

The prices vs. quantities tradeoff in monetary policy.

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Abstract :

Why do central banks sometimes choose to control directly the quantity of credit, rather than to influence indirectly interest rates through market operations ? This paper states that the choice of monetary policy instrument is determined not primarily by the nature of the macroeconomic disturbances but by the nature of the interaction between the central bank and the banks. The dilemma prices vs. quantities arises only in a second-best equilibrium. I build a simple model that derives under which conditions it is optimal for a central bank to ration directly credit at an interest rates below the market clearing rate. Asymmetries of information between banks and firms (imperfect financial markets) and a monopoly of the central bank on banks refinancing are crucial to this result. The model also offers a new interpretation of expansive policy when the interest rate does not play any role (with the zero lower bound interest rate as a particular case). The opposite case is when the interest rate is used as a screening device. It corresponds to the real bills doctrine. Finally, this theoretical framework makes clear that, in a imperfect information context, quantitative (second-best) monetary policy always creates rents. The model helps to explain why central banks in developing countries still use many quantitative instruments. It also provides a new account for the reaction of central banks during crisis.

"The rejoinder is that using rationing, not the price mechanism, is in fact the better way of ensuring that true needs are met. If a market clearing price is used, this may mean only that it will be driven up until those with more money end up with more of the deficit commodity."
Martin Weitzman (1977, p.2).

1 Introduction

The choice of quantitative instruments by central banks is still not well understood from a theoretical point of view. Today, monetary policy is almost always modeled through an interest rate rule although many central banks in the world still use discount ceilings, limits on credit expansion or reserves/treasury bonds requirements. These quantitative instruments have been the main instruments for decades, especially after World War II, in Europe, Asia or Latin America (Hodgman 1973, Alexander and Enoch 1995, De Melo, Denizer 1997, Schreft 1992, Monnet 2011). The recent financial crisis has created a new interest for this kind of tools but the debates mainly focus on the consequences of expansive monetary policy that relies on the central bank's balance sheet (quantitative easing) (Adrian and Shin 2009) without providing a general theoretical foundation for such a policy.

Historical analysis suggests that, except in some extreme events, quantitative instruments have mainly been used during restrictive episodes : during normal or expansive times, the quantitative controls were repealed or they did not bind. Recent debates and models of quantitative easing are very limited about the potential tools that could be used when inflation strikes back. A general framework is thus needed to understand the use of quantitative tools both in restrictive and expansive times.

In most of the standard models, central banks intervention on prices or on quantities are equivalent. As long as the central bank can control the interest rate or the money (or credit) supply, it can achieve its objective. This equivalence is not surprising : in a perfect market, if one moves the quantity or the price, the other variable adjusts. The new equilibrium is reached through the manipulation

of any of these two variables. This simple remark is nonetheless very important because it leads to a clear distinction between the instruments and the objectives of monetary policy. As long as there is determinacy in the model, the choice of the instruments does not depend on the choice of the objectives. Conceptually, GNP targeting, inflation targeting, interest rate targeting or money growth targeting can thus be achieved both through interest rates or quantitative instruments.

In a classical paper William Poole (1970) made a clear distinction between targets and instruments, the latter being any variable on which the central bank has perfect control. He first stated that in a simple deterministic IS-LM model, the instruments of monetary policy (interest rates or money base) are equivalent. The second result of Poole's paper (which is the one that is mainly remembered) is that this equivalence does not hold anymore in a model with stochastic disturbances. The choice of instruments thus depends on the nature of the shocks. Finally, under certain circumstances, a combination is possible between the two types of instruments.

This model still remains today the best framework to think about the dilemma 'quantities versus prices' in monetary policy (Collard and Dellas 2007). Nevertheless, the fact that the choice of instruments depends on the nature of the stochastic disturbances is at odds with some observations of central banks choices and neglects the role of financial markets. Indeed, the choice of the type of instruments is highly persistent (it often lasts several decades) rather than adapting to shocks of different nature and it mainly depends on the relationships between central banks operations and the financial system. Quantitative instruments are often associated with less developed financial systems of closed economy, while interest rates are often associated with open , liberalized and well developed financial system without many imperfections (Alexander and Enoch 1995, De Melo, Denizer 1997). Another usual distinction refers to quantitative instruments as direct instruments in opposition to the market-based indirect instruments (Alexander and Enoch 1995). This distinction highlights the fact that the main feature of quantitative instruments is that they are used to distort the market and they take place in a

very imperfect environment. Because of the impossibility to allocate loans through a planning or a market process in a full information environment, the central bank chooses a second-best equilibrium with non market-clearing in an imperfect environment. When the central bank chooses to ration quantities at an interest rates below the market clearing rate, then there is no more an equivalence between moving quantities or moving prices, even in an environment without macroeconomic stochastic disturbances. It is always a second-best equilibrium.

Monetary policy with a non-market clearing money market or credit market is not common in the literature. Many macroeconomic models include a constraint such that the credit market does not clear but this constraint is not the consequence of monetary policy. Policy only relax or increases it. In these models, credit constraints amplify the effect of monetary policy whatever is the instrument used by the central bank (Bernanke, Gertler 1995).

