Segmented Asset Markets and Optimal Exchange Rate Regimes[1]

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Revised: June 2004

[1] We would like to thank Andy Atkeson, Mick Devereaux, Huberto Ennis, Andy Neumeyer, Mark Spiegel, and seminar participants at Duke, FRB Cleveland, FRB NY, Penn State, UBC, UCLA, UC Santa Cruz, USC, Warwick, CMSG 2003, ITAM-FBBVA Summer Camp 2003, SED 2003, NBER IFM meeting Fall 2003, for helpful comments and suggestions. The usual disclaimer applies. Végh would like to thank the UCLA Academic Senate for research support. The views expressed here do not necessarily reflect the views of the Federal Reserve Bank of New York or the Federal Reserve System.

Abstract

This paper revisits the issue of the optimal exchange rate regime in a flexible price environment. The key innovation is that we analyze this question in the context of environments where only a fraction of agents participate in asset market transactions (i.e., asset markets are segmented). We show that flexible exchange rates are optimal under monetary shocks and fixed exchange rates are optimal under real shocks. These findings are the exact *opposite* of the standard Mundellian prescription derived under the sticky price paradigm wherein fixed exchange rates are optimal if monetary shocks dominate while flexible rates are optimal if shocks are mostly real. Our results thus suggest that the optimal exchange rate regime should depend not only on the type of shock (monetary versus real) but also on the type of friction (goods market friction versus financial market friction).

KEYWORDS: Optimal exchange rates, asset market segmentation

JEL CLASSIFICATION: F1, F2

1 Introduction

Fifty years after Milton Friedman's (1953) celebrated case for flexible exchange rates, the debate on the optimal choice of exchange rate regimes rages on as fiercely as ever. Friedman argued that, in the presence of sticky prices, floating rates would provide better insulation from foreign shocks by allowing relative prices to adjust faster. In a world of capital mobility, Mundell's (1963) work implies that the optimal choice of exchange rate regime should depend on the type of shocks hitting an economy: real shocks would call for a floating exchange rate, whereas monetary shocks would call for a fixed exchange rate. Ultimately, however, an explicit cost/benefit comparison of exchange rate regimes requires a utility-maximizing framework, as argued by Helpman (1981) and Helpman and Razin (1979). In such a framework, Engel and Devereux (1998) reexamine this question in a sticky prices model and show how results are sensitive to whether prices are denominated in the producer's or consumer's currency. On the other hand, Cespedes, Chang, and Velasco (2000) incorporate liability dollarization and balance sheets effects and conclude that the standard prescription in favor of flexible exchange rates in response to real shocks is not essentially affected.

An implicit assumption in most, if not all, of the literature is that economic agents have unrestricted and permanent access to asset markets.[1] This, of course, implies that in the absence of nominal rigidities, the choice of fixed versus flexible exchange rates is irrelevant. In practice, however, access to asset markets is limited to some fraction of the population (due to, for example, fixed costs of entry). This is likely to be particularly true in developing countries where asset markets are much smaller in size than in industrial countries. Table 1 shows that even for the United States, the degree of segmentation in asset markets is remarkably high. The table reveals that 59 percent of U.S. households did not hold any interest bearing assets (defined as money market accounts, certificates of deposit, bonds, mutual funds, and equities). More strikingly, 25 percent

[1] There are some exceptions when it comes to the related issue of the costs and benefits of a common currency area (see, for example, Neumeyer (1998) and Ching and Devereux (2000), who analyze this issue in the presence of incomplete asset markets).

of households did not even have a checking account as late as in 1989. Given these facts for a developed country like the United States, it is easy to anticipate that the degree of asset market segmentation in emerging economies must be considerably higher. Since asset markets are at the heart of the adjustment process to different shocks in an open economy, it would seem natural to analyze how asset market segmentation affects the choice of exchange rate regime.[2]

Table 1: US Household ownership of financial assets, 1989

	Interest-bearing assets		
Checking account	No	Yes	Total
No	19%	6%	25%
Yes	40%	35%	75%
Total	59%	41%	100%

Source: Mulligan and Sala-i-Martin (2000). Data from the Survey of Consumer Finance.

This paper abstracts from any nominal rigidity and focuses on a standard monetary model of an economy subject to stochastic real and monetary (i.e., velocity) shocks in which the only friction is that an exogenously-given fraction of the population can access asset markets. The analysis makes clear that asset market segmentation introduces a fundamental asymmetry in the choice of fixed versus flexible exchange rates. To see this, consider first the effects of a positive velocity shock in a standard one-good open economy model in the absence of asset market segmentation. Under flexible exchange rates, the velocity shock gets reflected in an excess demand for goods, which leads to an increase in the price level (i.e., the exchange rate). Under fixed exchange rates,

[2]In closed economy macroeconomics, asset market segmentation has received widespread attention ever since the pioneering work of Grossman and Weiss (1983) and Rotemberg (1984) (see also Chatterjee and Corbae (1992) and Alvarez, Lucas, and Weber (2001)). The key implication of these models is that open market operations reduce the nominal interest rate and thereby generate the so-called "liquidity effect". In an open economy context, Alvarez and Atkeson (1997) and Alvarez, Atkeson, and Kehoe (2002) have argued that asset market segmentation models help in resolving outstanding puzzles in international finance such as volatile and persistent real exchange rate movements as well as excess volatility of nominal exchange rates.

the adjustment must take place through an asset market operation whereby agents exchange their excess money balances for foreign bonds at the central bank. In either case, the adjustment takes place instantaneously with no real effects. How does asset market segmentation affect this adjustment? Under flexible rates, the same adjustment takes place. Under fixed exchange rates, however, only those agents who have access to asset markets (called "traders") may get rid of their excess money balances. Non-traders – who are shut off from assets markets – cannot do this. Non-traders are therefore forced to buy excess goods. The resultant volatility of consumption is costly from a welfare point of view. Hence, under asset market segmentation and in the presence of monetary shocks, flexible exchange rates are superior than fixed exchange rates.

Asset market segmentation also has dramatic implications for the optimal exchange rate regime when shocks come from the goods market. We show that when output is stochastic, non-traders in the economy unambiguously prefer fixed exchange rates to flexible exchange rates because pegs provide a form of risk pooling. Under a peg, household consumption is a weighted average of current period and last period's output which implies that the consumption risk of non-trading households is pooled across periods. Under flexible rates, however, the real value of consumption is always current output which implies no intertemporal risk sharing. Trading households, on the other hand, prefer flexible exchange rates to fixed exchange rates since maintaining an exchange rate peg involves injecting or withdrawing money from traders which makes their consumption more volatile under a peg. However, using a population share weighted average of the welfare of the two types, we show that under fairly general conditions, the non-traders' preferences dominate the social welfare function. Hence, when output is stochastic, an exchange rate peg welfare dominates a flexible exchange rate regime.[3]

In sum, the paper shows that asset market segmentation may be a critical friction in determining the optimal exchange rate regime. More crucially, results under asset market segmentation run

[3]We derive the results in the text under incomplete markets, which is the more realistic assumption (see Burnside, Eichenbaum, and Rebelo (1999) for a related discussion.) We show in the appendix that the same results obtain under complete markets (and, are in fact, even starker).

counter to the Mundellian prescription that if monetary shocks dominate then fixed rates are preferable, while if real shocks dominate flexible rates are preferable. This discrepancy reflects the difference in the underlying friction. In the Mundell-Fleming world, sticky prices presumably reflect some imperfection in goods markets, whereas in our model asset market segmentation captures some imperfection in asset markets (for example, fixed cost of entry). Of course, which friction dominates in practice is ultimately an empirical issue. However, our results suggest that policy judgements regarding the choice of exchange rate regimes need to be based on a broader set of analytical factors than just the standard sticky price-based Mundell insight. In particular, aside from a judgement regarding the relative importance of alternative shocks (e.g., monetary or real shocks), this decision should also be based on a judgement regarding the relative importance of alternative frictions (e.g., sticky prices or asset market segmentation) since different frictions have conflicting implications.

