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Macroeconomic Implications of Gold Reserve Policy of the Bank of England during the Eighteenth Century*

Elisa Newby†
University of St Andrews

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Preliminary, comments welcome

ABSTRACT

By imposing a simple adjustment cost on gold purchases the Bank of England was able to manage external drains of monetary gold while maintaining the convertibility of pound during the eighteenth century. This was a period during which constant political disturbances and external shocks on the market price of gold made monetary policy a challenging task. The implications of adjustment cost were not just limited to the gold reserves of the Bank, but stabilised consumption and the price level.

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† Centre for Dynamic Macroeconomic Analysis, School of Economics and Finance, Castlecliffe, The Scores, St Andrews, Fife KY16 9AL, Scotland, UK. Tel +44 (0) 1334 462445. E-mail: emsn@st-andrews.ac.uk.

1 Introduction

The threat of Stuart restoration during the Jacobite rebellions in the first half of the eighteenth century did not only cause a dynastic crisis, but also resulted financial caos in London. This panic manifested itself in regular runs on the Bank of England of 'alarming dimensions'.[1] The Bank's customers took their convertible deposit notes to the Bank in order to convert them to gold specie. As the Bank was in danger of running out of gold, it employed a delay strategy to slow down the gold flow. The Bank paid out specie in tiny six-pence pieces, which took so long to count that time was gained for the panic to ease and gold demand to reduce to the normal level. The method of paying gold in small pieces placed, in practice, an adjustment cost on gold purchases.

This example raises the question of why the Bank of England, the most powerful monetary institution of the country, was forced to use such an unconventional method to secure its gold reserves. The answer lies both on the importance of the gold convertibility rule, which had become the essential part of the monetary policy, and on those difficulties the Bank had to deal with in order to maintain the rule. The eighteenth century was an era of constant wars and domestic political disturbances, and demand for gold was at its highest during the time of crisis. As both historical and theoretical analysis shows, it was not the automatic operations of the gold standard rule, but rather these unconventional practices that evolved over the time, which had a crucial role in implementing the monetary policy.

Emergence of the gold convertibility as a core monetary policy rule was neither an accident nor a plan, but an outcome of institutional development. According to Fetter (1965) the Bank of England was not established in 1694 to perform central banking functions any more than the goldsmiths.[2] Together with the Royal Mint the Bank of England controlled minting of silver and gold specie, but was not able to regulate printing of paper money or various forms of credit currency. Already by the beginning of the eighteenth century paper forms of money – private banks' notes and

[1] Acres (1931) Vol I, p 107.

[2] Fetter (1965) p. 23.

bills of exchanges – exceeded specie money.[3] Despite its lack of control the Bank of England was able to maintain the gold convertibility of the pound with fairly low bullion levels even during wars and domestic crises, which could have potentially caused heavy external drains.

Apart from the gold convertibility rule the eighteenth century was an era when there was no generally accepted theory or practice of money or banking in place.[4] Monetary and fiscal institutions such as Bank of England, Royal Mint and Treasury existed, but their policies were often inconsistent and the laws concerning these institutions or their activities were inadequate and contradictory. Nevertheless, the main principle of a commodity standard, the obligation of the monetary authority to sell gold at the fixed money price, was firmly in place: England had been on the commodity money system from medieval times and on *de facto* gold standard from 1717 onwards, when Isaac Newton, the Master of the Royal Mint, fixed the parity between gold and silver so that silver was slightly over valued in relation to gold.

Monetary policy during the Pre-classical Gold Standard, which prevailed in England from 1717 to 1797, has not been analysed theoretically before. Although the heyday of the Classical Gold Standard lasted only for 35 years, between 1880 and 1914, it has received much more attention. Being a period of relative domestic stability and peace the era of the Classical Gold Standard presents a stark contrast to the turmoil of the eighteenth century. The gold standard functioned as an international rule: North America, Germany and France, the main trade partners of Great Britain, participated in the gold standard system, and even the smaller European nations were joining in. The business of printing paper money was now a strict monopoly of the Central Bank, and in absence of the usury laws, which set the maximum legal rate of interest at five percent, the gold stock of the central bank could have been protected indirectly through interest rate policy.

Bordo and Kydland (1995) argue that the gold standard was intended as a contingent rule: during a war or other emergency the government could challenge the rule by

[3]Davies (1776) p.278.

[4]This is a one of the main themes in Fetter (1965).

temporarily suspending the commodity standard on the understanding that the convertibility would be restored at the original parity after the emergency had passed.[5] The convertibility in the eighteenth century was not, however, suspended until 1797, thus England fought three wars[6] staying on the gold standard. In this paper I argue that the gold standard in the eighteenth century functioned as a contingent rule, but in a different manner than during the Classical Gold Standard. The Bank did not suspend the cash payments; instead it imposed an adjustment cost to notes-to-gold conversion in order to reduce the outflow of gold. Through the lens of a dynamic stochastic general equilibrium model I analyse the effects of the adjustment cost, which were not limited solely to the gold reserve policy, but had an effect on the economy as whole by stabilising the gold demand, consumption and the price level.

This paper is arranged as follows: Section two analyses the Bank of England's ability to control the money supply and its gold reserves, and the institutional development of which outcome was the emergence of the gold convertibility as the most important monetary policy rule. Section three explains in detail how the Bank was able to use the adjustment cost strategy in conducting monetary policy during the eighteenth century. Section four analyses wider implications of this adjustment cost in a dynamic stochastic general equilibrium framework. Section five summarises the results.

2 The Gold Convertibility Rule and Central Banking in the Eighteenth Century

2.1 Emergence of the Gold Convertibility as a Core Monetary Policy Rule

The establishment of the Bank of England in 1694 as a private joint stock bank that was in charge of public finance, was the most successful out of the hundreds of financial

[5] Bordo and Kydland (1995).

[6] The War of the Spanish Succession (1701-1714), The Seven Years' War (1756–1763) and the American War of Independence (1775–1783). The French Revolutionary Wars started at 1793.

experiments of the late seventeenth century. The Bank was born, 'out of the marriage of convenience' between the business community of the City and the government of the day:[7] the merchants were motivated by profit opportunities and the government needed cash to pay its war expenditures. Establishment of a credit institution, which was under direct control of Parliament, gradually ended the dominance of the goldsmiths over the credit market, whose business practices had largely been unregulated.[8] Parliament's priority was to find ways to limit the power of the King and government over the Bank in lending. The Bank had to instantly stop payment 'if it had ceased to receive the interest on the sum which it had advanced to the government'[9] and the Bank was not allowed to lend to the government without the explicit consent of Parliament.

