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The Long-Run Non-Neutrality of Monetary policy: A General Statement in a DGE Model

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Introduction

The authors have previously discussed this topic in a number of different places, such as Kam (2000, 2005), Kam and Moshin (2006), Kam and Smithin (2012), Smithin (2003, 2009, 2013) and Tabassum (2012).

The idea of the long-run neutrality of changes in monetary policy is part of the DNA of the "classical" approach to economic theory, going back at least to Hume in 1752 (Humphrey 1998, 8-9). There have always been challenges to this position, of course. Historically, the so-called "forced savings" effect (Hayek 1932, 1939, Humphrey 1983, Smithin 2013) was often treated as a sort of "exception that proves the rule" to the general theoretical presumption of monetary neutrality. In the mid-twentieth century there was considerable discussion of the analogous "Mundell-Tobin effect", so-called after the contributions of Mundell (1963) and Tobin

(1965) which also appeared to show non-neutrality (Begg 1980, 1982, Blanchard and Fisher 1989, Smithin 1980, Turnovsky 2000, Walsh 1998). However, these sorts of arguments have not been well received, to say the least, by the majority of economic theorists in the mainstream of the profession.

One argument that has frequently been made is that a correct understanding of the so-called "microfoundations of macroeconomics" will enable the theorist to confidently rule out anything like a forced savings result. Walsh (1998, 48-9), for example, puts forward a number of arguments against some of the twentieth century demonstrations of the Mundell-Tobin effect, the most important of which is that:

> the..... behavioural relationships are *ad hoc* in the sense that they are not explicitly based on maximizing behaviour by the agents of the model. This limitation can lead to problems when we try to understand the effects of changes in the economic environment, such as changes in the rate of inflation. The effects will depend in part, on the way in which individual agents adjust, so we need to be able to predict how the demand function for money if the underlying time series behaviour of the inflation process were to change ... (d)oing so will ... highlight channels leading to quite different predictions than Tobin found ...

Now this is *not*, in fact, a generally valid argument from either the philosophical or methodological point of view. According to King (2012, 9) there are two main problems with what he (unhesitatingly) calls the "microfoundations dogma", namely "the fallacy of composition and downward causation". Therefore:

> Since the microfoundations dogma is inconsistent with both of these principles, the dogma itself must be *false*. (Emphasis added)

Nonetheless, as suggested in the quote from Walsh (and there are very many other examples in the literature) the idea that an appeal to "*the*" microfoundations is decisive is now so widely accepted among the relevant peer group of academic economists that this, in itself, in the current intellectual environment, provides an extremely difficult challenge for those trying to engage in meaningful debate Therefore, Kam (2000, 2005), for example, took a different approach to that of King in addressing the question of monetary non-neutrality. This was to show that non-neutrality *still* applies even in a framework which has impeccable microfoundations by the standards of "orthodox neoclassical economics". The purpose of the exercise was essentially a question of communication with colleagues who may be well-versed in mathematical techniques but not necessarily in questions of epistemology.

Kam's work was based on a modification of the well-known Sidrauski model (Sidrauski 1967) which had been a staple of graduate-level textbooks for many years (Blanchard and Fisher 1989, Turnovsky 2000, Chiang and Wainwright 2005), and still is to this day. However, as the previously cited author (King 2012, 1) has stated, and Woodford (2010, 1-4) has shown, the canonical model in twenty-first century theoretical macroeconomics is one version or another of the dynamic general equilibrium (DGE) model. When probabilistic elements are incorporated into the argument, *e.g.* in empirical work, this is also known as the dynamic *stochastic* general equilibrium (DSGE) model (Woodford 2010, 1). It is therefore important also for the purposes of communication to now make a more general statement about the issues in the context of a theoretical DGE model.