Lastly, we also study the implications of asset market segmentation for the debate regarding inflation targeting versus money targeting. Since most of the existing work on this topic has been done in a closed economy context, we study the question in that context as well. Mirroring the results in the open economy version, we find that under asset market segmentation, money-targeting is welfare superior to inflation targeting when shocks are monetary while inflation targeting is the superior policy if shocks are real.

The paper proceeds as follows. Section 2 presents the model and the equilibrium conditions while Section 3 describes the allocations under alternative exchange rate regimes and derives the optimal regime under monetary and output shocks. Section 4 studies the implications of asset market segmentation for the inflation targeting versus money targeting debate in a closed economy context. Finally, Section 5 concludes. Algebraically tedious proofs are consigned to an appendix. The appendix also derives the complete markets case.

2 Model

The basic model is an open economy variant of the model outlined in Alvarez, Lucas, and Weber (2001). Consider a small open economy perfectly integrated with world goods markets. There is a unit measure of households who consume an internationally-traded good. The world currency price of the consumption good is fixed at one. The households' intertemporal utility function is

$$W_t = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} u(c_s) \right\}, \tag{1}$$

where β is the households' time discount factor, c_s is consumption in period s, while E_t denotes the expectation conditional on information available at time t.

The households face a cash-in-advance constraint. As is standard in these models, the households are prohibited from consuming their own endowment. We assume that a household consists of a seller-shopper pair. While the seller sells the household's own endowment, the shopper goes out with money to purchase consumption goods from other households.

There are two potential sources of uncertainty in the economy. First, each household receives a random endowment y_t of the consumption good in each period. We assume that y_t is an independently and identically distributed random variable with mean $\bar{y}$ and variance σ_y^2.[4] Second, following Alvarez et al, we assume that the shopper can access a proportion v_t of the household's current period (t) sales receipts, in addition to the cash carried over from the last period (M_t), to purchase consumption. We assume that v_t is an independently and identically distributed random variable with mean $\bar{v} \in [0, 1]$ and variance σ_v^2. Only a fraction λ of the population, called traders, have access to the asset markets, where $0 \leq \lambda \leq 1$.[5] The rest, $1 - \lambda$, called non-traders, can only hold domestic money as an asset. In the following we shall refer to these v shocks as velocity shocks.[6]

[4] We could allow for different means and variances for the endowments of traders and non-traders without changing our basic results.

[5] Note that though traders do have access to asset markets, these markets are incomplete. More specifically, traders do not have access to asset markets where they can trade in state contingent assets spanning all states. Hence, as will become clear below, random shocks can induce wealth effects and consumption volatility for traders as well, despite their access to competitive world capital markets. In the appendix, we analyze the complete markets case and show how the same key results obtain. Hence, our results on the optimal exchange rate regime under asset market segmentation do not depend on whether asset markets for traders are complete or not.

[6] There are alternative ways in which one can think about these velocity shocks. Following Alvarez, Lucas, and

The timing runs as follows. First, both the endowment and velocity shocks are realized at the beginning of every period. Second, the household splits. Sellers of both households stay at home and sell their endowment for local currency. Shoppers of the non-trading households are excluded from the asset market and, hence, go directly to the goods market with their overnight cash to buy consumption goods. Shoppers of trading households first carry the cash held overnight to the asset market where they trade in bonds and receive any money injections for the period. They then proceed to the goods market with whatever money balances are left after their portfolio rebalancing. After acquiring goods in exchange for cash, the non-trading-shopper returns straight home while.the trading-shopper can re-enter the asset market to exchange goods for foreign bonds. After all trades for the day are completed and markets close, the shopper and the seller are reunited at home.

2.1 Households' problem

2.1.1 Non-traders

The non-trader's cash-in-advance constraint is given by:

$$M_t^{NT} + v_t S_t y_t = S_t c_t^{NT}, \tag{2}$$

where M_t^{NT} is the beginning of period t nominal money balances while S_t is the period t exchange rate (the domestic currency price of foreign currency). Equation (2) shows that for consumption purposes, the non-traders can augment the beginning of period cash balances by withdrawals from current period sales receipts v_t (the velocity shocks). Money balances at the beginning of period $t+1$ are given by sales receipts net of withdrawals for period t consumption:

$$M_{t+1}^{NT} = S_t y_t (1 - v_t), \tag{3}$$

Weber (2001) one can 'think of the shopper as visiting the seller's store at some time during the trading day, emptying the cash register, and returning to shop some more'. The uncertainty regarding v can be thought of as the uncertainty regarding the total volume of sales at the time that the shopper accesses the cash register. Alternatively, one can think of this as representing an environment where the shopper can purchase goods either through cash or credit. However, the mix of cash and credit transactions is uncertain and fluctuates across periods.

where S_t denotes the domestic currency price of consumption goods at time t.

The usual flow constraint follows from combining (2) and (3):

$$M_{t+1}^{NT} = M_t^{NT} + S_t y_t - S_t c_t^{NT}. \tag{4}$$

Given the cash-in-advance (2), it follows that:

$$c_t^{NT} = \frac{M_t^{NT} + v_t S_t y_t}{S_t}. \tag{5}$$

2.1.2 Traders

The traders begin any period with assets in the form of money balances and bond holdings carried over from the previous period. Armed with these assets the shopper of the trader household visits the asset market where she rebalances the household's asset position and also receives the lump sum asset market transfers from the government. Thus, for any period t, the accounting identity for the asset market transactions of a trader household is given by

$$\hat{M}_t^T = M_t^T + (1 + i_{t-1}) \frac{B_t}{\lambda} - \frac{B_{t+1}}{\lambda} + S_t(1+r)f_t - S_t f_{t+1} + \frac{T_t}{\lambda}, \tag{6}$$

where $\hat{M}_t^T$ denotes the money balances with which the trader leaves the asset market and M_t^T denotes the money balances with which the trader entered the asset market. Also, B denotes aggregate one-period nominal government bonds, i is the interest rate on these nominal bonds, f are foreign bonds (denominated in terms of the consumption good), r is the exogenous and constant world real interest rate, and T are aggregate (nominal) lump-sum transfers (i.e., negative taxes) from the government.[7,8] Note that nominal bonds maturing at date t pay an interest rate i_{t-1} since

[7] We assume that these transfers are made in the asset markets, where only the traders are present. Note that since B and T denote aggregate bonds and aggegate transfers, their corresponding per trader values are B/λ and T/λ since traders comprise a fraction λ of the population.

[8] The assumption of endogenous lump-sum transfers will ensure that any monetary policy may be consistent with the intertemporal fiscal constraint. This becomes particularly important in this stochastic environment where these endogenous transfers will have to adjust to ensure intertemporal solvency for *any* history of shocks. To make our life easier, these transfers are assumed to go only to traders. If these transfers also went to non-traders, then (5) would be affected.

this rate was contracted in $t-1$.[9] After asset markets close, the shopper proceeds to the goods market with $\hat{M}^T$ in nominal money balances to purchase consumption goods. Like non-traders, traders can also augment these starting money balances with random withdrawals from current sales receipts to carry out goods purchases. Thus, the cash-in-advance constraint for a trader is given by[10]

$$S_t c_t^T = \hat{M}_t^T + v_t S_t y_t. \tag{7}$$

Combining equations (6) and (7) gives

$$M_t^T + \frac{T_t}{\lambda} + v_t S_t y_t = S_t c_t^T + \frac{B_{t+1}}{\lambda} - (1+i_{t-1})\frac{B_t}{\lambda} + S_t f_{t+1} - S_t(1+r)f_t, \tag{8}$$

In this set-up the only reason that traders hold money overnight is the separation between markets. In particular, if the seller could access the asset market at the end of the day, then the trading household would use all their remaining sales receipts from the period to buy interest bearing bonds. However, since asset markets close before the opening of the goods market, traders are forced to hold money overnight. Thus, period-t sales receipts net of withdrawals become beginning of next period's money balances

$$M_{t+1}^T = S_t y_t (1 - v_t). \tag{9}$$

Note that since v, S, and y are all exogenous, the traders' money holdings evolve exogenously over time.