Another novel aspect on its operations was that the Bank of England managed its own specie and bullion reserves, which enabled it to issue notes payable on demand.[10] This had been impossible for previous monarchs, who had no reserves of any kind; for example Charles II's orders were payable only with eighteen months delay.[11] Although the first balance sheet of the Bank shows that its gold reserves were low compared to its liabilities and its assets mainly consisted of government paper, the merchants accepted the notes at par in payments very soon after its establishment. The confidence of merchants was the most important determinant of the Bank's strength.[12]

The Bank of England was not the first public institution, which had issued fiduciary currency, but the first one to be able to issue it in a sustainable manner and learn from its own mistakes. The first lesson in the management of public finance and convertibility came already in 1696. Charles II had started to issue tallies, wooden sticks that had previously been used as evidence of tax payments, to persons who made either advances or gave supplies to the king, promising to redeem them later with interest.[13] Tallies were issued to such an extent that even thought the interest rate on them was

[7] Davies (1776) p. 256.
[8] Vilar (1976) p. 213.
[9] North and Weingast (1989) p. 821.
[10] Feavearyear (1963) p. 127.
[11] Feavearyear (1963) pp. 126-127.
[12] Vilar (1976) p. 281.
[13] Feavearyear (1963) p. 110.

increased, no more could be placed. At the date of the Bank's foundation the value of tallies outstanding was around £5,000,000 and they were accepted in the City only at a considerable discount of 25 or 30 percent.[14] The Bank, however, in addition to deposits and interest bearing notes, had a right to raise working capital through discounting the bills of exchange, which tallies practically were. The acceptance of tallies at the Bank had two immediate effects: the value of these wooden sticks rose to par, and satisfied government was again able to issue them, using the income to pay the suppliers of the army.

The tallies resulted in a credit expansion accompanied by a fever of gambling in the stock market, increased gold and silver prices and depreciated the currency. The price of silver and commodities increased about 25 percent but the price of gold and the gold guineas went up about 40 percent. The circulating coins became badly clipped: during the recoinage between 1695 and 1696 £4,700,000 worth of clipped coins brought to the Royal Mint contained only £2,700,000 worth of silver.[15]

After the first credit expansion the special position of the Bank of England, as a banker to government and as a London note issuer, was gradually recognised. The purpose of the Bank was not to absorb as much government debt as possible, as this would not have been a sustainable strategy – the Bank's purpose was to make the government debt an attractive investment option. In order to attract the public to buy government paper, the value of money had to stay stable and the public's confidence towards the monetary system strong. Maintaining gold convertibility became the main way to gain trust and stability. The long term national debt was not created by the Bank of England's direct purchases, but through the issue of bills and bonds which were traded on the London Stock Exchange. At the same time that the national debt was born, paper money came into existence, as people gradually realised that the money could take other forms than just specie with intrinsic value.

[14] Feavearyear (1963) p.127.

[15] Feavearyear (1963) p. 141.

2.2 Control of the Bank of England over the Money Supply

The supply of Bank of England notes alone could not satisfy the demand for capital during the Industrial Revolution. The growth of the country banks, especially after 1750, increased regional money supply. The English banking system developed as a three layered pyramid as seen in Figure 1, consisting of the Bank of England, the rest of the London private banks and the country banks.[16] By the second half of the eighteenth century the Bank of England notes had become the main currency used in large payments in London. London private banks gradually ceased to issue notes because they could not compete with the interest rate the Bank of England paid.[17] Bank of England notes rarely circulated outside the London area where the country bank notes were the main medium of exchange. The system resembled the gold exchange standard of the twentieth century: the private bank notes were convertible to the Bank of England notes, which in turn were convertible to gold on demand. As seen in Figure 2, the gold backing of the Bank notes was far from perfect.

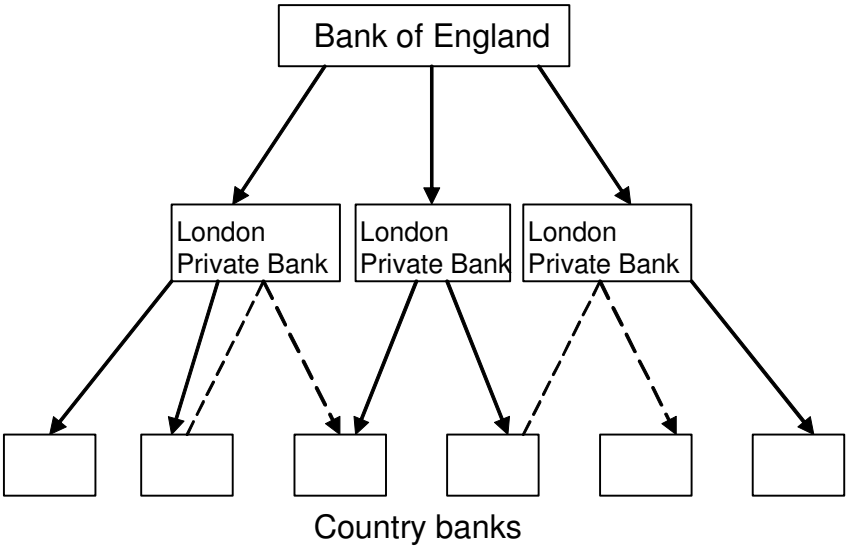

Figure 1: Credit Pyrdamid in the Eighteenth Century

Many of the London bankers kept their reserves in the Bank notes or towards the

[16] Fetter (1965) Pressnell (1956) pp.75-76.

