Using Options To Stabilise FX: A New Exchange Rate Mechanism

Introduction

This paper[1] describes a new FX-stabilisation mechanism.

In late 1992, sterling was ejected from the European exchange rate mechanism. Since then the United Kingdom has a strong political aversion to attempts to 'manage' the level of the currency. Because of this political aversion, it is important to emphasise the differences between that mechanism, and this proposal.

The new FX stabilisation mechanism proposed here is entirely different to that European ERM. That ERM could be likened to a brick wall: the price of the member currencies was not allowed cross certain thresholds. Eventually, the weight of speculative money overwhelmed the walls. In contrast, the mechanism proposed here is analogous to a field of tall grass. There are no fixed barriers that might test the credibility of the system. Instead, as the wind blows, the grass slows the wind by 'absorbing' its energy. Further, the central banks are fairly remunerated for providing this stabilisation.

Before describing the mechanics of the reduction of FX volatility, it should be asked whether the authorities would wish to reduce volatility? Yes: many politicians have complained that financial markets are excessively volatile, but very few have ever complained that they are insufficiently volatile. Financial intermediaries, who endeavour to make profits from the turnover that can be triggered by changes in prices, may well desire volatility, but when the elected or appointed authorities comment on volatility it is almost always to suggest that less would be better. How far should volatility be reduced? Obviously zero volatility means fixed prices, and this must be wrong when new information is constantly arriving into the market place. Given that all interested parties (with the exception of some of the intermediaries) seem to desire lower volatility, but that zero is too low, the natural course is to put in place a modest option-selling programme, and then to assess whether it was too much or too little. In any event, we proceed on the assumption that the authorities actively desire lower volatility.

The working of this mechanism is simple: **governments should commit themselves to frequent and regular auctions of short-dated physically-delivered FX options**.

Hedging option holdings

Why do official sales of options would reduce market volatility? The answer lies in the financial risks inherent in owning such an option.

Consider the position of a trader who owns one option, with two weeks to expiry, that gives the trader the right to buy £1 for ¥200 on the expiry date (a GBP call JPY put). Let us imagine that the pound is currently worth much less than the strike: say ¥180. Clearly, the option is almost worthless: why spend ¥200 on a pound (by exercising the option) when a pound can be bought at the cheaper price of ¥180 in the market. If the pound were to appreciate to ¥190, the option would still have only a small value. But if the pound were to appreciate to ¥200, the option would increase in value substantially, and if sterling were to increase to ¥210, then the option would be worth at least ¥10.

The point is that as £/¥ moves from below to above the strike, not only does the value of the option increase, but each additional ¥1 further move increases the value of the option by more than previous moves.

So a trader who is hedging this option exposure would start with little hedge, and whenever the pound rose the trader would sell a little more sterling. Likewise, as the pound falls, and particularly as the pound falls through the strike, the holder of the option would buy pounds.

It is stressed that this process of 'delta-hedging' is not just a theoretical construct; it is standard and necessary practice for option traders. It is inherent in the ownership of the option. Commercial banks are risk-averse, and option desks do not wish to acquire exposure to the underlying markets. If an option trader did have a directional view, the exposure given by the option would substitute for actively acquiring this position by chasing the market.

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[1] This paper is based on sections 2 and 3 of *Mechanisms For Central Banking*, June 1996, published by the Financial Markets Group of the London School of Economics, special paper no. 84, ISSN 1359-9151-84, Julian D. A. Wiseman, with a foreword by Professor Charles Goodhart.

Indeed, if a particular option holder decided not to hedge its position as the market moves, then this would not hamper the stabilisation. Other private-sector banks would detect the reduced level of buying or selling in the broker and retail markets. They would deduce that there is trading to come, even if only after the expiry of the option, and would buy or sell in anticipation of this. In other words, private-sector banks would not only delta-hedge their own positions, they may also delta-hedge the others'.

In effect, official sales of options are a self-enforcing sub-contracting of FX market intervention, from the central banks to the highest bidder in the private-sector.

Why can't the central banks do their own delta-hedging?