A trader chooses c_t, B_{t+1} and f_{t+1} to maximize (1) subject to the flow constraint (8). Combining first-order conditions, we obtain:

$$u'(c_t^T) = \beta(1+r)E_t\left\{u'(c_{t+1}^T)\right\}, \tag{10}$$

$$\frac{u'(c_t^T)}{S_t} = \beta\,(1+i_t)\,E_t\left[\frac{u'(c_{t+1}^T)}{S_{t+1}}\right]. \tag{11}$$

[9] Alternatively, we could work with one period discount bonds so that the time t price of a bond paying one unit of the local at time $t+1$ would be $\frac{1}{1+i_t}$.

[10] Throughout the analysis we shall restrict attention to ranges in which the cash-in-advance constraint binds for both traders and non-traders. In general, this would entail checking the individual optimality conditions to infer the parameter restrictions for which the cash-in-advance constraints bind.

Equation (10) is the standard Euler equation for the trader which relates the expected marginal rate of consumption substitution between today and tomorrow to the return on savings (given by $1+r$) discounted to today. Equation (11), on the other hand, determines the optimal holdings of nominal bonds. Equations (10) and (11) jointly determine the modified interest parity condition for this economy which reflects the standard portfolio choice between safe and risky assets.

2.2 Government

The government in this economy holds foreign bonds (reserves) which earn the world rate of interest r. The government can sell nominal domestic bonds, issue domestic money, and make lump sum transfers to the traders. Thus, the government's budget constraint is given by

$$S_t h_{t+1} - (1+r)S_t h_t + (1+i_{t-1})B_t - B_{t+1} + T_t = M_{t+1} - M_t, \tag{12}$$

where B denotes the amount of nominal government bonds held by the private sector, h are foreign bonds held by the government, M is the aggregate money supply, and T is government transfers to the traders. Equation (12) makes clear that the money supply can be altered in three ways: through open market operations, through interventions in the foreign exchange market, or through transfers. Importantly, all three methods impact only the traders since they are the only agents present in the asset market.

2.3 Equilibrium conditions

Equilibrium in the money market requires that

$$M_t = \lambda M_t^T + (1-\lambda)M_t^{NT}. \tag{13}$$

The flow constraint for the economy as a whole (i.e., the current account) follows from combining the flow constraint for non-traders (equation (4)), traders (equations (7) and (9)), and the government (equation (12)) and money market equilibrium (equation (13)):

$$\lambda c_t^T + (1-\lambda)c_t^{NT} = y_t + (1+r)k_t - k_{t+1}, \tag{14}$$

where $k \equiv h + \lambda f$ denotes per-capita foreign bonds for the economy as a whole.

To obtain the quantity theory, combine (3), (9) and (13) to get:

$$\frac{M_{t+1}}{1-v_t} = S_t y_t. \tag{15}$$

Notice that the stock of money relevant for the quantity theory is end of period t money balances (i.e., M_{t+1}). This reflects the fact that, unlike standard CIA models (in which the goods market is open before the asset market and shoppers cannot withdraw current sales receipts for consumption), in this model (i) asset markets open and close before goods market open (which allows traders to change this period's money balances for consumption purposes); and (ii) both traders and non-traders can access current sales receipts.

Combining (3) and (5) gives the consumption of non-traders:

$$c_t^{NT} = \frac{S_{t-1}y_{t-1} + (v_t S_t y_t - v_{t-1}S_{t-1}y_{t-1})}{S_t}. \tag{16}$$

To derive the consumption of traders, we use equation (9) to substitute for M_t^T in equation (8). Then, subtracting $S_t y_t$ from both sides allows us to rewrite (8) as

$$(1+r)f_t - f_{t+1} + \frac{(1+i_{t-1})\frac{B_t}{\lambda} - \frac{B_{t+1}}{\lambda} + \frac{T_t}{\lambda}}{S_t} + y_t - c_t^T = \frac{M_{t+1} - M_t}{S_t},$$

where we have used equation (15) to get $M_{t+1} - M_t = [(S_t y_t - S_{t-1}y_{t-1}) - (v_t S_t y_t - v_{t-1}S_{t-1}y_{t-1})]$. Using equation (12) in the equation above gives

$$\frac{k_{t+1}}{\lambda} - (1+r)\frac{k_t}{\lambda} = y_t - c_t^T + \left(\frac{1-\lambda}{\lambda}\right)\left(\frac{M_{t+1} - M_t}{S_t}\right), \tag{17}$$

where k_0 is given exogenously. Equation (17) gives the trader's flow constraint in equilibrium. The left hand side captures the net acquisition of foreign assets (per trader) by the economy while the right hand side gives periodic trader income net of consumption. Given the precise monetary regime, we can iterate forward equation (17) and impose the trader household's first order condition for optimal consumption (equation (10)) to derive the trader's policy function for consumption along a rational expectations equilibrium path.

It is worth noting that the last term on the right hand side of (17) captures the source of redistribution in this economy. Any changes of money supply occur through central bank operations in the asset market where only traders are present. Hence, the traders receive the entire incremental money injection while their own increase in money balances is only a fraction λ of the total. This leads to redistribution of $\left(\frac{1-\lambda}{\lambda}\right)\left(\frac{M_{t+1}-M_t}{S_t}\right)$ from non-traders to traders. Note that as $\lambda \to 1$ this term goes to zero. It is important to note that this channel exists solely due to asset market segmentation.

3 Alternative exchange rate regimes

Having described the model and the equilibrium conditions above, we now turn to allocations under specific exchange rate regimes. We will look at two pure cases: flexible exchange rates and fixed exchange rates. The end goal, of course, is to evaluate the welfare implications under the two regimes. In all the policy experiments below, we shall assume that the initial distribution of nominal money balances across the two types of agents is invariant. In particular, we assume that $M_0^T = M_0^{NT} = \bar{M}$.

In order to make the analytics of the welfare comparisons tractable, we shall also assume from hereon that the periodic utility function of both agents is quadratic:

$$u(c) = c - \zeta c^2. \tag{18}$$

To focus our results, we shall proceed by analyzing the effect of each shock in isolation. In particular, we first study an environment where the only shock is the velocity shock and then go to the other case where the only shock is the real shock.

3.1 Velocity shocks only

In this subsection we focus solely on velocity shocks. Hence, we set $\sigma_y^2 = 0$. Thus, there is no uncertainty about the endowment process. Every period all households receive the fixed endowment $\bar{y}$.

3.1.1 Flexible exchange rates under velocity shocks

We assume that under flexible exchange rates, the monetary authority sets a constant path of the money supply:

$$M_t = \bar{M}.$$

Further, the government does not intervene in foreign exchange markets and, for simplicity, we assume that initial foreign reserves are zero. Then, the government's flow constraint reduces to:

$$(1 + i_{t-1})B_t - B_{t+1} + T_t = 0. \tag{19}$$

The quantity theory equation (15) determines the exchange rate:

$$S_t = \frac{\bar{M}}{(1 - v_t)\bar{y}}. \tag{20}$$

The exchange rate will thus follow the velocity shock and be high (low) when the shock v is high (low).

Using (20), consumption of non-traders (given by equation(16)) under flexible exchange rates can be written as:

$$c_t^{NT,flex} = \bar{y} \ , \qquad t \geq 0. \tag{21}$$

Equation (21) shows that consumption of non-traders remains constant at all times. Intuitively, under floating exchange rates, prices change in proportion to the velocity shocks. Since the velocity shock is common to all agents, there is no redistribution of purchasing power between agents.

To determine consumption of traders under the floating exchange rate regime, we can iterate forward equation (17) under the condition $M_t = \bar{M}$ to get

$$c_t^{T,flex} = r\frac{k_0}{\lambda} + \bar{y} \ , \qquad t \geq 0, \tag{22}$$

where we have used the fact that under the quadratic utility specification adopted above, equation (10) – which describes the optimal consumption plans for traders – reduces to $c_0 = E_0(c_t)$ for all $t > 0$. Hence, under flexible exchange rates, consumption of traders is also constant over time. The intuition is the same as before. Since, prices change in proportion to their velocity shock, there are no real balance effects on the traders. Hence, their consumption remains invariant over time.