The approach followed in this model differs from standard macroeconomic models of monetary policy including Poole's model. It states that the choice of monetary policy instrument is determined not primarily by the nature of the macroeconomic disturbances but by the nature of the interaction between the central bank and the banks (financial system). It is related to the literature about optimal regulation with parameter uncertainty that makes clear how the dilemma prices versus quantities arises. This approach was pioneered in a seminal paper by Weitzman in 1974. Our model borrows from this approach as it uses the fact that two elements are crucial to have the prices vs quantities tradeoff : asymmetry of information and a planner (or a monopoly power). The quantities vs. prices tradeoff is a second best problem by its nature. In a recent paper, Stein (2011) uses Weitzman's insights and shows that monetary policy can be deemed to be a planning problem with quantities as an optimal instrument when there is financial instability due to pecuniary externalities. Stein then promotes a cap and trade system as an instrument of monetary policy. But in Stein's model, the central bank affect banks behavior through quantities rather than prices because of the assumption that interest rates are fixed and independent of quantities. This model cannot

explain why the central would prefer to control quantities rather than prices.

In this paper I use the model of equilibrium rationing derived by Klemperer and Gilbert (2000) and show how it can be applied and extended to monetary policy. Such a model then explains why a central bank would prefer to use quantitative controls rather than a market interest rate as its primary instrument. It is thus complementary to Stein's model as it provides foundations to the case when the central banks adjusts quantities at a fixed interest rate which is no longer a market clearing interest rate. The two crucial assumptions are first asymmetries of information between banks and firms, and second, a monopoly power of the central bank on banks refinancing.

These assumptions are restrictive but not unrealistic. They offer a very coherent account of the fact that quantitative control are mainly used in closed economy with asymmetry of information and a strong ability of the central bank to control credit. While this is usually the case of emerging economies, it might also be relevant for developed and financially liberalized economies during and after financial crises. During a crisis, central banks refinanced banks directly because of the lack of confidence in the money market (lender of last resort operations). The spirit of the model derived in this paper is very close to XIXth century monetary theory as the central bank is considered as a bank among others but with more power on the money market. As in Thornton or Bagehot writings, the strategic interactions between the banks and the central banks is thus crucial, and the *lender of last resort* and the *real bills doctrine* are thus naturally some specific cases of the model. The main contribution is to add some insights from imperfect information and rationing theory to this framework. A important result due to imperfect information is that the role of interest rates is very limited for monetary policy. Such a framework may seem very anachronistic for monetary policy in the XXIst century while central banks have lost their monopoly power and have become "armies with only a signal corps" (Friedman 1999). It takes an opposite view to the wicksellian-newkeynesian paradigm (Woodford 2003, Gali 2008) that incorporates the whole central bank behavior in a single interest rate. Such features of the model may be limited to understand monetary policy in a world with almost perfect financial

market where central bank play almost no role in banks refinancing. But they shed light on the opposite situations when banks are indebted to the central bank: lender of last resort operations, zero lower bound interest rate, developing financial system etc.

The main intuition of the model is that the interest rates set by central banks (as any price) have a dual role (cf Gilbert and Klemperer 2000): they allocate credit and money but they also provide an incentive for investment. Then the interest rate set by the central bank also works as a signal that may exclude banks from the market. This effect that is due to imperfect information and is common in economic literature (cf Stiglitz and Weiss 1981). The main mechanism is that the central bank can thus run a restrictive monetary policy at a relatively low interest rates and then exclude less banks (and then less projects) from the market. Contrary to the market clearing case, there are more banks receiving credit at the equilibrium but each bank receives a lower amount of credit. The rationale for such a choice could be either a political economy argument (maximizing the number of entrepreneurs), a policy to favor financial development through an increase in the number of banks, or a willingness to increase investment if the investment function has decreasing marginal returns to credit.

In an expansive monetary policy, when the central bank commits to refinance all the banks whatever their demand, the interest rate is fixed and does not play any role but the central bank adjusts the quantity of credit in function of the demand (as in Stein 2011). This is not true anymore if the central bank can choose endogenously its maximum supply of credit and then use the interest as a screening device.

The model has four important conclusions : first under certain assumptions, for a restrictive policy, the central bank may prefer to ration the supply of credit and sets an interest rate below the market clearing rate. Second, when the central bank has to run an expansive monetary policy, then the interest rate does not play any role and the central bank is not able to maximize its profit anymore. The zero lower bound interest rate is a particular case of this situation. Third, there

is a strong difference if the central bank follows a rule that determined money supply or interest rate or if the central bank determines endogenously the supply of money in function of banks demand for credit. In the latter case, the choice between an expansive or a restrictive monetary policy relies on the interest rate as a screening device to exclude low types. This case corresponds to the *real bills doctrine*. Fourth, quantitative (second-best) monetary policy always create rents for some banks. In both restrictive monetary policy with rationing and expansive policy, low type banks benefit from credit that they would not have obtained otherwise and high type banks benefit from lower interest rate.

2 Set up of the model

This section presents a simple model that highlights the strategic interactions between a central bank and commercial banks. It is in fact an adaptation of the model of equilibrium rationing by Gilbert and Klemperer (2000) to the case of monetary policy. Gilbert and Klemperer constructed a general model to explain why a seller can have some interest to ration quantities and sell a good at a price below the market-clearing price.