It has been suggested that this programme could be 'simulated' by the central banks; the central banks calculating the delta-hedges and executing them themselves, rather than incentivising the private sector to do so. There are two difficulties with such a central-bank role. First, delta-hedging is mostly 'science', but still involves a certain amount of judgement. If the market is thin, or has been temporarily manipulated, a trader may well decide to not to delta-hedge — at least for the moment. Thus an 'automated' delta-hedging programme, in which market moves automatically trigger intervention, would invite manipulation. Second, the Central Banks' delta-hedging programme would require at least daily intervention. The Fed, ECB, BoJ and BoE would be active almost constantly in FX markets, and it would be difficult to signal credibly that the intervention was the whole delta-hedging and nothing but the delta-hedging. Hence the need for the central banks to 'privatise' the FX stabilisation (by the sale of options) rather than keeping it in-house.

Naturally, the recommended programme of option sales entails some implementation details.

Implementation details

It is envisaged that a multilateral group of central banks would jointly write a 'model agreement', covering such sales of options, to be signed by pairs of central banks. There would be an advantage if all the monetary-authority pairs signed the same type of agreement, with only the parameters varying from one pair to the next. If agreements are not the same then the market would suspect that the differences are important, with slight wording changes giving rise to doubts about the motivation for the difference.

It seems natural to envisage a central core of four currencies (USD, EUR, JPY and GBP), each of which is stabilised against the other three, the four central banks thus selling options on the six possible cross rates: /$, $/¥, /¥, £/$, /£ and £/¥. Other currencies would be attached to this core in a manner appropriate to trade flows.

- This model agreement should be public, as should each specific agreement between central banks. The model agreement should include a statement, explicitly non-binding, that both parties intend to announce any mutually agreed change to the agreement eight weeks before its implementation. But each party would have a right to cease further sales of options without notice — in the expectation that this clause would be invoked only in the event of default or war or similar manifest event.
- Once an option is sold, it is irrevocably and unconditionally guaranteed by both parties, severally and jointly.
- It might occur to policy-makers to issue options only in times of market instability. This would be unwise: the admission of panic would exacerbate volatility, and uncertainty about the sale of options would itself be a cause of speculation and volatility. Hence the model agreement should state that the parties have agreed to conduct auctions regularly, according to a pre-determined calendar. This calendar may well specify twice-weekly auctions.
- For this policy to be most effective the private-sector banks need to own options that are near to expiry, and that have strikes near the current level of the market. This could not be done with auctions as infrequent as monthly or quarterly. The ideal situation would be for options with almost no time to expiry to be auctioned continuously, but this is impractical. Conducting twice-weekly auctions of options with fourteen or so days to expiry seems a reasonable compromise.
- As an additional aid to ensuring that there are always options with strikes near the money, each auction could be of options with several strikes: say at-the-money, atm$\pm\sigma$ and atm$\pm 2\sigma$, for some suitable σ. It is possible to achieve this effect more smoothly and elegantly using the exotic option described in the appendix.

- To ensure that the pool of potential bidders is sufficiently large that a cartel could not operate, this scheme should only be implemented in widely-traded currency pairs. All of the six cross rates between $, , ¥ and £ easily satisfy this criterion.

It has been suggested that central-bank selling of options would inhibit private-sector selling, and that this is undesirable. Certainly the central banks would become the dominant provider of short-dated volatility. But this was the objective; financial markets being short volatility causes instability (in October 1998 the 'street' was very short of options on $/¥, and this short greatly exacerbated the explosive collapse in the dollar). However, the owners of the central-bank-provided options are likely to become keen sellers of both long- and short-dated volatility to the corporate sector, thus cheapening corporations' cost of financial insurance.

There is a trade-off in this whole approach. Although the authorities will reduce the volatility of FX prices, they will increase the variability and unpredictability of their own FX reserves. Further, the authorities must not delta-hedge its short option positions, as to do so would necessitate the government selling into falling markets and buying into rising markets, undermining the whole purpose of the programme.

Conclusion

Central bank sales of options would reduce market volatility in a credible and sustainable manner, and central banks would be fairly remunerated for doing so. Sales of options would not only reduce actual FX volatility, but would also reduce non-financial corporations' cost of hedging FX exposures.

Appendix. Smoother stabilisation using an exotic option

This paper proposes stabilising the currency market by selling options. It is possible to improve on the effectiveness of this by selling a suitable exotic structure, rather than plain vanilla options.

