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The trade-off between inflation and unemployment in an 'MMT world': an open-economy perspective

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This paper is focused on modern monetary theory's (MMT) treatment of inflation from an open-economy perspective. It analyses how the inflation process is explained within the MMT framework and provides empirical evidence in support of this vision. However, it also makes use of a stock–flow consistent open-economy model to underline some limits of the theory when it is applied in the context of a non-US (relatively) open economy with a flexible exchange-rate regime. The model challenges the contention made by MMT-ers that measures such as the job guarantee programme can achieve full employment without facing an inflation–unemployment trade-off.

Keywords: *central banking, post-Keynesian, open-economy model*

JEL codes: *E51, E120, F410*

1 INTRODUCTION

This paper is focused on modern monetary theory's (MMT) treatment of inflation from an open-economy perspective.

After a summary of the main theoretical elements of MMT and of their origins in the history of economic thought (Section 2), the paper reconstructs its theory of inflation and the proposal of a job-guarantee (JG) programme as a measure that is able to achieve full employment without triggering any wage–price spiral, and more generally without generating any inflation process (Section 3). MMT relies on an active role played by the central bank for its policy prescriptions to be implemented and this approach has often been stigmatised by its critics as a 'recipe for hyperinflation' (Section 4). In Section 5 we show that criticism based on the correlation between an (increased) monetary base and inflation cannot be supported by empirical evidence.

However, the impact of 'full employment' fiscal policies on the current-account position of a country seems to be one of the major critical points of the prescriptions elaborated within this theoretical framework. Even countries that are relatively high in the hierarchical international monetary and financial system cannot overlook problems related

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to the potential depreciation of their currency and its inflationary consequences. In Section 6 we discuss the approach of MMT to open-economy issues (exchange-rate determination and external constraints on economic policy). In Section 7 we test the JG programme in an 'ideal MMT world' via a stock–flow consistent (SFC) open-economy model, building on the benchmark created by Godley/Lavoie (2007). MMT endorses the sectoral balance approach to national accounting pioneered by the British economist Wynne Godley, and therefore this kind of macro model seems particularly suitable for the purpose.

The results of the simulations demonstrate that an MMT-style fiscal policy can be very effective in boosting employment even in a relatively open economy with flexible exchange rates. Yet the contention that the JG programme can achieve full employment without generating inflation does not find validation. MMT claims that the traditional trade-off between inflation and unemployment can be definitely averted, whereas our model tells a different story. These results are summarised in Section 9 (Conclusions), which also features a more general assessment of the MMT 'project'.

2 WHAT IS MMT?

In his Nobel Memorial Lecture (1982), the American economist James Tobin declared that

> macro-economic models of one brand or another are very influential. … They shape the thinking of policy-makers and their advisers about 'the way the world works'. They colour the views of journalists, managers, teachers, housewives, politicians, and voters. Almost everyone thinks about the economy, tries to understand it, and has opinions on how to improve its performance. Anyone who does so uses a model, even if it is vague and informal. (Tobin 1982: 172)

Although it is hard to question the influence of economic theories in politics and in the public debate, this influence is usually exerted in a very indirect way. Non-specialist readers rarely engage in the same debates that are taking place at an academic level. And often academic scholars try to keep their interventions directed to their peers and those directed to the wider public separated.

The outbreak of the global financial crisis in 2007–2008 has somehow loosened these barriers. The success of books such as Piketty's *Capital in the Twenty-First Century* (2014) is an example of the growing interest of the general public in economic theory and related topics. The debate on so-called modern monetary theory (MMT) is another case in point. In the US the circulation of ideas propounded by MMT authors has been further strengthened by the endorsement of popular political figures, such as the Democrat congresswoman Alexandria Ocasio-Cortez. The economist Stephanie Kelton, one of the main representatives of this group of scholars, has been chief economic advisor of the US presidential candidate Bernie Sanders. Her book *The Deficit Myth* (Kelton 2020) has featured in the best-selling list of non-fiction in *The New York Times*.