A Neo-Wicksellian DGE model with a "Representative Agent", Endogenous Money and a *Constant* Rate of Time Preference

A first step is to construct a benchmark DGE model in which long-run monetary neutrality holds. This will involve a neo-Wicksellian framework (Smithin 2013, 125-32) with a "representative agent", endogenous money, and a constant rate of time preference. The supposed representative agent is a "worker-consumer", and solves the following dynamic optimization problem maximizing utility over an infinite time horizon:

(1) $$Max \sum \beta^t U(C_t), \qquad U'(C_t) > 0, \; U''(C_t) < 0$$

Subject to:

(2) $$W - W_{-1} = Y + r_D D - C - \delta K, \qquad 0 < \delta < 1$$

(3) $$Y = F(K), \qquad F'(K), > 0, \; F''(K) < 0$$

(4) $$W = K + D$$

Here, W is real wealth, D is the real value of an interest bearing financial asset denominated in the unit of account (such as interest-bearing bank deposits), K is the real capital stock, Y is real GDP, r_D is the real interest rate on the financial asset, and δ is the deprecation rate. The overall problem is;

(5) $$Max \sum \beta^t \{U(C_t) + \lambda_t[F(K_t) + r_D(Wt - Kt) - C_t - \delta K_t + W_{t-1} - W_t]\}$$

noting that:

(6) $$\beta = 1/(1 + \theta).$$

The term β is the "discount factor", where θ stands for the rate of time preference, taken as given. This assumption of a constant rate of time preference is, in fact, the precise modern equivalent of Wicksell's (1898, xxv) "natural rate" of interest. It is this which ensures an eventual result of monetary neutrality, rather than anything to do with the mathematical structure of the problem. The first-order conditions for the solution to the optimization problem are:

(7) $$U'(C) - \lambda = 0$$

(8) $$F'(K) - r_D - \delta = 0$$

(9) $$\lambda r_D + \lambda_{+1}\beta = 0$$

And the dynamic system reduces to:

(10) $U'(C)r_D = - U'(C_{+1})\beta$

(11) $F'(K) - \delta = r_D$

As shown by Kam (2000, 30-3), drawing on the literature in mathematical economics from the second half of the twentieth century, the dynamic properties of this type of model with two assets generally involve saddle-point stability. This specification is no exception. Therefore, if a plausible transversality condition can be identified, the system will converge to the steady-state:

(12) $r = \theta$

(13) $F'(K) - \delta = r_D$

The overall macroeconomic equilibrium can thus be characterized as;

(14) $r_D = \theta$

(15) $F'(K^N) - \delta = \theta$

(16) $Y^N = F(K^N)$

where K^N is the equilibrium ("natural") level of the capital stock, and Y^N is the equilibrium ("natural") level of output. Dropping the subscript on the real rate of interest, the political economy of these results can be expressed even more simply:

(17) $r = r^N \ (= \theta)$ (natural rate of interest)

(18) $Y = Y^N$ (natural level of output)

In equilibrium "the" real rate of interest will be at its natural level determined by the (constant) rate of time preference, as will the level of output.

How to Handle Inflation?

As shown above, it is a fairly straightforward exercise to derive the real equilibrium of the neo-

Wicksellian model. The results conform to what would be expected. However, as discussed by Rogers (2006) and Smithin (2003, 2013), for example, there is something of a problem for the theorist in any attempt to include an explanation of inflation in the analysis. To see this, note that (by definition) in equilibrium the real interest rate is given by the nominal interest rate less the (equilibrium) inflation rate:

(19) $$r = i - p$$

But then, from (17), it must also be true that:

(20) $$p = i - r^N$$

This implies that (*e.g.*) an increase in the nominal interest rate increases the inflation rate. This would *not* be a "Wicksellsian" result at all. It is counter-intuitive from a Wicksellian point of view, if not from an old-fashioned monetarist perspective (MacKinnon and Smithin 1993). The Wicksell-type argument would be, on the contrary, that a *lower* (not higher) interest rate leads to *higher* inflation.