We start by explaining the problem with vanilla options and demonstrate that an exotic option with smooth hedging characteristics would be superior. We proceed by defining the correct hedging property, converting this into the required payout function for the option, and then describing how this can be physically delivered.

Motivation for using an exotic structure

What is the problem with vanilla options?

Consider what happens if the government sells a straddle with a specific strike (such as a straddle that allows the holder to exchange £1 for ¥200 or vice versa). If, just before expiry, the price were close to the strike, then the market stabilisation effect would be very powerful. But if the price lay far from the strikes, then little hedge-rebalancing would be done and the market would be only slightly less volatile than it would have been otherwise. So the stabilisation is uneven, and market behaviour would be much smoother if this unevenness were removed.

This can be rephrased. If the central banks sell conventional options, each strike can be thought of as 'radiating' stability into nearby prices. So, as the FX rate varies, the market is subject to different amounts of stability. (Of course, at each price the market is more stable than previously, but not equally so.) An exotic structure would replace these intense 'point sources' of stability with a single option that functions as if it were composed of very many less intense sources of stability.

So, the difficulty lies in the discreteness of the strike or the distribution of strikes, and the non-standard option structure described in this appendix remove this discreteness. However, before starting on the mathematics it is worth asking whether or not the novelty of the option structure would, of itself, reduce demand for them or reduce their effectiveness.

The answer to this depends on the central banks' policy. If one central bank, as a once-off, auctioned an exotic structure, then not all of the investment banks would commit the time and effort required to understand the required pricing, hedging and risk management. Further, those that did make the effort would recognise the possibility of an error, and to allow for this risk would (indeed should) deliberately underbid. On the other hand, if several of the world's major central banks were to announce a regular programme of auctions of some specified new structure, then this would be quite different. The investment banks and academics would commit time and effort to devise and test the required mathematics and software. Bidding would still be cautious in the first few auctions, but as dealers acquire confidence that their pricing and hedging models are correct and in close agreement with the rest of the market, prices would move to much nearer fair value, and hedging strategies would become more finely tuned.

Of course, when the authorities sell debt, the target audience is typically the long-term investor, including private individuals. This provides a motivation for simplicity in the structure and workings of debt. But should the central banks decide to sell options on debt or FX, the target audience is not the end investor; rather it is the sophisticated financial institution that will dynamically manage the hedge. Indeed the central banks would prefer that the end-investor did not buy the options; seen from the central banks' perspective the optimal owners are commercial banks who can and do hedge their assets. There is therefore a sense in which the complexity of the exotic options will help their effectiveness.

The required hedging characteristics

Some terms need to be defined. The central banks will sell a structure that has some monetary value at expiry which is a function of the price of underlying instrument u. The monetary value of the payout is denoted $p(u)$, and the first and second derivatives of this function with respect to u are $p'(u)$ and $p''(u)$. Let v be the value of the underlying, forward to the expiry date, at the time the structure is sold.

What properties should the payout have?

- To avoid credit risk, the value of the option should always be non-negative, so $p(u) \geq 0$ for all u. This is conventional: in most markets option prices are always non-negative.
- The hedge should behave smoothly as a function of the underlying. We choose the smoothest possible hedge behaviour: the change in the hedge caused by a (say) 1% change in the underlying should be constant, and hence independent of the level of the market.

How do we measure the change in the hedge? Consider the case where the underlying asset is a barrel of oil, its price being measured in US$. It might seem natural to impose a rule that a 1% change in the price of the underlying changes the hedge by some fixed quantity of oil. But this approach would fail if the underlying were not oil, but instead were money. Consider the case where the asset is a pound sterling, which has a price denominated in yen. If the hedge changes by a constant number of pounds for a 1% change in u, then it changes by u times as many yen, which is therefore not independent of u. As we wish the hedging property to be symmetrical in £/¥ and ¥/£, this measure is not satisfactory. Instead the natural measure to keep constant is the product of the change in the yen and sterling hedges.

For example, assume that currently £1 = ¥200, and that a 1% change in this price causes the holders of the options to rebalance their hedge by a total of £100 million = ¥20 billion, these having a product of £¥2×10^{18}. If the price of a pound, u, were to change from ¥200 to ¥209·7152 then the 1% hedge amounts would become £97·65625 million and ¥20·48 billion. The hedge would change by fewer of the stronger pounds, but by more of the weaker yen. Observe that the product of these two numbers is still £¥2×10^{18}, and that their ratio returns the new FX rate of £1 = ¥209·7152.