The main unusual characteristic of the model is to include two financial markets. They are a market for loans between banks and firms, and a money market for banks refinancing. The structure of the model is as follows :

- banks lend to firms in an economy with imperfect information (modeled as a sunk cost). This market is called the *loan market*.
- the central bank has a monopoly on banks refinancing (i.e the central bank lends directly to private banks and there is no outside money market). This market is called the *money market*.

The central bank maximizes its profit and chooses the optimal use of instruments. Since there is a sunk cost on the loan market, the choice of instrument on the

money market will influence the decision of banks to invest or not in the sunk cost. Hence, the participation of banks on the money market (and so central bank's profit) is determined by instruments' choice.

The central bank can either run a restrictive policy (some banks might not receive as much credit as they wish from the central bank) or an expansive policy (the central bank will always meet the demand of the banks).

Two very different cases must be considered for the choice of the nature (that is whether it is expansive or restrictive) of monetary policy. The first case is when the nature of monetary policy is not determined within the model by the interactions between banks and the central bank but by an exogenous rule. The opposite case corresponds to when the central bank chooses the nature of the policy in function of these interactions. In the first case the nature of the policy is thus *exogenous* to the model. Monetary policy is determined by a rule (interest rate rule, money targeting, GDP targeting etc.) that does not care about the banking sector. In the second case, the policy is *endogenous* to the interaction central bank/banks. That is the decision to run a restrictive or an expansive policy is determined by the expected banks demand for central banks' credit and by the quality of the bank's bills (loans). It corresponds to the *real bills doctrine*.

Note that Gilbert and Klemperer (2000)'s model would only correspond to a restrictive policy with a capacity constraint (i.e the nature of the policy is determined exogenously).

Throughout the model, the assumption is made that credit equals money. That is a loan/credit from a bank to a firm is pure money creation because it will be refinanced by the central bank.

I first describe the relationships between banks and firms. Second, the nature and the role of the central bank is explained. Finally, the equilibrium shows under which condition it is more profitable for the central to use quantitative tools.

2.1 The banks

Banks lend to firms. Before granting credit to a firm, they need to invest a sunk cost to obtain information on the borrower. This sunk cost that banks incur to provide ex-ante information about customers is a typical source of banking relationship as documented notably by Rajan and Petersen (1995) or Gehrig (2000). It is a way to model the importance of asymmetries of information on the loan market.

When the investment in the sunk cost proves to be successful the bank can lend to the firm. Once the decision to lend to a firm has been made, then the bank can rediscount its bill at the central bank, or ask the central bank for a direct loan/facilities to be able to finance this credit.

Once a bank has invested in information search, its decision to lend to the firm is thus affected by the success or failure of the sunk investment, by the price of discount at the central bank and by its valuation for rediscounting.

There are two types of banks characterized by distinct valuation v_L and v_H of discounting at the central bank. These two types capture the fact that the need for rediscounting varies among banks. While during times of expansive monetary policy, the two types will decide to discount bills at the central banks, only the v_H type will still ask for rediscounting when the central bank charges a higher interest rate.

A bank can have a low valuation for rediscounting for many reasons, including the fact that even a success sunk investment can lead to default with a non zero probability. The low valuation for rediscounting can be another proxy for rigidities on the credit market : for the banks with a low valuation for rediscounting, the discount rate may be too high (see case B, section 3.1.1).

Note that the two types of banks can be alternatively considered as two types of projects. Then the banks can be involved in two types of projects at the same time. Some of these projects lead to a lower valuation of one unit of central bank's credit. As stated earlier, there are many interpretation of this low valuation but

it is sufficient for the model that there exists a 'marginal consumer' or a 'marginal project' that expects a lower surplus.

The distinct probabilities of the success of investment in the sunk cost for each type of banks are r_H and r_L respectively . A probability q_{HL} denotes the case when both investment are successful conditional on both types of banks choosing to invest. q_j is then the probability that only one type of bank has succeeded in its investment. As in Gilbert and Klemperer (2000), we assume for simplicity that investment successes are uncorrelated, so $q_j = r_j(1 - r_k), j \neq k$, and $q_{HL} = r_H \cdot r_L$. We thus have $r_L = q_L + q_{LH}$ and $r_H = q_H + q_{LH}$

We assume that, the valuation is positively correlated to the probabilities r and q , such that $v_L < v_H, r_L < r_H, q_L < q_H$.

An interpretation of this assumption could be the following : the projects for which a sunk investment is less likely to succeed are also the riskier projects. Hence a risk averse or risk neutral banker could have less valuation to carry on this kind of project. In other words, if a bank had to choose whether to discount bills to finance project H or project L, it would choose the first one because it gives a more secure return. The only assumption is that a higher probability in the success of the sunk cost investment is positively correlated with a higher valuation for rediscounting at the central bank.

Note that the relationship between banks and firms is modeled in a very simplified way only through the probability of success of an investment in a sunk cost. Hence, there is no explicit screening contract and the model does not explicitly distinguish between several types of firms. This set up has the advantage of being very general : it does not assume that the banks are able to set optimal contract to distinguish between firms types.

2.2 The central bank

In this model, the central bank has a monopoly on the money market. Banks rediscount their assets at the central bank rather than trading on the money mar-

ket.