3.1.2 Fixed exchange rates under velocity shocks

Under fixed exchange rates, the monetary authority sets a constant path of the exchange rate equal to $\bar{S}$. In particular, we assume that the nominal exchange rate is fixed at

$$\bar{S} = \frac{\bar{M}}{(1-\bar{v})\bar{y}}. \tag{23}$$

In effect, we are assuming that at time $t = 0$ the monetary authority pegs the exchange rate at the deterministic equilibrium level.

Under this specification, it is easy to see from equation (16) that consumption of non-traders under a fixed exchange rate is given by

$$c_t^{NT,peg} = \bar{y}\left[1 + (v_t - v_{t-1})\right], \tag{24}$$

$$c_0^{NT,peg} = \bar{y}\left[1 + (v_0 - \bar{v})\right]. \tag{25}$$

Equation (24) shows that under an exchange rate peg, consumption of non-traders will fluctuate by the full amount of their velocity shock. Intuitively, velocity shocks change the nominal balances that non-traders have available for consumption. Since the price level is now fixed, any change in nominal balances also implies a one-for-one change in real balances and, hence, affects the consumption of non-traders.

To determine the consumption of traders we again iterate forward on equation (17) by using the Euler equation $c_0 = E_0(c_t)$ and after imposing the condition $S_t = \bar{S}$ for all t, we get

$$c_0^{T,peg} = r\frac{k_0}{\lambda} + \bar{y}\left[1 + \left(1 - \frac{1}{\lambda}\right)\frac{r}{1+r}\left[(v_0 - \bar{v}) + E_0\left\{\sum_{t=1}^{\infty}\left(\frac{1}{1+r}\right)^t (v_t - v_{t-1})\right\}\right]\right]. \tag{26}$$

In deriving (26) we have used the fact that under pegged exchange rates, equation (15) implies that $M_{t+1} - M_t = -(v_t - v_{t-1})\bar{S}\bar{y}$.[11]

[11] More generally, consumption of traders under fixed exchange rates at any point in time $t > 1$ is given by

$$c_t^{T,peg} = r\frac{k_t}{\lambda} + y\left[1 + \left(1 - \frac{1}{\lambda}\right)E_t\left\{\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}(v_s - v_{s-1})\right\}\right].$$

To understand the consumption function of traders, note that under fixed exchange rates, the nominal value of GDP remains unchanged, i.e., $S_t\bar{y} = \bar{S}\bar{y}$ for all t. The quantity theory relationship requires that aggregate nominal money balances plus the aggregate withdrawal from current period sales be sufficient to purchase current nominal output. To keep nominal output unchanged over time, any change in cash withdrawals from current receipts, i.e., $v_t \neq v_{t-1}$, must be met by the monetary authority with an offsetting change in aggregate nominal money balances. This intervention must happen through transactions in the asset market where only traders are present. On a per trader basis then, the proportional change in nominal money balances needed for keeping the exchange rate fixed is $-\frac{1}{\lambda}(v_t - v_{t-1})$. Thus, under fixed exchange rates, a velocity shock of Δv not only changes real balances of traders by the full amount but also changes their real balances by $-\frac{1}{\lambda}$ due to central bank intervention. The net effect is $1 - \frac{1}{\lambda}$ which is the term that shows up in the coefficient on the velocity shocks in equation (26).

3.1.3 Optimal exchange rate regime

Having described allocations under the alternative exchange rate arrangements, we now turn to the key focus of the paper: determination of the optimal exchange rate regime. We shall conduct our analysis by comparing the unconditional expectation of lifetime welfare at time $t = 0$ (i.e., before the revelation of any information at time 0). In terms of preliminaries, it is useful to define the following:

$$W^{i,j} = E\left\{\sum \beta^t \left[c_t^{i,j} - \zeta\left(c_t^{i,j}\right)^2\right]\right\}, \quad i = T, NT\ , \quad j = flex,\ peg, \tag{27}$$

$$W^j = \lambda W^{T,j} + (1-\lambda)W^{NT,j}, \quad j = flex,\ peg. \tag{28}$$

Equation (27) gives the welfare for each agent under a specific exchange rate regime where the relevant consumption for each type of agent is given by the consumption functions derived above for each regime. Equation (28) is the aggregate welfare for the economy under each regime which is the sum of the regime specific individual welfares weighted by their population shares. Note that the quadratic utility specification implies that the expected value of periodic utility can be written as

$$E\left(c-\zeta c^2\right) = E(c) - \zeta\left[E(c)\right]^2 - \zeta Var(c). \tag{29}$$

where $var(c)$ denotes the variance of consumption.

Proposition 1 *When velocity shocks are the only source of uncertainty in the economy, the flexible exchange rate regime welfare-dominates the fixed exchange rate regime for both agents and hence, is the optimal exchange rate regime for the economy.*

Proof. It is easy to see that $E(c_t^{NT,flex}) = E(c_t^{NT,peg}) = \bar{y}$ while $E(c_0^{T,flex}) = E(c_0^{T,peg}) = r\frac{k_0}{\lambda} + \bar{y}$. Hence, for both types of agents, expected consumption under the two regimes is identical. However, $Var(c_t^{T,peg}) > Var(c_t^{T,flex}) = 0$ and $Var(c_t^{NT,peg}) > Var(c_t^{NT,flex}) = 0$ for all t. From the expression for expected periodic utility given by (29), it then follows directly that

$$W^{i,flex} > W^{i,peg}, \quad i = T, NT.$$

Hence, welfare under flexible exchange rates is greater than welfare under fixed exchange rates for both agents. Thus, aggregate welfare under flexible exchange rates is *unambiguously greater* than under fixed rates. ■

Intuitively, under flexible exchange rates the adjustment of the price level is proportional to the velocity shock of both agents. Hence, flexible exchange rates completely insulate the real balances of both agents which allows them to smooth consumption completely. Under fixed exchange rate on the other hand, a wealth redistribution occurs across agents due to velocity shocks. Specifically, in order to keep the exchange rate unchanged, the monetary authority intervenes in the asset market to accommodate the average effect of the velocity shock. This affects transfers to traders which induces redistributions. Hence, consumption of non-traders fluctuates over time while consumption of traders is affected by a wealth effect coming from asset market transfers.

We should note that in the special case where all agents are traders, i.e., $\lambda = 1$, our model reduces to a standard representative agent, small open economy model with perfect capital mobility. To determine the optimal exchange rate regime in this case we can focus exclusively on the welfare comparison for traders across the two exchange rate regimes.

Proposition 2 *When all agents in the economy are traders, i.e., $\lambda = 1$, the fixed and flexible exchange rate regimes are welfare equivalent.*

Proof. For $\lambda = 1$ it follows directly from equations (22) and (26) that

$$c_0^{T,flex} = c_0^{T,peg} = rk_0 + \bar{y}.$$

Hence, for $\lambda = 1$, consumption for traders is identical under both regimes. Moreover, since no stochastic terms enter the consumption function, welfare of traders (and hence aggregate welfare as well) must be identical under both regimes. Thus, welfare is independent of the exchange rate regime. ■

This result is similar to the well known result of Helpman and Razin (1979) who showed the welfare equivalence between fixed and flexible exchange rates for representative agent economies with perfect capital mobility where agents are subject to cash-in-advance constraints. Intuitively, under flexible exchange rates the price level adjusts exactly in proportion to the trader's velocity shock which leaves her real balances unchanged and thereby insulates her completely from any wealth effects due to real balance fluctuations. Symmetrically, when exchange rates are fixed, the monetary authority pegs the exchange rate by exactly offsetting the aggregate velocity shock through a corresponding intervention in asset markets. When all agents are in the asset market, the intervention amount in asset markets corresponds exactly to the size of the trader's velocity shock which leaves their real balances unchanged. As in the flexible exchange rate case, this intervention effectively insulates traders from any wealth effects due to their velocity shocks. Hence, the two regimes are identical from a welfare standpoint.