The outbreak of the COVID-19 pandemic, and the exceptional role played by governments and central banks all over the world to keep the economic system afloat, have made another contribution towards bringing heterodox economic ideas into the mainstream of public discussion.

All this attention for MMT has come with both positive and negative consequences. On the one hand, it has helped the public to understand better that economics is not a purely 'technical' discipline and economists can disagree on 'the way the world works' and what are the best policies to implement. The democratic 'eco-system' can surely benefit from a more pluralistic approach to economic debates. On the other hand, the discussion has sometimes been distorted by arguments that are the results of an oversimplification of what both

MMT theorists and their critics think and write. It has not been helped by the fact that the 'MMT world' comprises not only 'a core group of scholarly-driven' researchers, but also 'a more activist-driven group … . These activists are not, in most cases, scholarly-trained and often have limited knowledge of economics' (Rochon 2019: 157).

The publication of the first macroeconomics handbook from an MMT perspective (*Macroeconomics*, Mitchell et al. 2019) has been very important in providing an official reference of the core of the theory previously scattered through numerous publications and academic papers. The book will also be an important reference for this paper.

A special issue of the *Real-World Economics Review* (issue 89) has recently offered a good presentation of the 'state of the debate' on MMT, featuring contributions from supporters, adversaries and several other economists that cannot be easily classified in one field or another.

A complete literature review on MMT goes beyond the scope of this paper. In the rest of this section we will summarise some of the key points that characterise the theory, with a particular focus on the elements relevant to the treatment of inflation-related issues. Many of these ideas have for long time been part of the post-Keynesian tradition. In this context we are interested in discussing the ideas linked to MMT rather than their level of 'originality'.

> The most important conclusion reached by MMT is that the issuer of a currency faces no financial constraints. Put simply, a country that issues its own currency can never run out and can never become insolvent in its own currency. It can make all payments as they come due. For this reason, it makes no sense to compare a sovereign government's finances with those of a household or a firm. (Mitchell et al. 2019: 13)

The above statement is first of all grounded on a specific theory of money and its origin (Chartalism or neo-Chartalism in its latest developments), which ultimately derives from the work of Innes (1913; 1914), Knapp (1924) and Keynes (1930).

The reference to the 'sovereign government' in the quotation above is crucial. MMT authors assert that their theory only applies to governments with a sovereign currency. The definition of the latter is one of the most debated and controversial aspects of MMT.

Money is a creation of the state and taxes 'drive money': a certain currency is accepted as a means of payment – even when is not 'backed up' by precious metals, as in modern 'fiat currency' systems – because citizens know that they, or other fellow citizens, can pay taxes with it.[1] Two of the most important requirements[2] to qualify a currency as sovereign are: (i) the liabilities of the government must all be denominated in that currency (for example, government bonds cannot be denominated in a foreign currency such as the US dollar, if the government in question is not the US); and (ii) the government must adopt a floating exchange-rate regime (for example, its central bank should not promise to redeem the local currency for a fixed quantity of foreign currency). Although these and other requirements are often used for 'binary' classification of international currencies (for example, sovereign vs non-sovereign currencies), MMT authors such as Tymoigne/Wray (2013) and Tankus (2018) have underlined that monetary sovereignty is a 'spectrum' which features different degrees and levels of sovereignty. In any case, MMT-ers have strongly denied that their theory, and the policy prescriptions that go with it, only apply to the country that issues the currency used as an international reserve (the US). Countries that can be considered 'sovereign currency nations' from the point of view of MMT 'account for the vast majority of global GDP – perhaps well above 80%' (Wray 2019: 7).

1. For recent critical appraisals of the argument that 'taxes drive money', see Rochon/Vernengo (2003), Kregel (2019) and Prates (2020).
2. For a more detailed list, see Wray (2019: 5).