Alternatively, suppose we try a typical "central bank reaction function", the proto-type of which was the famous "Taylor rule" (Taylor 1993). It should immediately be noted that at this point we have already had to postulate a second "agent", in the shape of a banking system of some kind, to make the model work. This does not, however, really comprise the attempt at providing "microfoundations". Something of the kind is inevitable as soon as any attempt is made to introduce money into the process. Even in the pristine neoclassical money and growth model descended from Sidrauski, there was always (at least implicitly) some kind of *deus ex machina* to actually *issue* the money (Harkness 1978, Smithin 1983). So, we can cheerfully suppose that there is a central bank which adjusts the nominal interest rate according to the rule:

(21) $$i = i_j + \gamma p, \qquad 0 < \gamma < 1$$

where the i_j are different possible values that could be chosen for the intercept. Then, from (20);

(22) $$i_j + \gamma p - p = r^N$$

and;

(23) $$p = [1/(1-\gamma)](i_j - r^N),$$

So the Wicksell-type argument *still* does not work. As $[1/(1-\gamma)] > 1$, a setting of i_j higher than the natural rate will cause inflation to rise, not fall, and *vice versa*.

Is This Where the "Taylor Principle" Comes In?

Smithin (2013, 130-1) has conjectured the problems associated with incorporating inflation into neo-Wicksellian models may actuall have played some role in the popularity of the disastrous policy "fad" known as the "Taylor Principle" (as opposed to Taylor rule) in the early twenty-first century (Mankiw 2001, 2003, Davig and Leeper 2007, 2010). This was the suggestion that the central bank should always to raise the nominal policy rate *more* than one-for-one with observed inflation, in a sort of "pre-emptive strike" against inflation. It turned out to be disastrous in the real world because it amounts to *deliberately* destabilizing real interest rates and hence financial markets. This is just one of many examples where mathematically-trained neoclassical economist theorists, blithely assuming monetary neutrality, are at cross-purposes with more practically oriented market participants or "market-watchers". Nonetheless, from the theorists' standpoint applying the "Taylor Principle" does solve some technical problems. Clearly it would give rise to a rule such as:

(24) $$i = i_j + (1 + \gamma)p, \qquad 0 < \gamma < 1$$

So that:

(25) $i = r_j + \gamma p$

Substituting back into (20):

(26) $r_j + \gamma p - p = r^N$

Finally, solving for inflation, we obtain;

(27) $p = [1/(1-\gamma)](r^N - r_j)$

where the r_j are the different values for the intercept that the central bank could choose in a *real* interest rate rule (Barrows and Smithin 2009, 258-9). This is a much more “Wicksellian” result. The argument now is that if the real intercept in the reaction function is consistently less than the “natural rate” (effectively the rate of time preference) there will be inflation. After much mathematizing, the modern neo-Wicksellian model therefore finally comes down to:

(28) $Y = Y^N$

(29) $p = [1/(1-\gamma)](r^N - r_j), \qquad 0 < \gamma < 1$

The conclusion is that in such a model the level of output Y is always at its natural value Y^N. This is the so-called “full employment” level, which is also supposedly the same as that which would prevail in a barter exchange economy. Furthermore, if the “base *real* policy rate”, r_j, is too low relative to the natural rate, r^N, there will be inflation and *vice versa.* These are exactly the results the theorist would be looking for, never mind their applicability, or otherwise, to an actual economy. Smithin’s (2013, 131-2) comment on all this was as follows:

> The historically-minded reader will note that the model in … [(28)–(29)] … is only a marginal advance from position already reached by Keynes (1930, 121-44) in chapter 10 of his *Treatise on Money*.

As previously argued by Kam and Smithin (2015, 13), this seems to be, and is, an unbelievably small reward for what has now been nine decades of intensive mathematical research in academia.

Endogenous Time Preference?

The key move made in the analysis by Kam (2000, 2005) was to endogenize the rate of time preference. It has been known at least since Uzawa (1968) that this would restore the property of *non*-neutrality.