In this model, the central bank is then a seller of discount while the banks are customers. The central bank cannot distinguish between two types of banks that have different valuation for discounting at the central bank.

If the central bank had perfect information about the valuation for rediscounting of each bank, then it can change the bank-by-bank discount ceilings by different amounts. It corresponds to a selective credit policy (Stein, 2011, reaches a similar conclusion). In this case, like any benevolent planner with perfect information, the central bank could design the allocation of rediscounting in the same way as a decentralized perfect market without informational problem. In history, central banks attempted to follow such a way for certain banks or sectors. The dilemma between quantities and prices does not apply to subsidized credit which was clearly inelastic to prices. Nevertheless, in a dirigist economy where economic freedom coincides with state intervention and where the planner information is imperfect, then this selective policy is not possible for all the banks and sectors. The following model abstracts from a perfect information case but do not reject the existence of selective credit and bank specific discount rates or discount ceilings¹.

The fact that the central bank maximizes its profit might seem surprising. One justification is to account for the fact that most central banks were private institutions making profits until WWII and that, since then, they still do make profits that they give to the government. A more important justification works as follows : when the central bank had to run a restrictive monetary policy in this model, the maximization of its profit guarantees that it will offer the larger quantity of credit in the economy (granted to banks, and then firms) given the objective of monetary policy. The maximization of central banks's profit is thus a way to model the inflation-output tradeoff: under the constraint of a monetary or an inflation target, the central bank is trying to maximize the amount of credit in the economy and then the total output. On the other hand, when the nature of monetary policy is *endogenous*, the profit maximization of the central bank is

¹However, even when central banks used bank by bank ceilings, they usually increased these ceilings by the same amount during credit restrictions.

not constrained by any rule. It corresponds to the view that a bond that does not increase central bank's profit is not 'good enough' and is thus inflationary (real bills doctrine).

2.3 Timing

The timing of the model is as follows :

1. The central bank announces the nature of the policy (expansive or restrictive) and its pricing policy. That is the result of the choice between rationing or market clearing prices is common knowledge before banks invest in sunk costs.
2. The banks invest in sunk costs to obtain information about the firms which are asking for credit.
3. The sunk investment is successful or not with probability r . If it fails, the banks decide not to lend to the firm. If it succeeds, the bank is ready to lend for a specific project. To ensure that they can lend, the banks must be sure that they are able to rediscount the bills at the central bank. Thus, they make the success of their sunk cost investment common knowledge. But there is no commitment to purchase : if the price is too high, then the bank will not lend and will not rediscount at the central bank.
4. The central bank observes the total demand in the economy for a unit of discount and announces the interest rates. But the central bank does not distinguish between two types of projects (i.e the valuations v_H and v_L). Banks choose whether to purchase or not.
5. When they learn the interest rate, banks know whether they will discount or not at the central bank. They then lend or not to the firms for the specific project. If they have committed, banks cannot cheat. That is they cannot get discount at the central bank and refuse to lend to the firm².

²This is guaranteed by the law and the procedure of discounting : a bank needs signatures of the parts to obtain rediscounting at the central bank.

3 The nature of monetary policy is exogenous

In this case, the amount of money/credit that the central bank is ready to provide to banks is fixed and determined exogenously by a monetary policy rule that does not take into account the banking sector. It corresponds to a wide range of central bank's policy: money targeting, fiscal theory of the price level, Taylor rule etc.

3.1 Restrictive monetary policy

Since the discount capacities of the central bank is fixed (there is a certain level above which the central bank considers that its policy would become too inflationary), monetary policy faces two possible cases : either the demand for discount is lower or equal to this upper bound, or the demand excess this limit. When the second case arises, the central bank faces a dilemma : is it better to raise interest rates and then select the customers that are the more willing to discount, or is it worth setting a lower interest rate and ration directly the demand for discount ? Table 1 and a simple example make this dilemma clear.

	Normal demand	Excess demand
Market clearing	P_N	P_E
Fixed rate and credit control	P_R	P_R and ration

Table 1: Restrictive monetary policy

Let's assume that v_L , that is the lowest valuation for one unit of credit, equals 3, and v_H equals 4. When sunk investment succeeds for only one type of projects, the demand does not excess supply and there is no need for a restrictive monetary policy. Since the central bank cannot distinguish between the two types, it must set the price not higher than the lower valuation. Let's say that the price when demand is normal is $P_N = 2$, then the central bank receives $\Pi_N = 2$. When there is excess demand, the central bank willing to maximize its profit (and then prevent the economy from inflation) will choose a price exceeding the low valuation, $P_E = 4$ and $\Pi_E = 4$. Given the characteristics of this economy (sunk cost,

monopoly power of the central bank), the dilemma is the following : is it possible to find a strategy with rationing and a price P_R such that $P_N < P_R < P_E$ and $\Pi_E < \Pi_R$? The answer will obviously depend on the values of the probabilities, the sunk cost and the valuation.

3.1.1 Equilibrium

The model is now solved following Gilbert and Klemperer (2000). They distinguish between the market clearing regime and the non market clearing regime with rationing.