3.2 Output shocks only

We now turn to the issue of real shocks and their effects in this model. To focus on this issue, we assume that $v_t = \bar{v}$ for all t and $\sigma_v^2 = 0$. In other words, there is no uncertainty regarding the velocity realization. However, we now assume that output, y_t, is i.i.d. with mean $\bar{y}$ and variance σ_y^2.

To analyze the welfare trade-offs under fixed and flexible exchange rates we shall continue to assume that under flexible exchange rates $M_t = \bar{M}$ for all t while under fixed exchange rates $S_t = \bar{S}$ $(= \bar{M}/(1-\bar{v})\bar{y})$.

The quantity theory equation in this case is given by

$$\frac{M_{t+1}}{1-\bar{v}} = S_t y_t.$$

Note that $M_t = \bar{M}$ implies that under a flexible exchange rate regime, nominal income is constant over time. Hence, nominal money balances of both types are also constant over time.

The above implies that consumption allocations for non-traders under the two regimes, using equation (16), are given by

$$c_t^{NT,flex} = y_t, \tag{30}$$

$$c_t^{NT,peg} = (1-\bar{v})\, y_{t-1} + \bar{v} y_t. \tag{31}$$

Note that in deriving equation (30) we have used the fact $S_{t-1}y_{t-1} = S_t y_t$ under flexible rates. Similarly, iterating forward on the periodic budget constraint for the trading households, equation (17), and imposing the relevant monetary regime on the result gives the consumption allocations for traders under the two regimes:

$$c_t^{T,flex} = r\frac{k_t}{\lambda} + (1-\beta)y_t + \beta\bar{y}, \tag{32}$$

$$c_t^{T,peg} = r\frac{k_t}{\lambda} + (1-\beta)\left[\left(\frac{\lambda-\Omega}{\lambda}\right) y_{t-1} + \left(\beta + \frac{1-\beta}{\lambda}\Omega\right) y_t\right] + \beta\left(\beta + \frac{1-\beta}{\lambda}\Omega\right)\bar{y}, \tag{33}$$

where $\Omega = [1-(1-\lambda)\,\bar{v}]$. It is easy to check that $E(c_t^{NT,flex}) = E(c_t^{NT,peg}) = \bar{y}$ and $E\left(c_t^{T,flex}\right) = E\left(c_t^{T,peg}\right) = r\frac{k_0}{\lambda} + \bar{y}$. Hence, expected consumption of both types is identical under the two regimes.

However the variance of consumption is different. Specifically,

$$Var(c_t^{NT,flex}) = \sigma_y^2, \tag{34}$$

$$Var(c_t^{NT,peg}) = \sigma_y^2\left[1 - 2\bar{v}\,(1-\bar{v})\right] < \sigma_y^2, \tag{35}$$

$$Var(c_0^{NT,peg}) = \bar{v}^2\sigma_y^2 < \sigma_y^2 \tag{36}$$

Hence, for non-trading households, consumption volatility is lower under a peg relative to a flexible exchange rate regime. Given that expected consumption is identical under the two regimes while volatility is lower under a peg, it follows that non-traders always prefer a fixed exchange rate regime to a flexible rate regime when shocks are real.[12]

To understand the intuition, note that under flexible exchange rates, a constant path of nominal money balances implies that the real value of last period's sales (in terms of current prices) is always equal to current output. Hence, current consumption (which is a weighted average of current and last period's real sales revenues) is just current output. Thus, the entire variance of current output is reflected in the variance of current consumption. Under an exchange rate peg on the other hand, the real value of last period's sales is always last period's output. Hence, current consumption is a weighted average of last period and current period's output. The resulting lower variance of consumption under a peg reflects a form of risk pooling: the consumption risk is pooled across periods.

The variance of consumption of trading households also differs across the two regimes. In the appendix (6.1) we show that

$$Var\left(c_t^{T,flex}\right) = \left[r^2 t\beta^2 + (1-\beta)^2\right]\sigma_y^2, \tag{37}$$

$$Var\left(c_0^{T,peg}\right) = (1-\beta)^2\left(\beta + \frac{1-\beta}{\lambda}\Omega\right)^2\sigma_y^2, \tag{38}$$

$$Var\left(c_t^{T,peg}\right) = r^2\left[\left((t-1)(\beta A + C)^2\right) + r^2C^2 + (1-\beta)^2\left(A^2+B^2\right) + 2r(1-\beta)AC\right]\sigma_y^2, \tag{39}$$

where $A = \frac{\lambda-\Omega}{\lambda}$, $B = \beta + \frac{1-\beta}{\lambda}\Omega$, and $C = \frac{\Omega}{\lambda} - (1-\beta)B$.

Our welfare metric is given, as before, by equation (28). In order to compare welfare across regimes we define $\Delta W \equiv W^{flex} - W^{peg}$. Substituting equations (34-39) in (27) and (28) gives

$$\Delta W = \lambda\Delta W^T + (1-\lambda)\Delta W^N = \frac{1}{\lambda}\left(c_2\lambda^2 + c_1\lambda + c_0\right), \tag{40}$$

[12] We should note that this result is crucially dependent on the household being able to consume some fraction of current sales, i.e., $v > 0$. If $v = 0$ then $c_t^{NT,flex} = y_t$ and $c_t^{NT,peg} = y_{t-1}$. Hence, both expected consumption and the variance of consumption would be identical under the two regimes.

where $c_2 = a^2\left((1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) + 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)$; $c_1 = -a^2\left(2(1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) - 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)$; $c_0 = a^2(1-\beta)^2$; and where $a = 1 - \bar{v}$.

Lemma 1 *Equation (40) has two roots:* $\lambda_1 = 1$ *and* $\lambda_2 = \frac{a^2(1-\beta)^2}{a^2\left((1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) + 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)}$.

Proof. See Appendix. ■

Lemma 2 $\beta \in (0.5, 1]$ *and* $\bar{v} > 0$ *are jointly sufficient conditions for* $\lambda_2 \in (0, 1)$.

Proof. See Appendix. ■

Proposition 3 *When endowment shocks are the only source of uncertainty in the economy and the conditions of Lemma 2 apply, the optimal exchange rate regime is a fixed exchange rate for all* $\lambda > \lambda_2$ *while flexible exchange rates are optimal for all* $\lambda < \lambda_2$.

Proof. See Appendix. ■

Thus, Proposition 3 shows that whenever the share of traders is above a critical threshold, fixed exchange rates are the optimal regime under real shocks. Note that this lower threshold goes to zero as v tends to unity. The striking feature of this result is that it is the opposite of the conventional wisdom derived under sticky prices. Recall that under sticky prices and real shocks, flexible exchange rates are optimal. Hence, once again the well-known optimal exchange rate results due to Mundell appear to be turned on their heads. Note that the conditions of Lemma 2 are quite non-restrictive.

To understand the intuition behind this result, it is helpful to note that while both types of agents face the same shock, their ability to cope with them is asymmetric. In particular, trading households have an extra instrument – financial assets – with which to smooth out their consumption flow in response to shocks. Thus, the welfare losses of traders in shifting from a flexible exchange rate regime to a peg is always smaller than the corresponding loss of a non-trading household moving from a peg to a flexible exchange rate regime. Thus, the preferences of non-traders typically dominates the overall welfare criterion.

The only caveat to this intuition occurs for very small values of λ. In particular, when $\lambda < \lambda_2$, a very small number of trading households have to bear the burden of maintaining an exchange rate peg for the entire economy by accepting all the monetary injections or withdrawals. Due to their very small numbers, the resultant consumption volatility of traders under a peg becomes very big. At the limit, consumption volatility of traders goes to infinity as λ tends to zero. However, our simulations show that for most realistic parameter values, λ_2 is very small (typically in the second or third decimal point).[13] Moreover, we also know that for $\lambda = 0$ the optimal regime is a peg since non-trading households unambiguously prefer exchange rate pegs to flexible regimes. Hence, typically the range in which flexible rates are optimal is very small. This suggests that exchange rate pegs are, in general, the optimal regime under output shocks.

