 0.12$) suffices to collect a substantial amount of resources (2.0 percent of GDP). Now the vast majority of the resources collected with exchange controls come from direct government revenues, s_t, and virtually nothing from a reduction in the external debt burden, $e_t i^* B^*/(1+i^*)$, as the real exchange rate appreciation is minor.

The finding that with multiple official exchange rates it is optimal for the government to impose a lower exchange-rate gap on imports than on exports provides insight for why exchange control regimes, even ones that start with a single official exchange rate, tend to transition toward multiple official exchange rates. For example, Argentina, the country used to calibrate the model, by the end of the calibration period, introduced a tax on foreign exchange import transactions called "impuesto país." This tax reduces the implicit subsidy on official imports and is therefore equivalent to a reduction in the import exchange rate gap γ_t^q. Because this type of tax is closely related to the exchange of currencies, the IMF's Article VIII considers it a multiple currency practice (IMF 2019, Box 1).

5 Conclusion

A sizeable number of emerging countries resort to exchange controls. Traditionally this type of intervention has been viewed as a tax on exports and a subsidy on imports. We show than when analyzed in the context of a general equilibrium framework this view can be misleading. First, exchange controls can give rise to rationing or dollar shortages, making them more akin to an import quota than to an import subsidy. When this happens exchange controls can cause widespread misallocation of resources and generate additional incentives for smuggling. Second, exchange controls generate fiscal resources not only because they represent a tax on exports but also because they reduce the real value of external public debt through an appreciation of the real exchange rate.

The paper considers the problem of a government that runs chronic fiscal deficits and has lost the political capacity to finance them through additional regular taxation, expenditure cuts, or further borrowing. Its remaining choices are to finance the deficit either by printing money or by imposing exchange controls. A key insight from this investigation is that the Ramsey government prefers a scheme with multiple official exchange rates, where exports face higher exchange controls than imports. The social planner favors lighter controls on imports to mitigate the misallocation caused by dollar shortages. This finding helps explain why exchange control regimes often include multiple currency practices. Under the optimal policy, both exchange controls and inflation finance substantial portions of the fiscal deficit. This result provides theoretical and normative support for the empirical observation that a primary reason for imposing exchange controls is to mobilize fiscal resources.

Appendix: Additional Results on the Macroeconomic Effects of Exchange Controls

This appendix extends the analysis of section 3.2 to additional macroeconomic variables, including the trade balance, the terms of trade, the real exchange rate, consumption, labor, seignorage, and fiscal revenue from exchange controls. It shows that the government faces a tradeoff between financing the fiscal deficit with the inflation tax or with exchange controls.

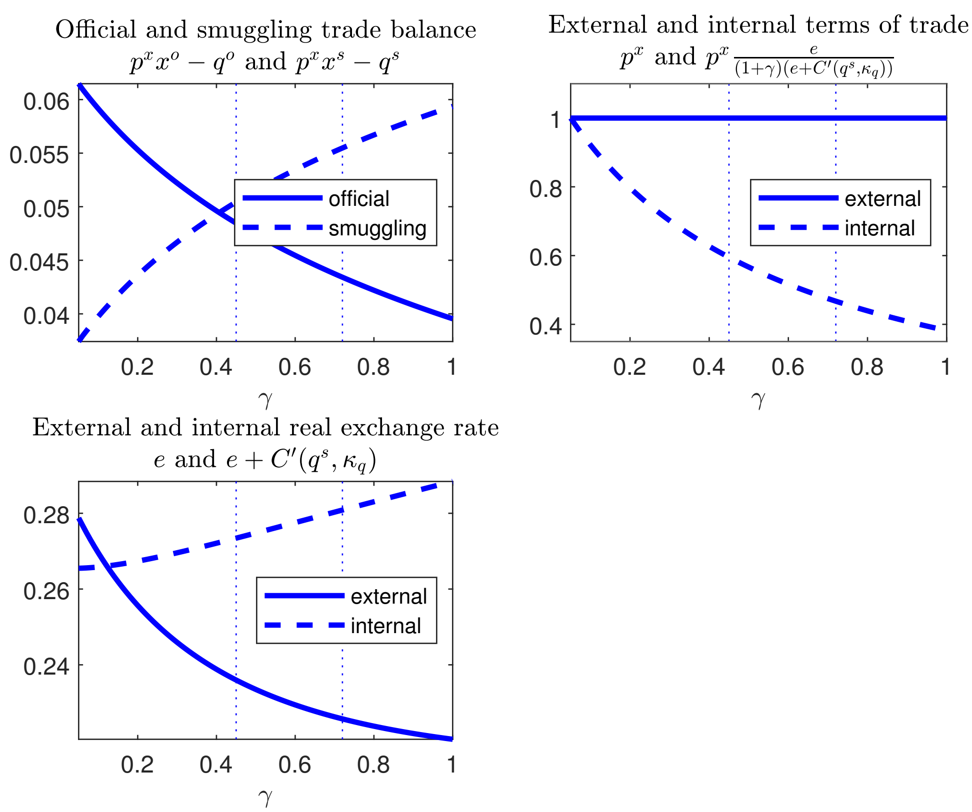
To simplify the intuition, in this appendix the analysis focuses on values of γ larger than 5 percent, for which the economy experiences dollar shortages and which represent the case of greatest empirical interest.