However the particular specification used by Uzawa was always highly controversial (Kam 2000, 15-16). Uzawa had assumed that time preference depends positively on the level of current utility which itself is an increasing function of consumption. Inflation raises the opportunity cost of holding real balances and renders the initial equilibrium too costly. This increases the real interest rate and decreases the demand for real balances, which increases savings and the capital stock. This does make the rate of time preference endogenous, but the argument that if consumption *increases* the rate of time preference *increases* is not at all convincing. In effect, the very act of consumption is supposed to make the representative agent "impatient" for still more consumption. This does not seem reasonable. Persson and Svenson (1985, 45) dismiss the Uzawa specification as "... arbitrary and even counter-intuitive". Blanchard and Fischer (1989, 71) go much further, and specifically warn budding economic theorists that:

> [although the] ... specification avoids the pathological results of the constant discount rate ... the Uzawa function, with its assumption (that the rate of time preference increases in instantaneous utility is not ... attractive as a description of preferences and is not recommended for general use.

Kam (2000, 2005), however, building on a suggestion by Epstein and Hynes (1983), has put forward an alternative, far more intuitively plausible, method of making the rate of time preference endogenous. The idea is simply to make time preference a positive function of total real wealth (not of consumption itself). Because the wealth effect on time preference is *positive*, this amounts to reinstating the idea that there is some sort of "propensity to consume" out of wealth, as well as out of income. Therefore, following the treatment in Kam (2005, 129) let:

(30) $$\theta = \theta(W), \qquad \theta'(W) > 0$$

The first order conditions will now be:

(31) $$U'(C) - \lambda = 0$$

(32) $$\lambda[F'(K) - \delta - 1) + \lambda_{+1}\beta = 0$$

(33) $$\lambda(r_D - 1) + \lambda_{+1}\beta = 0$$

And, the revised dynamic system, where once again the relevant interest rate is r_D, is therefore:

(34) $$F'(K) - \delta = r_D$$

(35) $$U'(C)[F'(K) - \delta] = -U'(C_{+1})\beta$$

Again this will be a saddlepoint. The steady-state of the system becomes:

(36) $$F'(K) - \delta = r_D$$

(37) $$F'(K) - \delta = \theta(W)$$

There is no longer any natural rate of interest in this model. All of time preference, the net "marginal product of capital", and the real interest rate on money, must essentially conform to the standard set by the conscious monetary policy of the central bank (Smithin 2003, 2013).

A Simple Theory of Banking and the Relationship between Commercial Banks and the Central Bank

As mentioned previously one possible interpretation of the nature of the financial asset in the optimization problem is as an interest-bearing bank deposit. Logically speaking, therefore, there has to be at least one other “agent” in the system, namely a commercial bank and, for that matter, even a third agent in the shape of the central bank. As in Kam and Smithin (2012), therefore, let the simplified balance sheet of a “representative” commercial bank be as follows. Here *$D* is nominal bank deposits, S stands for (negative) settlement balances at the central bank, R is nominal reserves, and L is the nominal dollar amount of loans outstanding.

A Simplified Commercial Bank Balance Sheet

<u>Assets</u>		<u>Liabilities</u>	
Reserves	R	Deposits	*$D*
Loans	L	Settlement Balances	S
	-------		--------
	$R + L$		*$D + S*

The “optimization problem” for the commercial bank is therefore;

(38) $$Max\ \Pi = i_L L - i_D D - i_0\, \sigma(S - R) - \mu L$$

where Π stands for money profit, i_L is the nominal prime lending rate, i_D is the nominal deposit rate, and i_0 is the nominal policy rate (*i.e.*, the “overnight” rate). Substituting in from the bank balance sheet:

(39) $$Max\ \Pi = i_L L - i_D(L + R - S) - i_0 \sigma(S - R) - \mu L$$

Note that if we were to use a standard notation from statistical probability theory, then:

(40) $$\sigma = \int_0^{\infty} f(x)dx$$

That is, σ would be the subjective probability, as assessed by bank officials, of the commercial bank being out of the money at the clearing house. The expression μ might be interpreted as the average cost per dollar (or euro or yen) for making bank loans, but a difficulty with this is that there is no precise analogue to a textbook (physical) production function in banking (Dow and Smithin 1999). It is probably safer to say that μ must be high enough to cover costs and earn a "normal" rate of return for the banks given existing institutional arrangements, market structure, banking legislation, regulations, *etc*. (It is ultimately determined by these four sets of conditions). Substituting in from the balance sheet the optimization problem becomes:

(41) $$\text{Max: } \Pi = i_L L - i_D(L + R - S) - i_O \sigma (S - R) - \mu L$$

The choice variables are the volume of loans granted, and the quantity of precautionary reserves banks choose to hold. First order conditions are obtained by differentiating with respect to L and R, and setting the results equal to zero:

(42) $$i_L - i_D = \mu$$

(43) $$i_D = \sigma i_O$$

The mark-up between commercial bank lending rates and deposit rates will be equal to μ, and the deposit rate in commercial banks is a "mark-down" from the central bank's setting of the policy rate. In effect, the degree of the mark-down depends on the subject assessment of “risk” (as this is called in neoclassical economics, a true Keynesian would prefer to call it uncertainty) for a commercial bank of *not* "keeping in step" (Keynes 1930, 23) with their rivals. In the past, a similar sort of result has sometimes been called the "two-for-one" rule (Rogers and Rymes 2000, 259). However to get a value of exactly $\sigma = 0.5$ would depend on making the twin assumptions of ergodicity *and* a normal distribution, which are unlikely both to hold in practice.

Combining equations (42) and (43), there is a linear relationship between policy rate and the bank lending rate, providing an account of how changes in the central bank policy rate are transmitted to interest rates in general. This is:

(44) $$i_L = \mu + \sigma i_0$$

Next, subtract the observed inflation rate, p, from both sides of equation (44):

(45) $i_L - p \;=\; \mu + \sigma r_0 \;-\; (1-\sigma)p,$

The term r_0 is the inflation-adjusted "real" policy rate of interest, that is the nominal policy rate adjusted for the currently observed inflation rate, $r_0 = i_0 - p$. This gives some insight into the discussion by Smithin (2007, 2009) about a "real interest rate rule" for monetary policy. As a practical matter, such a rule would have to involve a target for the inflation adjusted policy rate (as defined) because the true expected inflation rate is not known. The question then is whether the similar inflation-adjusted real commercial bank lending rate in equation (45) can also be taken as a "proxy" (Taylor 1993) for the real lending rate itself. If so, and in the absence of any other reliable indicator on which borrowers can base their estimates, equation (45) could be re-written as:

(46) $r \;=\; \mu + \sigma r_0 \;-\; (1-\sigma)p$

Where term r stands for the real interest rate *actually involved in economic decision-making* (*e.g.*, the interest rate in an investment function, or in an "IS curve" in a macro model). Equation (46) thus shows how central bank activities can indeed have influence over this rate and, thereby, over the real economy in general. Notice, particularly, the *negative* theoretical relationship between inflation and real interest rates in this situation. This is nothing other than the forced saving (or Mundell-Tobin) effect, already discussed above.

A Real Interest Rate Rule for Monetary Policy?

From (42) and (43), we can see that it must also be the case that:

(47) $r_D = \sigma r_0 - (1-\sigma)p$

This raises the possibility that the central bank could actually pursue a feedback rule intended to fix the real rate of return on the financial asset (the bank deposits) held by the agent. To set r_D = *r'*, for example, the central bank must follow the rule:

(48) $$r_0 = (1/\sigma)r' + [(1-\sigma)/\sigma]p$$

This looks to be quite complicated in itself. In practice, any rule followed by the central bank is obviously going to have to be more straightforward such as simply, $r_0 = i_0 - p$, long advocated by Smithin (2003, 2007, 2009, 2013).[4] Real world central bankers will not be able to cover every contingency, and their main objective should really be *not* to add to instability (unlike their adherence to the Taylor Principle). However, if we are prepared to allow that the central bank could, in principle, follow such a rule this would greatly simplify the theoretical model such that we can better understand some of the model's features. This will therefore be the assumption in what follows.