[17] Pressnell (1956)

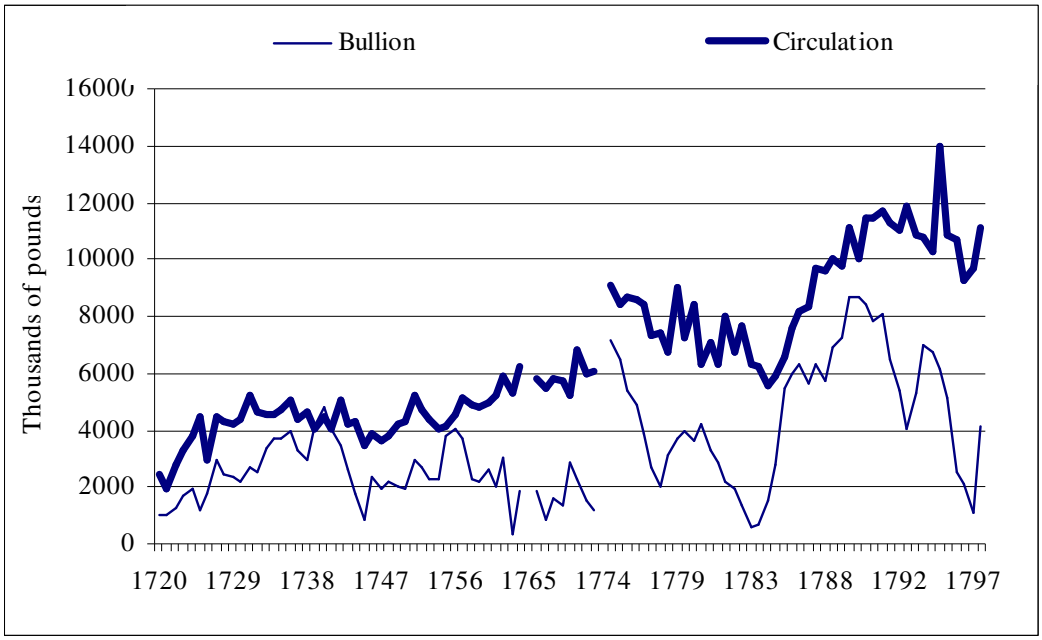

Figure 2: The Circulation of the Bank of England Notes and Bullion Reserves, annually 1720-1797. Clapham (1944) , Appendix C, pp. 295-296.

end of the eighteenth century, kept accounts in the Bank. They had, therefore, direct access to the Bank of England's notes and bullion. The London private banks integrated small country bank units by supplying links between country banks in agricultural areas, which had excess capital for lending and the industrial areas, which had excess demand for capital.

The passing of the Bubble act in 1708 limited the maximum partners of banks in England and Wales to six and gave the Bank of England a monopoly in joint stock banking. The capital of any other bank was therefore limited to what could be provided by up to 6 partners, which meant that English banks were severely undercapitalised.[18] The number of the country banks grew hand in hand with the Industrial Revolution. The growth was, however, uneven, as it was phenomenal for the country banks that their numbers would have been brought down by a crisis and the note circulation down by third or by half, but one or two years after each crisis both their number and note issue was again greater than ever. In 1750 there were twelve country banks outside

[18]Dowd (1989) p. 118 .

London but in 1793, there were nearly 400.[19] The number of London private banks almost doubled in the second half of the eighteenth century. Data on the circulation of country bank notes is not available until 1804 and onwards when the law required stamp duties to be paid on private notes. The value of all notes stamped in 1805 was £10,700,000 thus the private bank notes consisted of almost 40 percent of the total paper money in circulation.[20]

The Bank of England's control over the country banks was not obvious as they did not keep substantial amounts of reserve in the Bank notes or gold, but in deposits with London private banks.[21] Therefore, the main influence of the Bank over the country banks was through the London money market. According to Pressnell (1956) to some extent the Bank functioned as a lender of a last resort: 'when money was scarce country banks in general turned to London much as London firms turned to the Bank of England as the lender of last resort'.[22] If there was small urgent need for money, the coin was still the only form of money available as small notes were illegal in England and Wales. The country banks then drew down their gold deposits from London and London banks drew cash from their accounts with the Bank.

It was widely believed at the time that the instability of English banks was not due to their undercapitalisation and money supply, but to their freedom to set their own terms of redemption and issue small notes.[23] As silver and small coins were rare, notes with face value of six pence became acceptable. Therefore, controlling the value of the money through limiting the money supply stayed in the back ground. In 1775 Parliament forbade English banks from issuing notes of less than £1 in order to protect the public, especially illiterate poor people, who commonly used the small notes. Two years later Parliament passed further laws reducing the negotiability of paper money and specifying some security measures, such as signatures and dates, on notes.

Until the Suspension Period there were no organised discussion about the relation

[19] eavearyear, Clapham and Pressnell all accept the view that i

[20] Pressnell (1956) p. 188.

[21] Pressnell (1956) p.76.

[22] Pressnell (1956) p. 76.

[23] Dowd (1989) p. 118.

of the credit of the private banks to the total money supply or of the potential problems resulting from the fast growth of the country banks. The banking problems stayed in the background of the political agenda as more acute questions such as parliamentary reform, the American War of Independence and the French Revolution dominated the discussion.[24] It is possible that the country banks' credit issue did not bother decision makers because it did not create major inflation. Between 1790 and 1793 the canal mania had increased the credit demand for investments, which were slow to yield return. The outbreak of the French Revolutionary war in 1793 was followed by deep financial crisis in England, but the war really just accelerated the crisis, which was the result of the situation before the war, namely the credit structure of the private banks.[25] The Bank of England, sometimes with the help of the Treasury, was able to maintain the gold convertibility four further years, but in February 1797 the Bank ceased the gold payments altogther to protect its reserves and maintain its notes in circulation.

3 Strategies to Secure Convertibility during the Pre-classical Gold Standard

3.1 Arbitrage Profits

Any kind of commodity standard has to deal with the dilemma of arbitrage profits, which arises when the market price of the commodity backing the currency increases above the mint or monetary price, the price the individual has to pay to purchase the commodity from the central bank. For example, if the monetary price of gold were below the market price, gold could be purchased from the central bank and sold at a higher price in the private market. The arbitrage profit is the difference between the monetary and the market price of gold.

The theory of the Classical Gold Standard rules out these arbitrage profit opportunities by the automatic price adjustment mechanism. The circulating money stock

[24] Fetter (1965) p. 11.