The top left panel of Figure A.1 shows that the official trade balance, $p^x x^o - q^o$, declines as the gap between the market exchange rate and the official exchange rate, γ, widens. This is a consequence of the binding import restriction. When import restrictions are binding, the official trade balance is proportional to official exports, $p^x x^o - q^o = \rho p^x x^o$. And because x^o is decreasing in γ, so is the official trade balance. This effect has negative fiscal consequences, because the official trade balance is the base of the exchange-control "tax" (see equation (24)). The figure shows that the decline in the official trade surplus is offset by an increase in the smuggling trade balance ($p^x x^s - q^s$). The reason this is so is that by the market clearing condition (28), the country's overall trade balance surplus must equal interest payments on external debt, $i^* B^*/(1 + i^*)$. As these payments are independent of γ, a declining official trade balance must be perfectly offset by an increasing smuggling trade balance.

The exchange-rate gap distorts the terms of trade and the real exchange rate. The top right panel of Figure A.1 shows that as exchange rate controls become more stringent, the internal terms of trade deteriorate, that is, imported goods become more expensive relative to exported goods in the domestic economy. Put differently, as exchange rate controls increase, exporters perceive that they become less competitive in international goods markets. This is because as γ increases, they receive less income for their external sales and because they have to pay higher marginal smuggling costs for imported inputs. The deterioration of the internal terms of trade explains why the economy becomes more closed with tighter exchange controls.

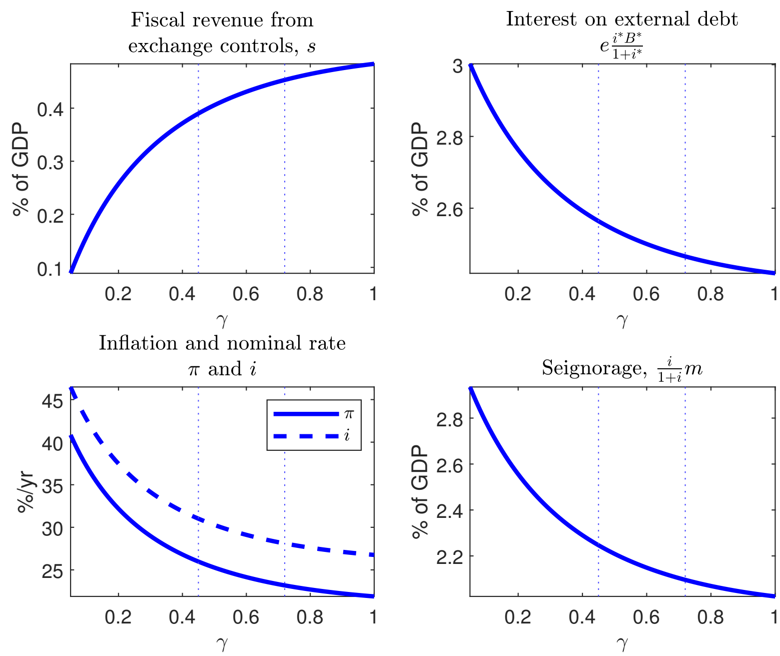
The bottom left panel of Figure A.1 shows that as the exchange rate gap increases, the internal real exchange rate, $e + C'(q^s, \kappa_q)$, depreciates, that is, as γ increases, producers of nontradable goods find that imported materials become more expensive relative to the final good they produce. The increase in the domestic price of imports results from higher marginal smuggling costs as the dependence of firms on smuggled imports increases with γ