3 INFLATION AS EXPLAINED BY MMT

MMT's theory of inflation explicitly takes inspiration from the works of Keynes (1936; 1940) and Kalecki (1943). As Keynes put it in chapter 21 of *The General Theory*: 'When a further increase in the quantity of effective demand produces no further increase in output and entirely spends itself on an increase in the cost-unit fully proportionate to the increase in effective demand, we have reached a condition which might be appropriately designated as one of true inflation' (Keynes 1936 [2017]: 262). What Keynes called 'true inflation', MMT would call 'demand-pull' inflation. It occurs when the system reaches the point of full utilisation of its productive capacity, both in terms of capital utilisation and in terms of availability of workers. At this point, the government should curb inflation forces, cooling down the effective demand. This is another fundamental 'task' of taxes. We have already seen that from an MMT perspective taxes 'drive the money', in other words they make the money of account chosen by the state accepted for payments. 'The second reason to have taxes (once a currency is established and widely adopted) is to reduce aggregate demand' (Mitchell et al. 2019: 323) to keep inflation in control. In this way, 'taxes create real resources space in which the government can spend to fulfil its socio-economic mandate. Taxes reduce the non-government sector's purchasing power and hence its ability to command real resources, leaving real resources for the government to command its spending' (ibid.: 323).

That is not a trivial problem at all. In his recent critical assessment of MMT, Jan Kregel has pointed out that the real challenge in the main political issues of our time – such as the environmental risks and the 'green new deal' that has been advocated to combat them – rests on 'the availability of appropriate resources, and if there are none, the policy process of shifting resources to these uses' (Kregel 2019: 86). MMT-ers tend to respond to this kind of argument by stressing that in contemporary societies demand-pull inflation should be considered a limit case, given the fact that 'fortunately – or unfortunately depending on one's view – modern economies usually operate with sufficient slack' (Wray 2019: 7).

However, prices can rise, and an inflation phenomenon can materialise, even before the point of full capacity utilisation is reached. And this is not only due to the fact that in a productive system there are several bottlenecks and different sectors hit their maximum production at different moments in time, so that an 'inflation gap' can appear in certain industries even when in the system there are still idle resources.

MMT-ers reject the law of diminishing returns, therefore the increase in costs and prices that can follow an increase in production *before the point of full capacity utilisation* should not be explained through a decrease in productivity. Instead, MMT-ers endorse Kalecki's vision of inflation as the result of the distributional struggle over the respective shares of income between different sectors, or classes, of society. A higher level of employment, or a lower level of unemployment, can encourage workers to claim higher nominal wages, fostering a wage–price spiral.

Given the fact that for MMT-ers the achievement of full employment should be among the main duties of a government, instruments are required to manage in an orderly way the fundamental trade-off between inflation and employment that has been at the centre of macroeconomic debate since Phillips's famous paper[3] published in 1958.

A first tool is given by 'income policy': the Scandinavian model, based on the distinction between a competitive sector (where wages can only grow in line with productivity

3. The relationship between unemployment and inflation is usually referred to as the 'Phillips curve' in the economics literature, after the work of the New Zealand economist Alban William Phillips. Actually, the relationship studied by Phillips in his seminal 1958 paper was between unemployment and change in the nominal wage rate. What has become known as the Phillips curve is the price-level-modified curve built by Samuelson/Solow (1960).

gains and foreign inflation) and a sheltered sector (where wages should be aligned with those of the competitive sectors), is described in the MMT handbook (Mitchell et al. 2019: ch. 17) as a good example of the utilisation of this approach.

Yet the main idea put forward by MMT-ers for inflation management is the so-called buffer employment ratio (BER), which is strictly related with the proposal of the JG programme. The idea of the former can be traced back to the 1960s in the work of the American economist Hyman Minsky and his envisaging of the government as an 'employer of last resort' (Minsky 1965a; 1965b; 1967; 1973). In a nutshell: the government should ensure that workers who cannot find a job and would swell the ranks of the unemployed can receive a job offer from the government at a national minimum wage (for further and more recent developments of the original proposal, see Wray 1998; Tcherneva 2018; 2020; Wray et al. 2018; Cucignatto 2021).

The BER is defined as the ratio between people employed by the JG programme over the total employment in the economy. Evidently, the BER would be higher in a time of recession and lower in a time of expansion, as people tend to move to non-JG positions – where the wages are higher – when there is the possibility to do so. However, the BER could also be 'actively' used to manage the inflation pressures in the same way as the 'unemployment buffer stock' has traditionally been used under inflation-targeting monetary policy regimes.