The payout function

Assume the price of a pound in yen is u, and that this changes to $u(1+\varepsilon)$. The amount of sterling in the hedge (the delta) goes from $p'(u)$ to $p'(u+u\,\varepsilon) \approx p'(u) + u\,\varepsilon\,p''(u)$. Thus the change in the sterling part of the hedge is $u\,\varepsilon\,p''(u)$, and that of the yen part is $u^2\,\varepsilon\,p''(u)$. Hence we wish $u^{3/2}\,\varepsilon\,p''(u)$ to be independent of u, and hence $p''(u)$ to be proportional to $u^{-3/2}$.

We know that the minimum value of $p(u)$ should be 0, and we therefore need one additional boundary condition. At the time the options are sold (when the forward exchange rate is v) the options are delta-neutral, so $p'(v) = 0$, giving that

$$p(u) = v^{1/2} + u\,v^{-1/2} - 2\,u^{1/2}$$

this being denominated in yen.

There are three observations to make about this equation for $p(u)$:

- This equation is only specified up to a constant multiplier; $p()$ could be defined to be (say) 10^8 times larger. This is merely equivalent to taking one hundred million options with the 'small p' payout and bundling them together to create a structure with the 'large p' payout;
- This equation is symmetrical in £/¥ and ¥/£, a fact that can be verified by dividing through by u to convert to pounds, and then substituting $u^*=u^{-1}$ and $v^*=v^{-1}$ to allow for the change in quotation convention;
- We will later need $p'(u)$ and $p''(u)$. These are $p'(u) = v^{-1/2} - u^{-1/2}$ and $p''(u) = u^{-3/2}/2$;

Physical delivery

There is a further complication in the use of these option structures. Their purpose is to ensure that the holders' hedging strategies stabilise the market. Under this regime central banks avoid discretionary stabilisation — but they are still the ultimate providers of intervention. They are simply obliged to intervene rather doing so at their discretion; this obligation being imposed by the exercise of options.

However, the stabilisation would be destroyed if the central banks were to cash settle their options (or equivalently to repurchase them). At the instant of their repurchase or cash settlement the private sector would immediately unwind all its previous hedges. For example, if the pound had previously risen then the hedges would all be short of sterling, so this unwind would involve purchasing pounds, driving the price up further; and thus destabilising the market. The net effect would have been to save up some of the volatility that would otherwise have occurred during the life of the option until expiry, at which instant all this 'saved' volatility would be released. It is therefore essential that options are physically delivered and not cash-settled.

What does physical delivery mean in this context? Contrast it with cash-settlement: to cash-settle an option the parties take a fixing of the price of the underlying, which is then used to calculate the monetary value of the option. This monetary value is then transferred from the issuer to the holder (always in this direction because the value of an option is always non-negative). Immediately after the cash-settlement neither party has any delta (exposure to the underlying), as the option no longer exists and no underlying was transferred. Physical delivery is the opposite: no fixing is used; and delta is preserved because the underlying asset changes hands. Delta needs to be preserved over expiry, so these options must be physically delivered and not cash-settled.

How does one physically deliver the unusual payoff functions derived above? Fortunately there is a general technique that allows physical delivery of a wide class of payout functions.

An option, by definition, allows the holder a choice. At expiry the holder of one of these options will choose a number x. The holder then will then receive $p'(x)$ units of the underlying asset (the pound in this example) and $p(x) - x\,p'(x)$ in money (yen). Observe that the monetary (yen) value of the payout at expiry is

$$u\,p'(x) + p(x) - x\,p'(x)$$

and x will be chosen by the holder to maximise this payout. Differentiating once with respect to x and setting to zero gives

$$0 = u\,p''(x) + p'(x) - x\,p''(x) - p'(x) \quad \Rightarrow \quad x = u$$

so the holder of the option should choose the value of x to be the current price u of the underlying. Thus the payout is

$$u\,p'(u) + p(u) - u\,p'(u) = p(u)$$

as required.

Also observe that just before expiry the holder's monetary exposure to the underlying is $p'(u)$, and just after the holder is long $p'(u)$ units of the underlying, so exposure to the underlying is conserved over expiry — which was the original motivation for physical delivery.