Figure A.1: The Real Exchange Rate, the Terms of Trade, and the Trade Balance as Functions of the Exchange Rate Gap



Note. See notes to Figure 2.

Figure A.2: Fiscal Variables, the Nominal Interest Rate, and the Inflation Rate as Functions of the Exchange Rate Gap



Note. See notes to Figure 2.

(recall the discussion around Figure 2). By contrast, the external real exchange rate appreciates (e falls) with γ, that is, nontradable goods become more expensive relative to tradables measured at world prices. This is because as γ increases domestic producers face higher prices for imported inputs, as they have to rely increasingly on smuggling, which is expensive. As mentioned earlier, movements in the external real exchange rate are not relevant for producers (because smuggling costs introduce a wedge between the world price and the domestic price of imported inputs), but do matter for the government. The appreciation of the external real exchange rate caused by higher values of γ has positive and negative fiscal consequences. On the positive side, it reduces the value of interest payments on the external debt in terms of consumption goods ($ei^*B^*/(1+i^*)$ falls). On the negative side, all else equal, the appreciation of the external real exchange rate reduces the value of fiscal revenues from exchange controls ($e\gamma/(1+\gamma)(p^x x^o - q^o)$ falls).

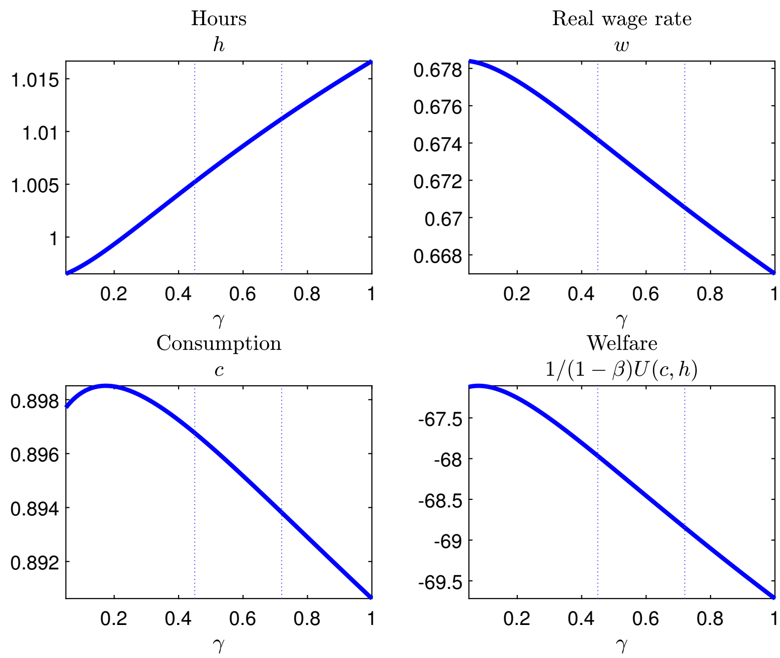
The fiscal consequences of changing the exchange-rate gap are displayed in Figure A.2. The fiscal space, $s - \tau - ei^*B^*/(1+i^*)$, improves with the exchange rate gap γ through two channels, a tax channel and a debt-burden reduction channel. The tax channel is displayed in the top left panel of the figure. This panel shows that revenue from exchange controls, $s = \gamma/(1+\gamma)e(p^x x^o - q^o)$, is increasing in the exchange-rate gap. This source of fiscal revenue can be interpreted as the product of a tax rate, $\gamma/(1+\gamma)$, and a tax base, the official trade balance expressed in units of the consumption good, $e(p^x x^o - q^o)$. As γ increases, the tax rate increases but the tax base falls (recall that both e and $p^x x^o - q^o$ fall with γ). However, the tax base declines proportionally less than the tax rate rises, resulting in increased fiscal revenue from exchange controls. The debt-burden reduction channel is displayed in the top right panel of Figure A.2. As γ increases, the value of external interest payments in terms of units of consumption, $ei^*B^*/(1+i^*)$, falls (recall that the external real exchange rate e appreciates with γ). Jointly the tax channel and the debt-burden reduction channel raise the fiscal space by 1 percentage point of GDP when γ increases from near 0 to 1, with ρ fixed at 0.088.