Situation 1 : market clearing interest rates

We first derive the general formulation of the market clearing interest rates. In this case, the projects associated with a low valuation for rediscounting will not be carried on when there is excess demand for credit. Hence, credit for the project of type L is only successful when the sunk investment has not proven successful for the H type. The probability of this situation is q_L , and the commercial bank obtains the following profit $M = q_L(v_L - P_N) - s$. The condition for free entry leads to the expression of the price :

$$P_N = v_L - \frac{s}{q_L}$$

Note that if the interest rate set by the central bank exceed this value, M will equal $-s$, and there will be a non null probability of no transaction in the normal demand case.

When there is excess demand, the central bank will maximize its profit and then avoid inflationist pressures setting the highest interest rate the bank are willing to pay for high value projects : $P_E = v_H$ The central bank's profit in the market clearing case is then :

$$\Pi_{mc} = (q_L + q_H)(v_L - \frac{s}{q_L} + q_{HL}v_H)$$

From there, two subcases can occur :

- **case A.** The central bank set interest rates such that both types of bank invest. The profit Π_{mcA} of the central bank is thus as described above.
- **case B.** The central bank set interest rates such that only the high type will invest. In this case, the size of the projects is always smaller. The profit of the central bank is thus $\Pi_{mcB} = (q_H + q_{LH})v_H - s$.

A central bank that is willing to increase production or unemployment to its natural rate would probably not allow the first situation. Nevertheless, we cannot rule it out. The condition that distinguish these two subcases is the following :

Proposition 1. The central bank will induce both types of banks to invest if $\Pi_{mc} \geq r_H v_H - s = (q_H + q_{LH})v_H - s$, that is if $s \leq q_L [(q_L/q_H)v_L - (v_H - v_L)]$

This condition clearly points out that if s is sufficiently high, the low value type of projects will always be excluded from investment and discounting.

Situation 2 : credit rationing

When there is excess demand, the central bank can adopt another strategy and ration. Rationing means that excess demand will not be ruled out through a sufficient increase in interest rates but through a quantitative ceiling on credit for every bank. A central bank that does not want to discriminate will thus choose a limit on discount demand such that the quantity of discount will be equal among the two types of banks. The interest rate with rationing P_R will thus be lower than P_E . The low-value projects thus receive half a unit on average in the excess demand state and the bank surplus is then now

$$M = q_L(v_L - P_R) + q_L \left(\frac{1}{2}(v_L - P_R) \right) - s$$

Setting this equal to zero yields

$$P_N = v_L - \frac{s}{q_L + \frac{1}{2}q_{LH}}$$

The profit of the central bank with rationing is thus :

$$\Pi_R = (q_L + q_H + q_{HL}) \left[v_L - \frac{s}{q_L + \frac{1}{2}q_{LH}} \right]$$

To compare with the market clearing outcomes, we must again distinguish two cases.

Proposition 2.

In **case A**, the central bank will prefer credit rationing if and only if

$$q_{LH}(v_H - v_L) \leq \left(\frac{q_H}{q_L} - \frac{q_H + \frac{1}{2}q_{LH}}{q_L + \frac{1}{2}q_{LH}} \right) s$$

Proposition 3.

In **case B**, the central bank will prefer credit rationing if and only if

$$q_{HL}(v_H - v_L) \leq q_L v_L - q_H(v_H - v_L) - \left(\frac{q_H + \frac{1}{2}q_{LH}}{q_L + \frac{1}{2}q_{LH}} \right) s$$

Interpretations The *proposition 1* is more likely to be satisfied if s is lower, if $q_L \cdot v_L$ (the gross social value of low type investment) is higher, or $v_H - v_L$ (difference between both variation, i.e the cost of lowering price to High type) is lower. When does rationing arise? In both cases, rationing is preferred if the difference between the valuations is sufficiently small. The central bank would not accept rediscounting for extreme differences of valuation between banks (either speculation or too much risk).³

In *case A* (with both type of bankers investing), rationing is preferred if s is high. It is the contrary in *case B*, hence the importance of *proposition 1*. *case B* rationing arises when s is too high such that low type do not participate. In this case the possibility of rationing is inversely related to s . Then the kind of rationing in *case B* arises when the sunk cost is sufficiently large that *Proposition 1* fails (so that some banks would not participate with market clearing), but not so large that it is too costly to attract the marginal banker by using rationing. To put it in other

³note that it corresponds to the conclusion in Weitzman (1977) that rationing is more effective as needs for the deficit commodity are more uniform.

words, when s is very large, the economy will be in *case B* : whatever the choice of the central bank, some banks will be excluded from the market. Otherwise, the economy is in *case A*. In this case, the central bank will choose rationing when s is not too small. As a consequence, the equilibrium rationing regime can be seen as an intermediary regime. When s is very low, the loan market between firms and banks is almost perfect and the central bank has no interest to avoid market clearing (market clearing would not exclude many banks). When s is very high the central bank does not use quantity rationing because many banks are excluded from the market anyway. In this case, the loan market between banks and firms is so imperfect that the central bank has no power to extend the participation of banks.

A simple monetary policy rule can be induced from such a behavior. For a given money base, m , the central bank could either choose a market clearing rate \hat{i} or a lower rate i_R with rationing. These two solutions are equivalent for money management as soon as the conditions stated above hold. Hence, once having determined the optimal m , the bank can choose two equivalent rules : $\hat{i} = \nu(m)$ or $i_R = \mu(m)$, where the difference between μ and ν is determined by the influential parameters highlighted in proposition 2 and 3 : the sunk cost, the difference of valuations and the relative probability of success.