If the economy were to get closer to full capacity utilisation the government could increase taxes (or cut expenditure) in order to diminish aggregate demand, raise the BER, and cool inflation.

Traditional (Keynesian) fiscal policies could still play a crucial role in cases of severe recessions to avoid deep slumps, or more generally when the system is far from its full potential. Yet, when the economy is in 'relatively good' health, only the JG, according to MMT-ers, can reach full employment without triggering an inflation spiral. Indeed, Keynesian policies focused on public expenditure

> attempted to maintain full capacity utilisation by 'hiring off the top' (that is, making purchases at market prices and competing for resources with all other sources of spending in the economy). In practice, these policies often focused spending on the most advanced sectors employing higher-skilled (usually unionised) workers in the defence sector, for example. (Mitchell et al. 2019: 304)

By contrast, the JG programme buys labour off the bottom, and in doing so does not contribute to the reinforcement of the distributional conflict and the related inflation tendency. MMT theorists think of the JG programme as part of a broader strategy carried out by the government to honour its 'social duties'. This strategy harks back to Abba Lerner's concept of 'functional finance':

> The first financial responsibility of the government (since nobody else can undertake that responsibility) is to keep the total rate of spending in the country on goods and services neither greater nor less than the rate which at the current prices would buy all the goods that is possible to produce. (Lerner 1943: 39)

Through the combination of traditional Keynesian fiscal policies and a JG programme, MMT claims to have overcome the once unavoidable trade-off between inflation and unemployment. The Phillips curve in an MMT world still exists, but it can be 'flattened' on the left-hand side at virtually any point, depending on the level of the BER.[4]

4. MMT theorists have also defined the concept of the NAIBER (the non-accelerating inflation buffer employment ratio). However, we think that this concept is highly problematic, given its evident link with the NAIRU (the non-accelerating inflation rate of unemployment). The NAIRU model is based on assumptions that seem incompatible with the MMT 'model'. At any rate,

4 HOW WILL YOU PAY FOR IT? MMT AND DEFICIT SPENDING

If the government needs to keep the total rate of spending in the country at a level that ensures full employment, one could raise the question: how should this spending be funded? The issue has been widely debated. Even among MMT theorists, the topic has not been tackled unambiguously. The tendency of many MMT-ers to consolidate the treasury and the central bank in a unique identity has created some confusion between the 'normative level' and the 'descriptive level' of the discussion (how the things *should* work and how they *actually* work). The positions have also evolved through time, as Lavoie (2013: 14) has pointed out in his analysis of the 'consolidation problem': 'Neo-Chartalists … have put some water in their wine, as the French say, admitting now that things are not as clear-cut as they originally seemed'.

When MMT-ers say the government does not need to borrow from the private sector before spending money, the stance could be interpreted in two ways: (i) the government *does not* borrow, and it initially uses the reserves credited by the central bank to its account at the same institution; and (ii) the government *does* borrow, but it *would not be necessary* to do that if the central bank credited the money to its account. The second interpretation is the one clearly suggested by Wray when he writes that 'since the Fed [Federal Reserve] is not supposed to allow "overdraft", Treasury will need to sell bonds over the course of the year even if it ends the year with total tax revenues greater than spending' (Wray 2019: 19).

There is a reason why MMT-ers have dwelt on the ambiguity for so long: it does not make so much difference to distinguish how the process started as long as it leads to identical outcomes *ex post*. When deficit spending takes place, the proportion between the currency emission (creation of the monetary base[5]) and government bonds bought by the private sector is 'determined by decisions made by households, firms, financial institutions' (Mitchell et al. 2019: 335) and that is why there could be no '*ex ante* decision of treasury to either borrow or print money' (ibid.: 335). Even if the central bank funded deficit spending by direct purchases of government bonds, the excess of liquidity injected into the system via government purchases of goods and services should be drained from the banking sector as long as the central bank wants to keep control of the overnight interest rate.[6] Draining excess monetary base from the system means selling government securities to it. And, again, only the 'decisions made by households, firms, financial institutions' can set the level of what is in 'excess'.