Consider now the effects of increasing exchange rate controls on the nominal interest rate, i, inflation, π, and seignorage revenue, $i/(1+i)m$, which are shown in the bottom panels of Figure A.2. We have already shown that the fiscal space increases with γ. This means that a widening of the exchange rate gap allows the government to rely less on seignorage revenue. As a result, as γ increases, inflation falls and the government lowers the nominal interest rate. This connection between inflation and exchange controls is the key trade off explored in this paper. Section 4 in the body of the paper studies how a Ramsey planner resolves this trade off.

Figure A.3 shows that employment increases with the exchange-rate gap. The intuition behind this result is as follows. The fall in the nominal interest rate resulting from an increase in γ induces households to remonetize (recall that by equation (4) money velocity is decreasing in the nominal interest rate). In turn, by optimality condition (5), the fall in money velocity reduces the distortion in the labor-consumption margin, $1 + s(v) + vs'(v)$, which causes an expansion in the supply of labor. In turn, the increase in the supply of labor results in a fall in the real wage (top right panel of Figure A.3).

Figure A.3 also shows that consumption is a nonmonotonic function of the exchange rate gap. An increase in γ has positive and negative effects on c. It depresses private consumption because it exacerbates the misallocation of resources. This occurs for two reasons. First, as the exchange rate gap increases, the economy suffers from a shortage of imported intermediate inputs for the production of consumption goods (q^n falls). Second, as the exchange rate gap widens, smuggling increases, which is resource consuming ($C(x^s, \kappa_x)$ and $C(q^s, \kappa_q)$ both go up). The positive effects of an increase in γ on consumption stem from a reduction in the distortions caused by inflation. Specifically, an increase in γ is associated with a fall in the interest rate, which reduces transactions costs ($s(v)$ goes down) and, as explained above, alleviates distortions in the labor-consumption margin, incentivizing the supply of labor for the production of consumption goods. The resource misallocation effect

Figure A.3: Hours, Wages, Consumption, and Welfare as Functions of the Exchange Rate Gap



Note. See notes to Figure 2.

and the disinflation effect of an increase in γ run in opposite directions, resulting in a hump-shaped relationship between γ and consumption (bottom left panel of Figure A.3). However, for most values of the exchange-rate gap considered in Figure A.3, the misallocation effect dominates and consumption falls as the exchange-rate gap increases.

Welfare is decreasing in the exchange-rate gap (bottom right panel of Figure A.3). This effect stems from two sources. First, labor is monotonically increasing in γ, so that, holding consumption constant, an increase in γ reduces welfare. Second, for values of γ for which consumption is decreasing, welfare unambiguously goes down with γ. And for values of γ for which consumption is increasing in γ, the labor effect dominates. In summary, the negative welfare effect of exchange-rate controls occur because by discouraging the use of traded intermediate inputs, they cause a misallocation of resources away from imports and toward labor effort.

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