3.2 Expansive policy and quantitative easing

Up to now the model has been designed to focus on the case of a restrictive monetary policy, following the framework developed by Gilbert and Klemperer (2000). Nevertheless, it can be easily extended to an expansive policy.

An expansive policy is modeled as the central bank's decision to provide two units of credit. It means that when the sunk cost investment succeeds for both types, the central bank is ready to meet the demand for credit of both types (the 'normal' situation). On the contrary, when only one type's investment succeeds, there is an excess supply of credit. This policy is exactly the opposite of the one described in the previous section. In the restrictive policy case, the central

bank decides to supply one unit of credit. The 'normal' situation corresponds to the success of the sunk cost investment of one type only. When the two types demand for credit, there is excess demand. To put it in other words, when the banks demand 2 units of credit an expansive policy means that the central bank is ready to supply these 2 units of credit while a restrictive policy means that the central bank offers only one unit. While a restrictive policy produces a case when the demand of one type is not satisfied, an expansive policy may provide the case when the supply of the central bank is not satisfied. In this model an expansive monetary policy is thus interpreted as a commitment of the central bank to supply as much credit (to rediscount as much bills) as the commercial banks demand. In the case of a demand/supply of 2 units of credit, the market clears and the interest rates is at a lower level than in the restrictive policy case with market clearing. When only one type of banks have successful investment (the demand of credit is one unit), then the central bank has excess supply.

In an expansive policy, the low type will always receive credit as long as their sunk cost investment has been successful (i.e $r_L = q_L + q_{HL}$) The profit of a low type bank is $M = q_L(v_L - P_N) + q_{HL}(v_L - P_N) - s$. The condition for free entry leads to the expression of the price :

$$P_N = v_L - \frac{s}{q_L + q_{HL}}$$

The profit of the central banks is thus

$$\Pi = (q_L + q_H + 2.q_{HL}) \left[v_L - \frac{s}{q_L + q_{HL}} \right]$$

It is straightforward that if the central banks decides to use quantitative tools rather than the interest rates, it would give directly one unit of credit to each type of bank during the 'normal' situation at the higher cost that the marginal bank is ready to pay. The profit of the low type banks is then $M = q_L(v_L - P_N) + q_{HL}(v_L - P_N) - s$ and the other similar results follow. With an expansive policy, there is equivalence between quantity or prices.

A crucial assumption to this result is the fact that banks cannot receive more than one unit of credit, that is they cannot receive a quantity higher that what they

can pay (the quantity they are asking for).

The expansive policy case has thus as strong property: the price (interest rate) plays no role. Whatever the demand of banks for central bank's credit, the interest rate is at the same level (see Table 2). The dilemma prices vs. quantities is not relevant anymore for the central bank because the price is the same in the two states of nature. The adjustment is thus necessarily made by quantities on the money market.

In this case, the central bank cannot anymore choose instruments in order to maximize its profit. It is fully constrained by the rule (expansive monetary policy). This policy is always socially optimal because the two types of banks always invest but the central bank can suffer from a big loss. Policy with a zero lower bound interest rate is the extreme case of this policy: central bank's profit will be either null or negative to ensure full participation of banks.

The model offers a new interpretation of the policy with a zero lower bound interest rate. This kind of policy is just a particular case of any exogeneously determined expansive policy, that is when interest rate plays no role and the adjustment is made through quantities on the money market.

In times of crisis, when the central bank has a monopoly on banks refinancing, there is imperfect information on the loan market and an expansive policy is decided in order to provide credit to all the banks, then it is normal that the price is fixed and plays no role. The quantity signal is the main instrument of policy. From a theoretical point of view, it can happen for a positive interest rate as well as for negative interest rate.

	Excess supply (low demand)	Normal demand/supply
Market clearing	P_N	P_N
Fixed rate and credit control	P_N	P_N and ration

Table 2: Expansive monetary policy

A simple monetary policy rule can be induced from such a behavior. For a given interest rate, \bar{i} , the central bank adjusts its quantity of money depending on

banks' demand. Hence the bank can follow two different rules : $m = \nu \bar{i}$ or $m = \mu \bar{i}$.

4 Endogenous nature of monetary policy

Up to now, I have assumed that the quantity of credit that is to be offered to the banking system (that is the quantity of money creation) is not chosen endogenously by the central bank in function of the parameters of the model. Although this assumption is quite realistic because monetary policy rules usually does not take explicitly into account characteristics of the banking system as an objective, it leads to questionable consequences. The main one is that in an expansive policy, the central bank is not able to maximize its profit.

It is due to the fact that the central bank maintains both types on the market since it has two units of credit to offer. But this policy can be inefficient for the bank if the price that the marginal bank is ready to pay is very low. The central bank could obtain a higher benefit implementing a screening scheme that would select the high types, thus allowing the bank to charge a higher interest rate in the low and in the high demand case, that is to offer only one unit of credit in the two states: a restrictive policy.