4 Closed economy case

We now turn our attention from exchange rate policy in an open economy to monetary policy in a closed economy context. Over the past decade, an ongoing debate in monetary policy design has been the relative merit of inflation targeting versus money targeting. Lately a consensus appears to be emerging in favor of inflation targeting. Most such conclusions are however derived from environments with nominal stickiness (either prices or wages) (see Clarida, Gertler and Gali (1999) for an overview of this literature). The framework studied in this paper provides an alternative structure within which this question can be asked. The reason the answers may be different is because the key friction here is an asset market friction as opposed to the sticky price friction analyzed by most of the existing literature on the topic.

The model is the same as the one analyzed above. In particular, the closed economy version is identical to the model analyzed by Alvarez *et al* (2001). Relative to the open economy case, the key difference is that in the closed economy version goods markets must clear internally. Hence,

$$\lambda c_t^T + (1-\lambda) c_t^{NT} = y_t, \qquad \text{for all } t. \tag{41}$$

The non-trading household's constraints remain unchanged relative to the open economy case.

[13]The simulation results are available from the authors on request.

Hence, consumption of non-traders is the same as before:

$$c_t^{NT} = (1 - v_{t-1}) \frac{S_{t-1} y_{t-1}}{S_t} + v_t y_t, \tag{42}$$

where S_t denotes the domestic nominal price level. The market clearing condition then gives consumption of the traders:

$$c_t^T = \left[1 + \left(\frac{1-\lambda}{\lambda}\right)\left(1 - \frac{c_t^{NT}}{y_t}\right)\right] y_t. \tag{43}$$

The trading household's budget constraint is the same as before except for the absence of foreign bonds. Thus,

$$M_t^T + \frac{T_t}{\lambda} + v_t S_t y_t = S_t c_t^T + \frac{B_{t+1}}{\lambda} - (1 + i_{t-1}) \frac{B_t}{\lambda}. \tag{44}$$

Optimal behavior by traders now entails satisfying just one condition (equation (11)) which determines the nominal interest i. It is easy to check that the quantity theory equation derived earlier continues to hold. Hence, the price level is determined by equation (15). Lastly, the government's budget constraint is now given by

$$(1 + i_{t-1}) B_t - B_{t+1} + T_t = M_{t+1} - M_t, \tag{45}$$

which is identical to the open economy case except for the fact that there are no foreign reserves, h, in the closed economy case.

4.1 Inflation targeting versus money targeting

In order to study the welfare merits of inflation targeting as opposed to money targeting, we assume that the two regimes are characterized by the following policy rules:

$$\text{Inflation Targeting:} \qquad S_{t+1} = (1+\mu) S_t, \qquad S_0 = \frac{(1+\mu)\bar{M}}{(1-\bar{v})\bar{y}}, \tag{46}$$

$$\text{Money Targeting:} \qquad M_{t+1} = (1+\mu) M_t, \qquad M_0 = \bar{M}. \tag{47}$$

Note that under inflation targeting we assume that the central bank also announces (and delivers through an appropriate choice of M_1) the initial price level S_0. The precise number for S_0 that we have assumed guarantees that the two regimes are symmetric in terms of the expected first period price level. Moreover, to keep the regimes symmetric, we have also assumed that the rate of growth of the relevant policy target is the same for both regimes.

4.1.1 Velocity shocks only

As before, we start by studying environments where the only source of uncertainty is the velocity shock. Hence, we set $\sigma_y^2 = 0$. Under our assumptions it is easy to check that consumption allocations under inflation targeting are given by

$$c_t^{NT,\pi} = \left[\frac{1}{1+\mu} + \left(v_t - \frac{v_{t-1}}{1+\mu}\right)\right]\bar{y},$$
$$c_0^{NT,\pi} = \left[\frac{1}{1+\mu} + \left(v_0 - \frac{\bar{v}}{1+\mu}\right)\right]\bar{y}.$$

Note that once c^{NT} is known, c^T is determined from the market clearing condition (41). Similarly, under money targeting consumption allocations are given by

$$c_t^{NT,m} = \left[\frac{1}{1+\mu} + \frac{\mu}{1+\mu}v_t\right]\bar{y},$$
$$c_0^{NT,m} = \left[\frac{1}{1+\mu} + \frac{\mu}{1+\mu}v_0\right]\bar{y}.$$

It can easily be checked that

$$E(c_t^{NT,\pi}) = E(c_t^{NT,m}) = \left(\frac{1+\mu\bar{v}}{1+\mu}\right)\bar{y},$$
$$Var(c_t^{NT,\pi}) = \bar{y}^2\left[1+\frac{1}{(1+\mu)^2}\right]\sigma_v^2, \qquad Var(c_0^{NT,\pi}) = \bar{y}^2\sigma_v^2,$$
$$Var(c_t^{NT,m}) = \bar{y}^2\left(\frac{\mu}{1+\mu}\right)^2\sigma_v^2 = Var(c_0^{NT,m}).$$

Hence, $Var(c_t^{NT,\pi}) > Var(c_0^{NT,\pi}) > Var(c_t^{NT,m}) = Var(c_0^{NT,m})$. Since expected consumption is identical under the two regimes while the variance of consumption is greater under inflation targeting, equation (18) implies that all agents unambiguously prefer money targeting to inflation targeting under monetary shocks.[14]

[14] Note that in the closed economy case, consumption of traders is given by $c_t^T = \left[1+\left(\frac{1-\lambda}{\lambda}\right)\left(1-\frac{c_t^{NT}}{\bar{y}}\right)\right]\bar{y}$. Hence, greater consumption volatility for non-traders also implies greater consumption volatility for traders.

4.1.2 Output shocks only

The second case of interest is where the only randomness in the economy is due to uncertainty about the endowment realization. Hence, we now assume that $\sigma_v^2 = 0$. It is again straightforward to verify that in this case the consumption allocations of the non-trading households under the inflation targeting regime of equation (46) are given by

$$c_t^{NT,\pi} = \frac{1-\bar{v}}{1+\mu} y_{t-1} + \bar{v} y_t \ ,$$
$$c_0^{NT,\pi} = \frac{1-\bar{v}}{1+\mu} \bar{y} + \bar{v} y_0.$$

Correspondingly, under the money-targeting policy given by equation (47), the consumption allocations are

$$c_t^{NT,m} = \left[\frac{1-\bar{v}}{1+\mu} + \bar{v}\right] y_t \ ,$$
$$c_0^{NT,m} = \left[\frac{1-\bar{v}}{1+\mu} + \bar{v}\right] y_0.$$

It is easy to check that $E(c_t^{NT,\pi}) = E(c_t^{NT,m}) = \left[\frac{1-\bar{v}}{1+\mu} + \bar{v}\right] \bar{y}$ for all $t \geq 0$. Thus, expected consumption is identical across regimes for both agents. However, the variance of consumption is different. In particular, it follows from the above that

$$Var(c_t^{NT,\pi}) = \left[\left(\frac{1-\bar{v}}{1+\mu}\right)^2 + \bar{v}^2\right] \sigma_y^2, \qquad Var(c_0^{NT,\pi}) = \bar{v}^2 \sigma_y^2,$$
$$Var(c_t^{NT,m}) = \left[\left(\frac{1-\bar{v}}{1+\mu}\right) + \bar{v}\right]^2 \sigma_y^2 = Var(c_0^{NT,m}).$$

Hence, $Var(c_t^{NT,m}) > Var(c_t^{NT,\pi})$ for all $t \geq 0$ from which it follows that both types unambiguously prefer inflation targeting to money targeting under real shocks.

5 Conclusion

The determination of the optimal exchange rate regime for an open economy is one of the oldest issues in international economics. The single most influential idea in this context has been the Mundellian prescription that if shocks facing the country are mostly monetary then fixed exchange rates are optimal whereas flexible rates are optimal if the shocks are mostly real. The key friction underlying Mundell's results was the assumption of sticky prices in the goods market. In this paper we have investigated the implications of frictions in the asset market as opposed to the goods market.