[25] Pressnell (1956) p. 457.

has to decrease when people buy gold from the central bank and as a result the market price level of all commodities, including gold, falls until the original rise in the market price of gold is matched. The arbitrage automatically keeps the market price of gold equal to the mint price of gold. Under the international gold standard, disturbances in the price level in one country were wholly offset by an automatic balance-of-payments adjustment mechanism, which involved shipping of gold from one country to another. This and other automatic operations of the gold standard have been the focus of much economic research.[26]

The price adjustment mechanism, however, did not work to the same extent during the Pre-classical Gold Standard as the gold standard did not yet operate as an international rule. Regular wars and revolutions in European countries caused political disturbances and commercial distress such as trade blockades. The law, which made the export of British bullion and specie abroad illegal, was supposed to prevent the flow of gold from Britain. But as the law was difficult to implement, it did not have much effect. According to Fetter (1965) there was a general acceptance by the bankers and merchants of London of the idea that in practice British monetary gold was withdrawn from the Bank and smuggled to the continent when the exchanges were unfavorable and the price of gold abroad was higher than at home.[27] Disruptions in gold supply and shipping conditions, especially during warfare on the sea, made the gold convertibility rule a challenging task to follow. Bank runs and financial panics were relatively common and demand for gold was at its highest during political disruption. If there were simultaneous gold supply blockades, the Bank of England was in danger of exhausting its gold reserves.

Another motivation for the Bank of England to restrict the outflow of monetary gold was to avoid the Bank making a loss on gold trade. Between 1774 and 1797 the average price of standard gold bullion had been £3. 17s. $7\frac{3}{4}$d.[28] As the mint price of gold was £3. 17s. $10\frac{1}{2}$d., the average market price was just 0.003 percent below the mint price. If the market price of gold was high and the Bank was forced to buy gold,

[26] Some of the most recent studies include Barro (1979) and Goodfriend (1988).

[27] Fetter (1965) pp. 4-6.

[28] Clapham (1944) Vol I, p. 8.

it made a loss, as gold had to be sold out at a fixed price. The Bank was an active gold trader and it employed its own gold dealers.[29] As the Bank had to exchange gold for its notes, buying gold did not increase the gold backing rate significantly, but helped to satisfy the gold demand in the short run.

3.2 Methods to Reduce Outflow of Monetary Gold

When monetary gold was withdrawn faster than it came in, the Bank of England had a number of strategies it used to reduce the outflow of the gold. For example the Bank offered to change its ordinary deposit notes to interest bearing notes or some other form of paper currency. In May 1696 the Governor of the Bank announced that government tallies would be given to any person 'under any uneasiness for want of his mony'[30] and people were invited to exchange their notes to sealed bills, which bore interest.[31] The same strategy was used again during the crisis following the South Sea Bubble in 1721.[32] As the lack of, and therefore the demand for, small change was chronic at the eighteenth century, the Bank persuaded the public to convert their large notes to the same amount of new notes which had smaller face value.

Various delay strategies were common too. In 1696 the Bank committed to pay all notes of £5 and under in full only alphabetically:

> beginning upon Wednesday the 28th day of October instant with Notes payable to names of A and B, and so on Wednesday of every week two letters through the alphabet.[33]

Another delay strategy was to pay demands for cash in shillings and six-pences. The process of counting the small gold coin caused considerable delay, and time was thereby gained during the worst periods of the crises.

[29] Clapham (1944), Vol I, p.132.
[30] Acres (1931) Vol I, p. 70.
[31] Clapham (1944) Vol I, p. 42.
[32] Acres (1931) p. 117.
[33] Acres (1931) pp. 73-74, as quoted in London Gazette, 26 November 1696.

The Bank adopted the delay strategy from the goldsmiths who had monopolised the banking business until the establishment of the Bank of England in 1694[34]. Even at the end of the eighteenth century only relatively wealthy individuals had accounts at the Bank, and ordinary people, the most likely to rush to save their small savings, deposited their valuables with the goldsmiths. The goldsmiths, who had to face the first wave of the cash runs, began to delay payments during the panic caused by the second Anglo-Dutch war in 1667, when the Dutch fleet was in the Thames and threatened to attack London. They and some other City business men considered the Bank of England as their competitor.[35] The leading goldsmiths remained hostile towards the Bank and could demand 'immediate payment in cash at a time when the knew the Bank was embarrassed'.[36]

Bank runs usually followed domestic disturbances such as the South Sea Bubble in 1721[37] and the Battle of Prestonpans in 1745 during the Jacobite Rebellion.[38] Often it was only a general feeling of uneasiness that made people prefer cash to notes. For example the serious illness of Queen Anne in 1713, her death in 1714 and uncertainty about her successor caused runs on the Bank[39]. Panics were sometimes groundless, and it seems that it was difficult to forecast which event actually provoked a bank run. For example Clapham mentions that during the Seven Years' War (1759-63) there was no acute banking pressure and the war years were a time of relative domestic prosperity.[40]

4 Implications of the Adjustment Cost Policy

Although these delay strategies and other methods the Bank used to slow down the flow of gold from its vaults might seem unconventional ways to conduct monetary policy, they proved to be effective strategies in managing the gold standard during the chaotic

[34] Acres (1931)Vol I p. 5.
[35] Acres (1931), Vol I p. 5.
[36] Acres (1931), Vol I, p. 98.
[37] Acres (1931) Vol I p. 116-117.
[38] Acres (1931) Vol I pp. 180-181. Clapham (1944) Vol I, pp. 233-234.
[39] Acres (1931) Vol I p. 107.
[40] Clapham (1944) Vol I, p. 236.

years of the eighteenth century. The impact of the adjustment cost policy was not just limited to the gold reserves of the Bank, but had an effect on the general price level and consumption.

As a starting point for a formal analysis I take Goodfriend's (1988) model on asset prices under the Classical Gold Standard. The economy has one perishable consumption good and one durable consumption good, gold. Only gold can be stored across the periods and therefore it has also the role of a capital good. Gold yields direct utility to its holder and enters into the household's utility function. The central bank buys gold from abroad and monopolises the domestic gold trade. The objective of the central bank is to stabilise consumption and the price level, and reduce variability of gold reserves.

The monetary price of gold, the price the household has to pay at the central bank, is always fixed at $\bar{q}$. Buying gold from the bank is associated with an adjustment cost[41] which can take the form of forgone leisure or we can think that the consumption good gets destroyed at a convex rate while the agent waits on the bank. The total cost of buying "new" gold from the central bank, $q_t\left(K_t - K_{t-1}\right)$, is the sum of the monetary price of gold and the convex adjustment cost,

$$q_t\left(K_t - K_{t-1}\right) = \bar{q}\left(K_t - K_{t-1}\right) + \theta\frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{K_{t-1}^m}, \tag{1}$$

where $\bar{q}$ denotes the fixed money price of the gold, K_t is the household's gold stock in period t, K_{t-1}^m is monetary gold stock in period $t-1$, parameter θ defines the steepness of cost curve, $0 < \theta \leq 1$. The adjustment cost is an increasing function of gold demand $\left(K_t - K_{t-1}\right)$ in period t and a decreasing function of the monetary gold stock K_{t-1}^m in period $t-1$. The larger the stock of gold in the central bank's vaults, the more willing the bank is to sell out gold.