Is there a "User Cost" of Producing Capital Goods rather than Consumption Goods?

There is still one "loose end" to be tied up. As we have abandoned the Taylor Principle the system no longer determines the inflation rate. We are back to the dilemma that was faced by theorists of the new consenus in "models without money" at the end of the twentieth century and the beginning of the twenty-first (Woodford 1998). This failing however can be remedied by introducing some frictions into the problem of the representative agent. One of the main choices that the agent faces is whether to allocate current output to investment goods (increase the capital stock) or to consumption. We can therefore suppose that there is a lump user-cost associated with making these changes.

Let *V* be nominal user cost, and *P* the price level. According to the usual logic of profit maximization, or cost minimization, there must therefore be a further marginal condition for the reprentative agent as follows:

(49) $V/P = F'(K)$

Next suppose that *nominal* user costs (in this money-using system) evolve according to:

(50) $V = V_0 P_{-1}$ $V_0 > 1$

Substituting (48) into (47);

(51) $V_0(P_{-1})/P = F'(K),$

which implies:

(52) $V_0/F'(K) = (1 + p)$

This therefore suggests a positive relationship between the level of GDP and inflation, due to the frictions associated with switching production from consumer goods to capital goods.

Formal Results

The solution system for the complete macroeconomic model is therefore:

(53) $F'(K) - \delta = r'$

(54) $\theta(K + D) = r'$

(55) $V_0/F'(K) = (1 + p)$

Totally differentiating:

(56) $F''(K)dK = dr'$

(57) $\theta'(W)dK + \theta'(W)dD = dr'$

(58) $- V_0F''(K)dK/[F'(K)]^2 = dp$

The results for changes in the target (real) rate of interest set by the central bank can therefore be summarized as follows:

(59) $dK/dr' = [1/F''(K)], \qquad < 0,$

(60) $dD/dr' = [1 - \theta'(W)]/\theta'(W), \qquad > 0,$

(61) $dp/dr' = - V_0/[F'(K)]^2 \qquad < 0,$

A tight money policy (a higher target interest rate) will succeed in reducing the inflation rate, but at the same time will permanently reduce the steady-state capital stock and the level of output. Monetary policy is non-neutral in the long run. At the same time real holdings of the financial asset will increase, which is not at all surprising as the asset (bank deposits) is interest-bearing. In effect, society's resources are being transferred from real assets to financial assets. This may just seem to be the commonsense result of deliberately increasing the rate of return to financial assets, but it had been extraordinarily difficult in the past to establish the existence of this sort of effect within the framework of formal mathematical economics.

These are the same sorts of results as those found in Atesoglu and Smithin (2006, 2007) Kam (2000, 2005), Mackinnon and Smithin (1993), Smithin (2003, 2009, 2013), and Tabassum (2012), so they do seem to be robust across a wide variety of model specifications. The main thing that should be interesting about them, from the point of view of the mainstream economist, is that the so-called microfoundations have been provided. It is therefore not possible to dismiss the non-neutrality findings on *a priori* methodological grounds

Conclusion

This note has provided an explanation of the non-neutrality of monetary policy in the context of a DGE model with "microfoundations". It has been shown that a real interest policy rule on the part of the central bank does influence the real value of commercial bank lending and deposit rates and will therefore affect the real economy *via* this route. There is a negative relationship between the inflation-adjusted real lending rate and the rate of inflation itself. This is the old "forced saving" effect.

Notes

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4. Smithin (2007, 2009, 2013) has shown that this also will ensure inflation stability.

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