Contrary to the previous section when the nature of monetary policy was exogenous, the central bank now chooses between restrictive or expansionary policy not because of countercycle policy but because of the quality of assets, that is whether it is more profitable for a central bank to promote safer investment (high types). This behavior corresponds to what has been called historically the *real bills doctrine*. The real bills doctrine goes back to Adam Smith (Perlman 1989) and had a great influence on monetary policy at least until the interwar period. It has been widely discredited then but some work has also rehabilitated it, showing how it can be an optimal policy (Sargent and Wallace 1982). According to the real bills doctrine, issuing money in exchange for real bills (i.e rediscounting) is not inflationary as long as the bills are goods (Laidler 1984, Perlman 1984). Contrary to the quantity theory of money, there is no direct link between the quantity of money in circulation and the price level. The value of money is determined by its

asset backing value. Hence, in the real bills doctrine, the nature of the policy of the central bank does not depend on an exogenous rule (money targeting, interest rate rule) but on the demand of banks for rediscounting. The role of the central is to discount the good bills, that is those that will lead to a real transaction.

At a first sight, another version of the real bills doctrine in this model would be to make central banks' supply of credit totally contingent on demand : one unit in the low state and two units in the high state. But since the banks cannot distinguish between types, this version is equivalent to the expansive policy described in the previous section for the profit of the central banks. Then for the real bills doctrine to be efficient when the central banks does not the type of the banks, screening through prices is the only method.

When the nature of monetary policy is endogenously determined, the central thus chooses between an expansive or a restrictive policy depending on its profit in this two situations. The restrictive policy is thus interpreted as a screening device to maintain low type banks outside of the market. A motivation behind this behavior is to discount only good bills and then to avoid an inflationary policy. The relative quality of the bills (difference between the v and r of both types) will thus be the crucial parameter.

I obtain the following condition:

Proposition 4 :

Screening (i.e restrictive policy) is preferred if

$$(q_L + q_H)(v_H) - s > (q_L + q_H + 2 \cdot q_{HL}) \left[v_L - \frac{s}{q_L + q_{LH}} \right]$$

The left hand side is derived as follows : the profit of the high type when the central bank charges a price higher than v_L would be $M = q_H(v_H - P_H) + q_{HL}(v_H - P_H) - s$, the interest rate is then $P_H = v_H - \frac{s}{q_H + q_{HL}}$. The profit of the central banks follows :

$$(q_H + q_{HL})(v_H) - s.$$

The right hand side was derived in the previous section.

The screening condition can be rewritten as

$$r_H v_H > (r_L + r_H) v_L - \frac{r_H}{r_L} s$$

The higher s is, the higher is r_H compared to r_L and the higher is the difference is the difference between v_H and v_L , then the higher is the probability that screening is preferred. These conditions are similar to the ones derived for *assumption 1* in the previous section. This condition holds for the values $r_H = 2/3$, $r_L = 1/3$, $v_H = 3$, $v_L = 2$ and $s = 1$ but does not hold, for example, for the following values $r_H = 2/3$, $r_L = 1/3$, $v_H = 3$, $v_L = 5/2$ $s = 1$ or $r_H = 3/5$, $r_L = 1/2$, $v_H = 3$, $v_L = 5/2$ and $s = 1$. When screening is preferred, interest are higher and the actual policy is restrictive. This simple result is relevant for policy analysis: a central bank that wishes to run an expansive policy can preferred to mitigate this expansion when there are some benefits to screen between banks. In particular when s is so high that the low type bank is always unprofitable ($s > r_L v_L$), then the central banks has always some interest to screen and run a restrictive policy. Note that $s > r_L v_L$ is equivalent to $P_N < 0$, that is a negative real interest rate (the zero lower bound).

$$r_H v_H > (r_L + r_H) v_L - \frac{r_H}{r_L} s$$

$$\frac{r_H}{r_L} s > (r_L + r_H) v_L - r_H v_H$$

$$\frac{r_H}{r_L} s > \frac{r_H}{r_L} r_L v_L > (r_L + r_H) v_L - r_H v_H$$

$$v_H > r_L v_L$$

This condition is always verified.

Regarding the quantities vs prices dilemma, it is important to note that the screening policy uses interest rates and not quantities. When the value of s and v is such that the central bank profit is lower when screening with a high interest rate, the central bank does not have to use quantity rationing. Instead it will run an expansive monetary.

5 Summary of the results

The following table sums up the results of the model and the different cases. It shows that interest rates play a role in only few cases. Quantitative rationing and quantitative adjustments, both with fixed interest rates, are common tools of monetary policy in an imperfect information context when the central bank has a monopoly power on banks' refinancing. The sunk cost s stands for the asymmetry of information on the loan market while the difference of valuations $v_H - v_L$ stands for the asymmetry of information on the money market (because the central bank cannot distinguish the two types).

Exogenous rule

- *Restrictive policy.*
 - Policy with a market clearing interest rate.
When s is very high: low type banks are excluded from the market anyway and do not participate.
When s is very low: markets are almost perfect and banks participate whatever is the price.
 - Policy with quantity rationing and a non-market clearing interest rate.
Intermediary values of s and the difference $v_H - v_L$ sufficiently small.
- *Expansive policy.*
 - Fixed interest rate with quantitative adjustments.

Endogenous rule

- *Restrictive policy.*

Policy with a market clearing interest rate. When s and the difference $v_H - v_L$ are very high. It is beneficial for the central bank to charge a high interest rate and exclude low types.