The circulating money stock, denominated in nominal units such as pounds, represents a liability of the central bank and takes the physical form of a paper claim rather than a commodity. Binding law requires the central bank to be prepared to buy or sell any amount of gold offered or demanded in exchange for paper money at the fixed

[41] This part of the model, an adjustment cost on durable goods, is inspired by Bernanke (1982).

pound price $\bar{q}$. The money stock per capita in period t can be defined as

$$M_t = \frac{\bar{q}K_t^m}{\eta_t}, \tag{2}$$

where $\eta_t \in (0, 1]$ is the gold reserve ratio. If $\eta_t = 1$, the paper notes represent warehouse certificates on gold and no fiduciary money circulates. The eighteenth century gold standard was, however, a partial gold standard, under which the circulating paper claims exceed the amount of backing commodity.[42]

If (2) is used to replace the central bank's gold stockpile in (1), the total cost of gold purchases becomes

$$q_t \left(K_t - K_{t-1}\right) = \bar{q} \left[\left(K_t - K_{t-1}\right) + \theta \frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{\eta_t M_t} \right]. \tag{3}$$

The higher the circulating money stock, the lower the adjustment cost of gold purchases.

In this Lucasian economy agents are households with two specialised individuals, a producer and a shopper. The discussion is restricted to a representative household. The shopper enters period t with predetermined holdings M_{t-1} of money, which the producer had gained during the previous period. Like in the Lucas's tree model the household does not consume its own production directly, but has to sell it in markets for money. With this money the shopper buys the consumption good and gold in the following period.[43] In period t the shopper has an opportunity to purchase the consumption good at price P_t, gold at fixed monetary price $\bar{q}$ and government bonds that yield a risk free interest rate R_t. By assuming that the adjustment cost reduces available consumption directly we add the adjustment cost into the cash-in-advance constraint

$$\frac{\bar{q}}{P_t} \left(K_t - K_{t-1}\right) + C_t \leq \frac{M_{t-1}}{P_t} + \frac{\bar{q}}{P_t} \theta \frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}}, \tag{4}$$

where K_t denotes the household's gold stock and C_t the household's consumption. The cash-in-advance constraint states that gold and consumption purchases in period t are limited by the cash holdings and the adjustment cost at the beginning of period t.

[42] This version for convertible currency is taken from Barro (1979), but was first described by David Ricardo in 1821.

[43] Sargent (1987)pp. 156-159.

Government bonds are not subject of cash-in-advance constraint, as we assume that gold deposits can be converted to bonds directly. The cash-in-advance constraint puts an emphasis on the fact that here I model a commodity *standard,* where money is used in exchange rather than a commodity *money system.*[44] To date the gold standard and other commodity standards have been modelled assuming that either specie or redeemable notes alongside with coins are used as a medium of exchange. This paper, however, makes a departure from the prevailing literature by considering an economy where only paper money circulates and gold operates purely as a backing commodity if held by the central bank or as a durable good if held by the household. Commodity money systems have been analysed recently by Barro (1979), Sargent and Wallace (1983), Goodfriend (1988) and Bordo, Dittmar and Gavin (2003).

An infinitely lived household's preferences are described by the utility function. The total utility is taken to be the sum of expected discounted values of present and future period utilities

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(C_t\right) + w\left(K_t\right) \right], \tag{5}$$

where $\beta \in (0,1)$ is the discount factor and E is an expectation conditional on information up to and including time period t.

By choosing sequences for $C_t,\ B_{t+1}$, M_t and K_t the household maximises (5) subject to the sequence of cash-in-advance constraints (4) and the following budget constraints

$$\frac{B_{t+1}}{R_t P_t} + \frac{M_t}{P_t} + \frac{\bar{q}}{P_t} K_t \leq \frac{M_{t-1}}{P_t} - C_t + \frac{\bar{q}}{P_t} K_{t-1} + \frac{Y_t}{P_t} + \frac{B_t}{P_t} \text{ for all } t, \tag{6}$$

where the endowment Y_t is an exogenous state variable, the government bonds are denoted by B_t and the price of the bonds is defined as the inverse of the interest rate $1/R_t \in (0,1]$. Initial conditions $M_0,\ K_{0,}$ and B_0 and $\bar{q}$ is given. The Lagrangian for the

[44] Velde and Weber (2000) introduce a "coins-in-advance" constaint in their model of bimetallism.

household problem is

$$\begin{aligned}\mathcal{L} &= E_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(C_t\right) + w\left(K_t\right)\right] \\ &+\lambda_t \left[\frac{M_{t-1}}{P_t} - C_t + \frac{\bar{q}}{P_t} K_{t-1} + \frac{Y_t}{P_t} + \frac{B_t}{P_t} - \frac{B_{t+1}}{R_t P_t} - \frac{M_t}{P_t} - \frac{\bar{q}}{P_t} K_t\right] \\ &+\mu_t \left[\frac{M_{t-1}}{P_t} + \frac{\bar{q}}{P_t}\theta \frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}} - \frac{\bar{q}}{P_t}\left(K_t - K_{t-1}\right) - C_t\right].\end{aligned}$$

The first order conditions necessary for the optimality of the household's choices are

$$C_t : \quad u'\left(C_t\right) = \mu_t + \lambda_t \tag{7}$$

$$B_{t+1} : \quad \frac{\lambda_t}{R_t P_t} = \beta E_t \frac{\lambda_{t+1}}{P_{t+1}} \tag{8}$$

$$M_t : \quad \frac{\lambda_t}{P_t} = E_t \beta \left[\frac{\lambda_{t+1} + \mu_{t+1}}{P_{t+1}} - \mu_{t+1} \frac{\bar{q}}{P_{t+1}} \theta \frac{\left(K_{t+1} - K_t\right)^{\frac{1}{\theta}}}{\eta_t M_t^2}\right] \tag{9}$$

$$K_t \quad : \quad 0 = u'\left(K_t\right) + \mu_t \frac{\bar{q}}{P_t}\left[\frac{\left(K_t - K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1} M_{t-1}} - 1\right] - \lambda_t \frac{\bar{q}}{P_t} \tag{10}$$

$$+\beta E_t \left\{\mu_{t+1} \frac{\bar{q}}{P_{t+1}}\left[1 - \frac{\left(K_{t+1} - K_t\right)^{\frac{1-\theta}{\theta}}}{\eta_t M_t}\right] + \lambda_{t+1} \frac{\bar{q}}{P_{t+1}}\right\} \tag{11}$$

$$\mu_t \left[\frac{M_{t-1}}{P_t} + \frac{\bar{q}}{P_t}\theta \frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}} - \frac{\bar{q}}{P_t}\left(K_t - K_{t-1}\right) - C_t\right] \geq 0, \quad \mu_t \geq 0. \tag{12}$$