How many options should be sold? Let us assume that currently £1=¥200, and that the authorities have decided that a 1% move in the exchange rate should give an 'intervention' amount of about ±£100 million or ±¥20 billion. Recall that we designed the payout function such that the 1% intervention amounts in sterling and yen when multiplied together (£¥2×10^{18}) will be independent of the prevailing FX rate. A 1% change in the FX rate will cause a change in the market's total hedge of

$£\ p''(u) \times (1\% \times u) \ = \ £\ (u^{-3/2}/2) \times (1\% \times u) \ = \ £\ u^{-1/2}/2 \times 1\% \ =$
$£\ 200^{-1/2}/2 \times 0{\cdot}01 \ \approx \ £0{\cdot}00035355 \ \approx \ ¥0{\cdot}07071$

so about 283 billion options will need to be sold. As the payout per option is very small, and the number of options sold is very large, it will be less unwieldy to choose a $p(u)$ that is (say) 100 million times larger.

There are two extra details associated with these structures.

- Exercise involves the holder choosing a number x, and all the holders are likely to choose x to be u. Purely for convenience, the central bank issuer could undertake to make a best-endeavours attempt to establish the mid-market value of the underlying just before expiry; this value, published immediately after expiry, would be used as a default value of x. Of course, at any time up to expiry holders may instead communicate their own choice of x.
- There is no central-bank-run clearing house for FX transactions, so FX transactions carry significant settlement (Herstatt) risk. If these options are freely transferable then the issuer may find itself being a counterparty to poor credits. Unfortunately there is no elegant answer to this difficulty. Perhaps private-sector banks of suitable creditworthiness could apply for settlement lines with the two central banks concerned, and only banks with lines would be permitted to exercise options (and then only up to the size of these lines). In this case other institutions would be allowed to hold the options, but settlement would have to be via (or guaranteed by) a bank with a sufficiently large settlement line. Alternatively, the issuers' exposure to the banks with settlement lines could be reduced by using a daily two-currency market-to-market that is based on a fix of the prevailing FX rate; although this would restrict ownership as well as exercise to those banks with lines. Perhaps a clearing house could stand between the central bank issuers and the investment community.

It should be remarked that the proposed structure has an extra advantage, namely that it does not make disasters contagious. For example let us consider the (extremely hypothetical) scenario where the worth of the pound measured in yen falls to near zero as a result of an earthquake, war, coup or economic collapse. For a value of u close to 0, exercise of the option necessitates the central banks buying a very large number of pounds (increasing as u^{-1}) in return for yen. The strength of the yen means that the number of additional yen being sold by the issuer falls (and the number of additional pounds purchased rises, the geometric average remaining constant). The total number of yen sold tends to a limit of $v^{1/2}$, this limit being achieved only when the pound is worthless. In the above example the maximum number of yen required in the intervention works out at ¥4 trillion, worth £20 billion at the old exchange rate and worth an effectively unlimited number of pounds at the new near-zero rate. So the sale and irrevocable guarantee of these options does not constitute a 'blank cheque', it never obliges one nation to print an infinite amount of its own money to support another nation's currency, and thus one nation's collapse need not bring down any others. The example chosen is obviously unlikely, but there are less wealthy nations which might be perceived, justly or otherwise, as being at risk of a sudden collapse. Because the proposed currency regime does not make disasters contagious, rich nations should have no fundamental objection to signing such currency-stabilising agreements with their main trading partners, even if these partners are considerably poorer.

Nonetheless, it might be that this upper limit to the scale of intervention, though finite, is still deemed to be too large. If the factor of 200 between the '1% stabilisation amount' and the 'maximum intervention' is indeed deemed to be excessive, then an alternative structure will be required. Rather than making the change in the hedge independent of u, it could be log-normally distributed around v. Mathematically we have that

$$u^{3/2}\ p''(u) \propto \phi(\ \ln(u), \ln(v), \sigma)\ /\ u$$

where $\phi(x, \mu, \sigma)$ is the normal distribution function, and with the same boundary conditions as above. (This lacks an analytical solution, so the agreement should include some code to execute the official numerical calculation of $p(x)$ and $p'(x)$.) It will be necessary to choose σ; the agreement between the central banks should specify how this is determined, either as a fixed value or proportional to implied volatility.

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