We have shown that when only a fraction of agents trade in asset markets (i.e., asset markets are segmented), the Mundellian prescription gets turned on its head. Fixing exchange rates entails central bank interventions in the asset market where only a fraction of agents are present. Hence, monetary shocks (shocks to velocity in our context) under fixed exchange rate regimes cause redistributions across agents thereby generating consumption volatility. On the other hand, when exchange rates are flexible, monetary shocks cause changes in the price level which insulate agents' real balances. Thus, asset market segmentation causes an inherent welfare bias towards flexible exchange rate regimes when shocks are monetary. We have also derived general conditions under which fixed exchange rates unambiguously welfare dominate flexible rates when the economy faces only output shocks, thereby overturning the well-know Mundellian prescription once again.

We believe that the key importance of our results lies in their calling into question the conventional wisdom regarding the choice of exchange rate regimes. The conventional thinking on this topic has followed the sticky-price insights of Mundell (1963). We believe that nominal frictions are but one of many possible frictions in any economy. More troublingly, we have shown that an alternative friction whereby there is segmentation in asset markets leads to the opposite conclusion regarding the choice of exchange rate regimes. Since a judgement regarding which friction is more important is ultimately an empirical issue and likely to be country-specific, the main implication of this paper is that an evaluation of the relative strengths of alternative frictions must be a key input into any policy debate regarding the choice of exchange rate regimes. Blanket conclusions based on just the sticky-price paradigm are likely to be misleading at best and plain wrong at worst. More generally, given that an optimal exchange rate regime will depend not only on the type of shock but also on what type of friction prevails in the economy, it makes it more likely that intermediate exchange rate regimes may be optimal, thus providing a rationale for Calvo and Reinhart's (2002) "fear of floating".

The paper has also explored, in a closed-economy context, the implications of our flexible price segmented asset markets model for the policy debate regarding inflation targeting versus money targeting. We have shown that under monetary shocks, money targeting unambiguously welfare-dominates a policy of inflation targeting. On the other hand, under output shocks the opposite is true: inflation targeting welfare dominates money targeting. It bears repeating that relative to standard results in this area which use the sticky price paradigm, our results reflect a very different friction in the form of asset market segmentation.

It is worth noting that in this paper we have ignored state contingent rules, which provides an interesting area of further research. Notice, however, that unless there are some costs or impediments to implementing and/or operating a state contingent rule, such a rule would, by construction, dominate any deterministic rule. Hence, the interesting question is either to study the optimal state contingent rule within some general class of state contingent rules or explicitly model some cost of having such rules and compare them with deterministic rules (along the lines of the "rules versus discretion" debate). In a related paper (Lahiri, Singh and Vegh (2004)), we explore precisely these types of questions.

In this paper we have ignored the issue of endogeneity of market segmentation. In particular, one would expect that agents endogenously choose to be traders or non-traders with the choice being sensitive to the cost of participating in asset markets as well as the prevailing exchange rate and/or monetary regime. However, we see no reason to believe that this would change our key results. As should be clear from the intuition provided in the paper, what matters for our results is that, at every point in time, some agents have access to assets market while others do not. What particular agents have access to asset markets and whether this group changes over time should not alter the essential arguments. A formal check of this conjecture is left for future work.

6 Appendix

6.1 Expressions for variances under output shocks

First, from equation (33), we obtain

$$Var\left[c_0^{T,peg}\right] = (1-\beta)^2 \left(\beta + \frac{1-\beta}{\lambda}\Omega\right)^2 \sigma_y^2. \tag{48}$$

Further, for any $t > 0$

$$Var\left[c_t^{T,peg}\right] = r^2 Var\left[\frac{k_t}{\lambda}\right] + (1-\beta)^2\left(A^2+B^2\right)\sigma_y^2 + 2rA(1-\beta)Cov[\frac{k_t}{\lambda}, y_{t-1}], \tag{49}$$

where $A = \frac{\lambda-\Omega}{\lambda}$ and $B = \beta + \frac{1-\beta}{\lambda}\Omega$. From equations (33) and (17), we get

$$\frac{k_{t+1}}{\lambda} = \frac{k_t}{\lambda} + \beta A y_{t-1} + C y_t - \beta B \bar{y}, \tag{50}$$

where $C = \frac{\Omega}{\lambda} - (1-\beta)B$. Iterating on equation (50), it can be shown that

$$\begin{aligned} \frac{k_1}{\lambda} &= \frac{k_0}{\lambda} + \beta A y_{-1} + C y_0 - \beta B \bar{y}, \\ \frac{k_t}{\lambda} &= \frac{k_0}{\lambda} + \beta A y_{-1} + (\beta A + C)\sum_{s=2}^{t} y_{s-2} + C y_{t-1} - t\beta B \bar{y}. \end{aligned} \tag{51}$$

Then, from equation (51), we obtain

$$\begin{aligned} Var[\frac{k_1}{\lambda}] &= C^2 \sigma_y^2, \\ Var\left[\frac{k_t}{\lambda}\right] &= \left((t-1)(\beta A + C)^2 + C^2\right)\sigma_y^2, \\ Cov\left[\frac{k_t}{\lambda}, y_{t-1}\right] &= C\sigma_y^2. \end{aligned} \tag{52}$$

Combining equation (52) with (49) yields

$$Var\left[c_t^{T,peg}\right] = r^2\left(\left((t-1)(\beta A + C)^2\right) + r^2C^2 + (1-\beta)^2\left(A^2+B^2\right) + 2r(1-\beta)AC\right)\sigma_y^2. \tag{53}$$

Using equations (48) and (53), the variance term of traders' life-time discounted utility under fixed exchange rates is obtained as

$$-\zeta\left((1-\beta)B^2 + \frac{C^2}{\beta} + \beta A^2 + 2AC\right)\sigma_y^2. \tag{54}$$

For the case of flexible exchange rates, from equation (32), we get

$$Var\left[c_t^{T,flex}\right] = r^2 Var\left[\frac{k_t}{\lambda}\right] + (1-\beta)^2\sigma_y^2. \tag{55}$$

Then, from equations (17) and (32), we get

$$\frac{k_{t+1}}{\lambda} = \frac{k_t}{\lambda} + \beta y_t - \beta\bar{y}. \tag{56}$$

From equation (56) it directly follows that

$$Var\left[\frac{k_t}{\lambda}\right] = t\beta^2\sigma_y^2. \tag{57}$$

Using equations (55) and (57), the variance term of traders' life-time discounted utility under flexible exchange rates is obtained as

$$-\zeta\sigma_y^2. \tag{58}$$

6.2 Proof of Lemma 1

Since both traders and non-traders have the same expected consumption under the two exchange rate regimes, the welfare gain is solely determined by the variance terms of life-time utilities. Using equations (34) - (36), for non-traders the welfare gains under the flexible exchange rate regime relative to the fixed exchange rate regime is

$$\Delta W^N = \zeta\left(\frac{\sigma_y^2}{1-\beta}\right)\left[\bar{v}^2 + \beta(1-\bar{v})^2 - 1\right]. \tag{59}$$

For traders, we use equations 54) and 58) to obtain

$$\Delta W^T = \zeta\sigma_y^2\left(\left((1-\beta)B^2 + \frac{C^2}{\beta} + \beta A^2 + 2AC\right) - 1\right). \tag{60}$$

Using equations (59) and (60) it can be easily shown that the weighted utility gain is a function of λ and $\bar{v}$:

$$\Delta W = \lambda\Delta W^T + (1-\lambda)\Delta W^N = \frac{1}{\lambda}\left(c_2\lambda^2 + c_1\lambda + c_0\right), \tag{61}$$

where $c_2 = a^2\left((1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) + 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)$; $c_1 = -a^2\left(2(1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) - 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)$; $c_0 = a^2(1-\beta)^2$; and where $a = 1 - \bar{v}$. Further, equation (61) can be factorized as

$$\triangle W = \left(\frac{1}{a^2\left((1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) + 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)}\right)\frac{1}{\lambda}(\lambda - 1) * \tag{62}$$

$$\left(\lambda - \frac{a^2(1-\beta)^2}{a^2\left((1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) + 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)}\right).$$

Hence the two roots are $\lambda_1 = 1$ and $\lambda_2 = \frac{a^2(1-\beta)^2}{a^2\left((1-\beta)^2 - \frac{1+\beta}{1-\beta}\right) + 2a\left(\frac{1}{1-\beta} - (1-\beta)\right)}$.