Combining (7), (8) and (9) and rearranging we get that

$$\mu_t = u'\left(C_t\right)\left[R_{t-1} - 1\right]\left[R_{t-1} - \bar{q} \frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{\theta \eta_{t-1} M_{t-1}^2}\right]^{-1} \tag{13}$$

The multiplier μ_t, the shadow value of liquidity services of money, has to be non-negative in order for the cash-in-advance constraint to be binding. As $R_{t-1} \geq 1$ the second term of this equation is positive. The third term, the adjustment cost term, is positive since

$$0 \leq \bar{q}\theta \frac{\left(K_t - K_{t-1}\right)^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}^2} \leq 1. \tag{14}$$

If the adjustment cost term equals unity, μ_t equals the marginal utility of consumption.

Combining (7) and (8) gives the Euler equation

$$\frac{u'(C_t) - \mu_t}{R_t P_t} = \beta E_t \frac{u'(C_{t+1}) - \mu_{t+1}}{P_{t+1}}. \tag{15}$$

Substituting (13) into (15) gives

$$\frac{u'(C_t)}{P_t} \left\{ 1 - [R_{t-1} - 1] \left[R_{t-1} - \bar{q}\theta \frac{(K_t - K_{t-1})^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}^2} \right]^{-1} \right\} \tag{16}$$

$$= R_t \beta E_t \frac{u'(C_{t+1})}{P_{t+1}} \left\{ 1 - [R_t - 1] \left[R_t - \bar{q}\theta \frac{(K_{t+1} - K_t)^{\frac{1}{\theta}}}{\eta_t M_t^2} \right]^{-1} \right\}. \tag{17}$$

The Euler equation can be written as

$$\frac{1}{R_t} \frac{u'(C_t)}{P_t} \{ g(R_{t-1}, K_t) \} = \beta E_t \frac{u'(C_{t+1})}{P_{t+1}} \{ g(R_t, K_{t+1}) \}, \tag{18}$$

where

$$g(R_{t-1}, K_t) = 1 - [R_{t-1} - 1] \left[R_{t-1} - \bar{q}\theta \frac{(K_t - K_{t-1})^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}^2} \right]^{-1} \tag{19}$$

and

$$g(R_t, K_{t+1}) = 1 - [R_t - 1] \left[R_t - \bar{q}\theta \frac{(K_{t+1} - K_t)^{\frac{1}{\theta}}}{\eta_t M_t^2} \right]^{-1}. \tag{20}$$

As $R_t \geq 1$ and $0 \leq \bar{q}\theta \frac{(K_t - K_{t-1})^{\frac{1}{\theta}}}{\eta_{t-1} M_{t-1}^2} \leq 1$, the function $g(\cdot)$ decreases, when the gold demand in period t increases. If $\bar{q}\theta \frac{(K_{t+1} - K_t)^{\frac{1}{\theta}}}{\eta_t M_t^2}$ approaches one, $g(R_t, K_{t+1})$ approaches zero.

With these preliminary solutions in hand we are now able to study the effect of the adjustment cost on consumption, especially the link between the adjustment cost and the variance of consumption.[45] The functional form of (5) and preferences follow Goodfriend (1988): In (5) the functional form of the utility of consumption is

$$u(C_t) = v_t \log C_t \tag{21}$$

where $v_t = v(1 + \nu_t) > 0$ and gold

$$w(K_t) = w_t \log K_t \tag{22}$$

[45] This part of the model is inspired by Hansen and Singelton (1983).

where $w_t = w(1+\omega_t) > 0$. Using these functional forms we can write the Euler equation (16) as

$$\beta R_t E_t \left(\frac{C_{t+1}}{C_t}\right)^{-1} \left(\frac{v_{t+1}}{v_t}\right) \left(\frac{P_{t+1}}{P_t}\right)^{-1} \left(\frac{g(R_t, K_{t+1})}{g(R_{t-1}, K_t)}\right) = 1 \tag{23}$$

Let

$$c_{t+1} = C_{t+1}/C_t, \tag{24}$$

denote the gross growth rate of consumption,

$$x_{t+1} = (v_{t+1}/v_t)(P_{t+1}/P_t)^{-1} g(R_t, K_{t+1}) / g(R_{t-1}, K_t) \tag{25}$$

and

$$u_{t+1} = c_{t+1}^{-1} x_{t+1}. \tag{26}$$

I have to assume that the joint distribution of c_{t+1} and x_{t+1} is lognormal which might, in the presence of adjustment costs, seem simplistic. However, as I here analyse the variance of perishable good consumption, not gold demand, this simplification seems acceptable.[46]

Since the nominal rate of interest R_t is known in period t the equation (23) can be written as

$$E_t(u_{t+1}) = \frac{1}{\beta R_t}. \tag{27}$$

Next let $\hat{c}_{t+1} = \log c_{t+1}$, $\hat{x}_{t+1} = \log x_{t+1}$ and $\hat{u}_{t+1} = \log u_{t+1}$. The distribution of $\hat{u}$ is log normal, with constant variance $var_t(u)$ and mean $\mu_{u,t}$. Therefore, the expected value of u_{t+1} is

$$E_t(u_{t+1}) = \exp\left[\mu_{u,t} + (var_t(u)/2)\right] \tag{28}$$

Equating (27) and (28) and solving for $\mu_{u,t}$ yields

$$\mu_{u,t} = -\log \beta R_t - (var_t(u)/2). \tag{29}$$

The difference between $\hat{u}_{t+1}$ and its mean $\mu_{u,t}$ is

$$V = \hat{u}_{t+1} - \mu_{u,t} \tag{30}$$

[46] Hansen and Singelton (1983), p. 252 list some ristrictions that are caused by the joint distribution asumption (for example for production technology), but they are not relevant in our model.