- *Expansive policy.*

When s and the difference $v_H - v_L$ are very low. The interest rate is chosen to attract both types and quantity adjusts depending on demand.

6 Second-best equilibrium and rents

One main characteristic of a second-best equilibrium is that in an economy with some market failures in one sector, actions to correct market failures in another related sector cannot increase the overall efficiency ; it may create a new inefficiency in the other sector(Lipsey and Lancaster 1956). The model presented in this article features this property. The sunk cost on the loan market creates a market inefficiency. Monetary policy with quantitative instruments (with a non clearing market interest rate) solves this inefficiency in mitigating the adverse effect of this cost on banks' participation in the loan and money markets. But such a policy immediately creates another inefficiency since the high types banks are now able to refinance themselves at an interest rate that is lower than the interest rate that they would accept. There is thus a surplus for the high type banks that we can call a rent. Compared to a market clearing case, a quantitative monetary policy always has the same consequences: the low bank types have access to the money market and the high type banks have access to the money market at a lower interest rate (and then obtain a surplus). The important result is that it arises both during a restrictive and an expansive monetary policy. Rents do not need an expansive policy to exist. When the central bank runs a monetary policy using the interest rate at a screening device, these rents disappear but there is a social cost (lower participation) that can also be a private cost for the central bank (lower profit). This model thus highlights that the choice of instruments (as a second best equilibrium) has strong consequences in terms of political economy. Rents creation is indeed a well known feature of monetary policy with quantitative tools (Hodgman 1973, Monnet 2011). But the model also suggest that an interest rate policy in imperfect financial economy also creates a rent for the high type banks.

7 Conclusion

This paper presents a model explaining the choice of direct quantitative rationing by central banks. The main insight of this model is to incorporate the strategic interactions between banks and the central bank. When there are asymmetries of information on the loan market between banks and firms, the central banks may have some incentives to ration credit to banks on the money market. There is not anymore market clearing on this second market. Such a mechanism aims to exclude less banks from the market during episodes of monetary restrictions. Using quantitative rationing thus enables the central banks to increase firms access to banking loans compared to a regime with market clearing interest rates. During a restrictive policy, a quantitative rationing policy can maximize the profit of the central bank because it attracts more banks on the money market and then increase the number of loans in the economy. In an expansive policy, there is no dilemma anymore because interest rates does not play any role. The adjustment on the money market and the signal effect work through quantities. The zero lower bound interest rate situation is only one particular case. But an expansive monetary policy may lower the profit of the central bank. While an expansive policy would be socially optimal, the central bank could have interest to use interest rates as a screening device and then increase this profit. This tradeoff illustrates the difference between a countercycle policy that would follow an interest rate or a monetary rule and the real bills doctrine that set monetary policy in function of banks demand for credit. An essential element of the real bill doctrine is to use a screening device in order to ensure the quality of the bills which are rediscounted. The model also clearly shows that in this second best world, every choice always create a rent for at least one type of agent.

In a second best world, the choice between quantities and prices is thus not trivial for a central bank. Contrary to the Poole model (1970), this result does not rely on the presence of stochastic disturbances but on the structure of the banking system and the interactions between banks and the central bank. The model also states clearly that the choice of quantitative rationing needs two crucial hypothesis : the central banks has a monopoly on banks refinancing, and the relationships between

banks and firms faces informational imperfections.

This model thus explains why central banks in emerging countries still use many direct quantitative instrument. It also accounts for the common use of these instruments in Europe under the Bretton Woods system before financial liberalization (Hodgman 1970, 1973) or quantitative credit policy with interest rates regulation (such as regulation Q in the USA).

Finally, it may also provide a framework to understand the choice of quantitative easing by central banks during the recent crisis. During the crisis, the money market is not liquid, the central banks lend directly to the banks and informational imperfections increase. This situation is very similar to the framework of this paper. If the situation were to remain, quantitative rationing instruments could also be effective to move out from quantitative easing to restrictive monetary policy. On the other hand, the model also shows that an expansive quantitative policy may be harmful because the central bank has to accept low quality loans.

This model tries to clarify conceptual issues about the choice of instruments as well as some political economy consequences of second best equilibria between banks and the central bank. But it has many limitations. The framework is limited to the case of a monopoly of the central bank on the money market. As already stated, it may be relevant for closed economies or economies with low financial development or desintermediation, and in times of crisis (lender of last resort situation). But further work must be devoted to extend the model to other situations. Finally this model is still a partial equilibrium model. In most of the model, I have assumed that the nature of the policy (expansive or restrictive) is determined exogenously. It focused in the strategic interactions between the central bank and the banks - which is missing in most macro models- but it says nothing about the interactions between the banking sector and other sector. Macroeconomic models with non market clearing markets (Greenwald and Stiglitz 1992, Bénassy 1993) may include the kind of central bank's behavior presented in this paper.

But thanks to its limitations and its narrow focus, the model has very clear empirical prediction: the state of financial development and the kind of interactions

between banks and central bank determine the instruments of monetary policy. Every episode of low and stable interest rates with many quantitative operations or controls from the central bank may correspond to the framework described in this article. Further work would be devoted to test whether there are verified and in what extent they can explain the historical evolution of central bank's instruments.

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