6.3 Proof of Lemma 2

Note first that $\lambda_2 > 0$ if and only if the denominator in the expression for λ_2 is positive, i.e. $a < 2\frac{1-(1-\beta)^2}{(1+\beta)-(1-\beta)^3}$, which requires $\bar{v} > 1 - 2\frac{1-(1-\beta)^2}{(1+\beta)-(1-\beta)^3}$. For $\beta \in [0,1]$, the right hand side of this inequality is negative. Hence, a sufficient condition is $\bar{v} > 0$. Thus, assuming $\bar{v} > 0$ ensures that $\lambda_2 > 0$. Next, $\lambda_2 < 1$ if and only if $a < 2\frac{1-(1-\beta)^2}{(1+\beta)}$. (For $\beta \in [0,1]$, this is also sufficient to ensure that $\lambda_2 > 0$.) This requires that $\bar{v} > 1 - 2\frac{1-(1-\beta)^2}{(1+\beta)}$. For $\beta \in [0.5, 1]$, the right hand side is negative. Hence, a sufficient condition again is $\bar{v} > 0$.

6.4 Proof of Proposition 3

The proposition follows directly from (62) where it is easy to see that $\Delta W > 0$ (< 0) for $\lambda < \lambda_2$ $(\lambda > \lambda_2)$.

6.5 Complete markets

This appendix solves a complete markets version of the model developed in the text. To economize on notation, we assume a discrete and finite state space.

In each period t, the economy experiences one of the finitely many events $x_t = \{v_t, y_t\}$. Denote by $x^t = (x_0, x_1, x_2......., x_t)$ the history of events up to and including period t. The probability, as of period 0, of any particular history x^t is $\pi(x^t) = \pi(x^t|x^{t-1})\pi(x^{t-1})$. The households' intertemporal utility function, as of period 0 is

$$W_0 = \sum_{t=0}^{\infty} \sum_{x^t} \beta^t \pi \left(x^t\right) u(c\left(x^t\right)). \tag{63}$$

For any period $t \geq 0$, the accounting identity corresponding to equation (6) for the asset market transactions of a trader household is given by

$$\begin{aligned} \hat{M}^T \left(x^t\right) = M^T \left(x^t\right) + \left(1 + i\left(x^t\right)\right) \frac{B\left(x^{t-1}\right)}{\lambda} - \frac{B\left(x^t\right)}{\lambda} + S\left(x^t\right) f\left(x^t\right) - \\ S\left(x^t\right) \sum_{x_{t+1}} q\left(x^{t+1}|x^t\right) f\left(x^{t+1}\right) + \frac{T\left(x^t\right)}{\lambda}, \end{aligned} \tag{64}$$

where $f\left(x^{t+1}\right)$ denotes units of state-contingent securities, in terms of tradable goods, bought in period t at a per unit price of $q\left(x^{t+1}|x^t\right)$. A trader receives payment of $f\left(x^{t+1}\right)$ in period $t+1$ if and only if the state x^{t+1} occurs. The cash-in-advance constraint (7) becomes

$$S\left(x^t\right) c^T\left(x^t\right) = \hat{M}^T\left(x^t\right) + v_t S\left(x^t\right) y_t. \tag{65}$$

Combining equations (64) and (65) yields

$$\begin{aligned} M^T\left(x^t\right) + \frac{T\left(x^t\right)}{\lambda} + v_t S\left(x^t\right) y_t = S\left(x^t\right) c^T\left(x^t\right) + \frac{B\left(x^{t-1}\right)}{\lambda} - \left(1 + i\left(x^t\right)\right) \frac{B\left(x^t\right)}{\lambda} + \\ S\left(x^t\right) \sum_{x_{t+1}} q\left(x^{t+1}|x^t\right) f\left(x^{t+1}\right) - S\left(x^t\right) f\left(x^t\right). \end{aligned} \tag{66}$$

We assume that actuarially fair securities are available in international asset markets. By definition, actuarially fair securities imply that

$$\frac{q\left(x_i^{t+1}|x^t\right)}{q\left(x_j^{t+1}|x^t\right)} = \frac{\pi\left(x_i^{t+1}|x^t\right)}{\pi\left(x_j^{t+1}|x^t\right)}, \tag{67}$$

for any pair of securities i and j belonging to the set x. Further, no-arbitrage implies that the price of a riskless security that promises to pay one unit next period should equal the price of a complete set of state-contingent securities (which would lead to the same outcome):

$$\frac{1}{1+r} = \sum_{x_{t+1}} q\left(x^{t+1}|x^t\right). \tag{68}$$

Using (67) repeatedly to solve for a particular security relative to all others and substituting into (68), we obtain:

$$q\left(x^{t+1}|x^{t}\right) = \beta\pi\left(x^{t+1}|x^{t}\right), \tag{69}$$

where we have assumed that $\beta = 1/(1+r)$. Note further that the availability of these sequential securities is equivalent to the availability of Arrow-Debreu securities, where all markets open only on date 0. Hence, by the same logic, it must be true for Arrow-Debreu security prices that

$$q\left(x^{t}\right) = \beta^{t}\pi\left(x^{t}\right). \tag{70}$$

The traders arrive in this economy with net foreign asset holdings of f_0 before period 0 begins. To ensure market completeness, we allow for asset market trade right before period 0 begins, so that traders can exchange f_0 for state-contingent claims payable after period 0 shock is realized. Formally,

$$f_0 = \sum_{x_0} q\left(x_0\right) f\left(x_0\right), \tag{71}$$

where $q\left(x_0\right) = \beta\pi\left(x_0\right)$.

Maximizing (63) subject to (66) yields

$$q\left(x^{t+1}|x^{t}\right) = \beta\pi\left(x^{t+1}|x^{t}\right)\frac{u'\left(c\left(x^{t+1}\right)\right)}{u'\left(c\left(x^{t}\right)\right)}. \tag{72}$$

Since $\beta = \frac{1}{1+r}$, it is clear from (69) and (72) that traders choose a flat path for consumption.

To obtain the level of constant consumption for traders, notice that the equilibrium flow constraint for traders (17) can be rewritten as

$$\begin{aligned} &\frac{h\left(x^{t}\right)}{\lambda} - (1+r)\frac{h\left(x^{t-1}\right)}{\lambda} + \sum_{x^{t+1}} q\left(x^{t+1}|x^{t}\right) f\left(x^{t+1}\right) - f\left(x^{t}\right) \\ &= y_t - c^{T}\left(x^{t}\right) + \left(\frac{1-\lambda}{\lambda}\right)\left(\frac{M\left(x^{t}\right) - M\left(x^{t-1}\right)}{S\left(x^{t}\right)}\right), \end{aligned} \tag{73}$$

where h_0 and f_0 are given exogenously. Using (70) and iterating forward on equation (73), it can be checked that under either regime and for any type of shock (i.e., velocity or output shock), consumption of traders is given by:[15]

$$c^T\left(x^t\right) = r\frac{k_0}{\lambda} + \bar{y}\ , \qquad t \geq 0, \tag{74}$$

where $k_0 = h_0 + \lambda f_0$.

Since the maximization problem of non-traders remains the same, it should be clear that all of our results go through. More specifically, since traders are indifferent between fixed and flexible exchange rates, social preferences are determined by what is best for non-traders. As shown in the text, non-traders unambiguously prefer flexible exchange rates under monetary shocks and fixed exchange rates under real shocks. Hence, under complete markets, flexible exchange rates are welfare-superior under monetary shocks and fixed exchange rates are welfare-superior under real shocks.

[15] This is accomplished by multiplying each period's flow constraint by $q\left(x^t\right)$ and summing it over all possible realizations. Then, summing over all periods and imposing tranversality conditions gives the intertemporal budget constraint.

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