thus the expected value of V equals zero.

$$E(V) = E_t\left(\hat{u}_{t+1} - \mu_{u,t}\right) = E_t\left[\hat{x}_{t+1} - \hat{c}_{t+1} + \log\beta R_t + var_t(u)/2\right] = 0 \tag{31}$$

where $\hat{u}_{t+1} = \hat{x}_{t+1} - \hat{c}_{t+1} + \log\beta R_t$. This implies that

$$E(\hat{c}_{t+1}) = E_t\left[\hat{x}_{t+1} + \log\beta R_t - var_t(u)/2\right]. \tag{32}$$

In order to analyse the variance of $\hat{c}_{t+1}$ we can ignore the constant term and $(var_t(u)/2)$. The predictable terms – variances of $\hat{x}_{t+1}$ and $\hat{c}_{t+1}$ – are related by the expression

$$\begin{aligned} var\left[E(\hat{c}_{t+1})\right] &= var\left[E(\hat{x}_{t+1})\right] & (33)\\ &= var\left[E\left(\log\left(\frac{v_{t+1}}{v_t}\right)\left(\frac{P_{t+1}}{P_t}\right)^{-1}\left(\frac{g(R_t, K_{t+1})}{g(R_{t-1}, K_t)}\right)\right)\right]. & (34)\end{aligned}$$

As noted above the function $g(R_t, K_{t+1})$ is a decreasing function of the demand for new gold $(K_{t+1} - K_t)$. Therefore, if the gold demand increases the adjustment cost stabilises consumption by reducing the variance of the expected consumption growth rate $var\left[E(\hat{c}_{t+1})\right]$. The higher the adjustment cost for gold, the lower the expected variance of the consumption growth rate.

How does the adjustment cost together with the central bank's gold stock pile policy affect the price level? In order to solve for the price path I combine the first order conditions (7) and (10), substitute μ_t (13) and use (19) and (20) to yield

$$\begin{aligned} 0 &= u'(K_t) + \frac{u'(C_t)}{P_t}\left[1 - g(R_{t-1}, K_t)\right]\frac{\bar{q}\left(K_t - K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}} - \frac{\bar{q}}{P_t}u'(c_t) & (35)\\ &\quad + \beta E_t\left\{\frac{\bar{q}}{P_{t+1}}u'(C_{t+1}) - \frac{u'(C_{t+1})}{P_{t+1}}\left[1 - g(R_t, K_{t+1})\right]\left[\frac{\bar{q}\left(K_{t+1} - K_t\right)^{\frac{1-\theta}{\theta}}}{\eta_t M_t}\right]\right\} & (36)\end{aligned}$$

Using recursive substitution and the law of iterated expectations we can express the above as

$$\begin{aligned} &\frac{\bar{q}}{P_t}u'(C_t)\left\{1 - \left[1 - g(R_{t-1}, K_t)\right]\frac{\left(K_t - K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right\} & (37)\\ = &\sum_{i=0}^{T} E_t\beta^i u'(K_{t+i}) + \beta^T E_t\frac{\bar{q}}{P_{t+T}}u'(C_{t+T})\left\{1 - \left[1 - g(R_{t-1+T}, K_{t+T})\right]\frac{\left(K_{t+T} - K_{t-1+T}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1+T}M_{t-1+T}}\right\}. \end{aligned}$$

As T approaches infinity, I impose the transversality condition, which states that

$$\lim_{T\to\infty} \beta^T E_t \frac{\bar{q}}{P_{t+T}} u'(C_{t+T}) \left\{ 1 - [1 - g(R_{t-1+T}, K_{t+T})] \frac{(K_{t+T} - K_{t-1+T})^{\frac{1-\theta}{\theta}}}{\eta_{t-1+T} M_{t-1+T}} \right\} = 0 \quad (38)$$

and (37) becomes

$$\frac{\bar{q}}{P_t} u'(C_t) \left[1 - [1 - g(R_{t-1}, K_t)] \frac{(K_t - K_{t-1})^{\frac{1-\theta}{\theta}}}{\eta_{t-1} M_{t-1}} \right] = \sum_{i=0}^{\infty} E_t \beta^i u'(K_{t+i}). \quad (39)$$

The price path can be written as

$$\frac{1}{P_t} = \left[\bar{q} u'(C_t) \left\{ 1 - [1 - g(R_{t-1}, K_t)] \frac{(K_t - K_{t-1})^{\frac{1-\theta}{\theta}}}{\eta_{t-1} M_{t-1}} \right\} \right]^{-1} \sum_{i=0}^{T} E_t \beta^i u'(K_{t+i}). \quad (40)$$

In order to include the central bank's response to temporary disturbances to gold supply conditions into the model, a central bank's gold stockpiling policy, which varies stochastically according to the gold supply conditions abroad, is introduced. The central bank's stock piling policy rule follows Goodfriend (1988) and is written in terms of its effect on the agent's gold stock.

$$K_t = \frac{K}{1 - \phi_t}. \quad (41)$$

where $\phi \sim N(0, \sigma^2)$ and $\phi_t \in [-1, 1]$. If a positive gold stockpile shock increases the gold stock of the central bank, $\phi_t > 0$, the gold backing η from (2) rises which through (4) indicates that the adjustment cost reduces.

Next we substitute (41), (21) and (22) to (40) and take expectations.[47] By using the covariance rule $E(XY) = EXEY + cov(X, Y)$ we can write the price path as

$$\begin{aligned} \frac{1}{P_t} &= \frac{1}{\bar{q}} \left[1 - [1 - g(R_{t-1}, K_t)] \frac{(K_t - K_{t-1})^{\frac{1-\theta}{\theta}}}{\eta_{t-1} M_{t-1}} \right]^{-1} \left(\frac{C_t}{v_t} \right) \\ &\quad \left(\frac{1}{K} \right) \left\{ w_t (1 - \phi_t) + \frac{\beta}{1 - \beta} [w - cov(w, \phi)] \right\}, \end{aligned} \quad (42)$$

where $1/P_t$ is the consumption price of currency in period t, i.e. inverse of the price level.

[47] See Appendix 1 for details.

With the adjustment cost policy the central bank is able to pursue price level smoothing: If the gold demand increases, the function $\left[1-\left[1-g\left(R_{t-1},K_t\right)\right]\frac{\left(K_t-K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right]$ decreases which implies that the price level decreases. Also, increase in the preference for gold w_t decreases the price level. On the other hand, positive covariance between the gold preference w and gold stockpile policy ϕ drives up the price level. If the household's gold demand is correlated with the gold supply conditions, i.e. there is a simultaneous gold inflow to the country and an increase in gold preference, the price level rises.

During the Classical Gold Standard the automatic adjustment mechanism reduced the outflow of monetary gold and reduced the arbitrage profit opportunities. This mechanism did not function in the eighteenth century, because the Bank of England was not fully in charge of the money supply and regular wars disturbed gold supply conditions. The adjustment cost on gold purchases had, however, similar effects on the economy. If there were an exogenous gold preference shock, the adjustment cost reduced the price level that made gold relatively more expensive. Without the adjustment cost the potential variability in consumption would have been larger: a positive gold preference shock would have increased household's gold purchases and through the cash-in-advance constraint less money would have been available for consumption purchases.

If both gold and consumption yield utility to household, why would the central bank want to discourage gold consumption? The answer lies in the fact that the central bank's objective here is to stabilise the economy. Gold consumption reduces the circulating money stock, which through the cash-in-advance constraint, reduces consumption and the market activity. Gold preference shocks make the economy less stable: as only a small percentage of the country's money supply was backed by monetary gold, it was important that the public preferred to hold paper and the gold preference shocks could have been controlled.

5 Conclusions

After the establishment of the Bank of England in 1694 the gold convertibility rule evolved as a core monetary rule. Two key factors challenged the feasibility of this rule: firstly, the Bank did not have a monopoly to issue paper money, and secondly, an external shock would increase the market price of gold above its mint price, which would give the public an opportunity to earn arbitrage profits. The main purpose of this paper was to analyse how the Bank of England might have been able to manage the gold convertibility rule despite these challenges with a simple adjustment cost policy, which increased the total cost of gold purchases. Furthermore, with the adjustment cost the central bank could manipulate the price level, stabilise consumption and encourage consumption instead of gold consumption.

In this paper we have addressed monetary policy during the Pre-classical Gold Standard, which provides a starting point for the analysis of the Suspension Period. Therefore, one could ask why the adjustment cost policy failed in 1797 when the Bank had to suspend the gold convertibility rule for 24 years. Firstly, until the end of the century the stable system of gold import and minting played a crucial role in monetary stability in England, but in the early 1790's there were large gold supply shocks: the Brazilian mines, which were the main source of new gold, started to dry up and the market price of Brazilian gold increased. The war that broke out in 1793 caused disturbances on the sea and increased the insurance costs of shipping.[48] After the assignants had failed, France tried to get back to the gold standard and in 1795 the demand bullion in Paris was so high that the guineas bought at the mint price of £3. 17s. $10\frac{1}{2}$d. per ounce from the Bank of England could be sold £4. 3s. 0d per ounce in Paris. The Bank tried to improve the exchange rate in February 1796 by shipping silver to Hamburg and buying Brazilian gold from Lisbon, but as the market price of gold bars were now much higher than the mint price, coinage was unprofitable and in the end, gold was sold as bars before the Bank had a chance to mint them. Finally, the war against revolutionary France and the direct financial support for British allies increased

[48] Vilar (1976) p. 227.

the government's demand for credit and specie. The adjustment mechanism failed as it could not stop the drain of specie that was not caused by the general public but by the government.

In the light of this model the Suspension Period could be seen, however, as an extreme adjustment cost, a long slow down in gold convertibility. The suspension was never perfect in the sense that the Bank kept converting those notes it wanted to withdraw from circulation, such as old bank notes, that were easy to counterfeit. The Bank also paid its dividends in gold and even increased them form 7.5 percent to 10.5 in 1807. The Suspension Period raises complex modlling issues, which are addressed in Newby (2007).

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6 Appendix

Taking the expectations of the price path function (40):

$$\frac{1}{P_t} = \left[\bar{q}u'\left(C_t\right)\left\{1-\left[1-g\left(R_{t-1},K_t\right)\right]\frac{\left(K_t-K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right\}\right]^{-1}\sum_{i=0}^{T}E_t\beta^i u'\left(K_{t+i}\right)$$

$$\frac{1}{P_t} = \bar{q}u'\left(C_t\right)\left[1-\left[1-g\left(R_{t-1},K_t\right)\right]\frac{\left(K_t-K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right] \tag{43}$$

$$\left[\frac{w_t}{K_t}+\sum_{i=1}^{\infty}E_{t+i}\beta^i\frac{w_{t+i}}{K_{t+i}}\right] \tag{44}$$

$$\frac{1}{P_t} = \bar{q}u'\left(C_t\right)\left[1-\left[1-g\left(R_{t-1},K_t\right)\right]\frac{\left(K_t-K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right] \tag{45}$$

$$\left[\frac{w_t}{K_t}+\sum_{i=1}^{\infty}\beta^i\left(E_tw_{t+i}E_t\frac{1}{K_{t+i}}\right)+cov\left(w_{t+i},\frac{1}{K_{t+i}}\right)\right] \tag{46}$$

$$\frac{1}{P_t} = \bar{q}u'\left(C_t\right)\left[1-\left[1-g\left(R_{t-1},K_t\right)\right]\frac{\left(K_t-K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right] \tag{47}$$

$$\left[\frac{w_t}{K_t}+\frac{\beta}{1-\beta}\left(\frac{w}{K}+\frac{1}{K}cov\left(w,1-\phi\right)\right)\right] \tag{48}$$

$$\frac{1}{P_t} = \bar{q}u'\left(C_t\right)\left[1-\left[1-g\left(R_{t-1},K_t\right)\right]\frac{\left(K_t-K_{t-1}\right)^{\frac{1-\theta}{\theta}}}{\eta_{t-1}M_{t-1}}\right] \tag{49}$$

$$\frac{1}{K}\left[w_t\left(1+\phi_t\right)+\frac{\beta}{1-\beta}\left(w-cov\left(w,\phi\right)\right)\right] \tag{50}$$

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Alex Trew
Castlecliffe, School of Economics and Finance
University of St Andrews
Fife, UK, KY16 9AL

Email: awt2@st-and.ac.uk; Phone: +44 (0)1334 462445; Fax: +44 (0)1334 462444.