All this has huge implications for the theory of inflation. When critics of MMT say that its policy prescriptions are a recipe for (hyper)inflation, they usually refer to the process of currency emission that necessarily follows government-deficit spending. The link between the monetary base and the money supply assumed by the money-multiplier theory, and the link between the money supply and level of prices assumed by the quantitative theory of money, are often the background of the most alarmist outcries on the danger of MMT

since MMT-ers have not devoted any effort towards estimating country-specific NAIBERs and do not promote any policy of targeting a particular level of NAIBER, we can consider this concept as inessential to the overall picture.

5. From a purely theoretical point of view, we could even think of situations where there is no creation of a monetary base at all. This is the case when: (i) no reserve requirements are applied on commercial banks; or (ii) the private banking sector does not intervene in the purchase of government bonds and the latter are entirely bought by the public with their bank deposits.

6. This is what happens in 'normal times'. The central bank can also decide to push the overnight rate on the 'floor of the corridor' (meaning at the level of the deposit rate). And in this case the excess of liquidity is not drained from the system. However, this outcome can be produced even when there are no purchases of government bonds in the primary market by the central bank, as the experience of quantitative easing in the European Union has clearly demonstrated.

policies. An example of this approach – although with a much more moderate and dialogic tone – is the recent 'Skeptic's guide to modern monetary theory' by Gregory Mankiw (2020). This intervention is explicitly based on the assumptions of 'the mainstream view, explained most simply by the quantity theory of money, that a high rate of money creation is inflationary' (ibid.: 142). Mankiw adds that 'mainstream macroeconomists also go beyond the most simplistic quantity theoretic reasoning', but he also acknowledges that 'these ideas refine the quantity theory of money rather than refute it' (ibid.: 142).

In the next section, we will provide some empirical evidence to test the hypothesis that monetary-base creation could represent a factor of risk for inflationary or hyperinflation spirals.

5 THE MONETARY BASE AND INFLATION: EVIDENCE FROM RECENT US DATA

In order to assess the relationship between the monetary base and prices, we make use of structural vector autoregression (SVAR) modelling on US monthly data provided by the Federal Reserve Bank of St. Louis (FRED). We use the industrial production index (Y), the federal funds rate (FF), the level of prices (P) and the monetary base (MB). All time series are seasonally adjusted. They start from January 1959 and end in November 2019. All the variables – except the FF – are transformed in logarithm form and are reported in Appendix 1.

The first step consists of the estimation of a reduced-form $VAR(p)$, shown in equation (1):

$$y_t = c + \sum_{i=1}^{p} A_i y_{t-p} + u_t, \tag{1}$$

where y_t is the $k \times 1$ vector of considered variables, c is the constant term, A_i is the $k \times k$ matrix of reduced-form coefficients, and u_t is a $k \times 1$ vector composed of the error terms. The lag P of the VAR is calculated through the Akaike information criterion (AIC). As shown in Table A1 (Appendix 1), the optimal lag is 10. We have also checked the stationarity of the $VAR(p)$ by assessing whether the *inverse* roots of the characteristic polynomial lie inside the unit circle (Table A2, Appendix 1).

To obtain a SVAR, an identification strategy has to be imposed on the reduced-form $VAR(p)$ (equation (1)). More precisely, a $SVAR(p)$ can be represented by the following equation (2):

$$B_0 y_t = c + \sum_{i=1}^{p} B_i y_{t-p} + w_t, \tag{2}$$

where B_0 represents the matrix of contemporaneous relationships between the k variables in y_t, B_i is the $k \times k$ matrix of autoregressive slope coefficients, and w_t is the vector of structural shocks (Kilian/Lütkepohl 2017).[7] Once zero short-run restrictions are imposed in B_0 and the SVAR is estimated, impulse response functions (IRFs) are calculated. Standard errors are estimated through the Monte Carlo methods (1000 repetitions) and IRFs are reported with two-standard error bound, namely a 95 per cent confidence interval.

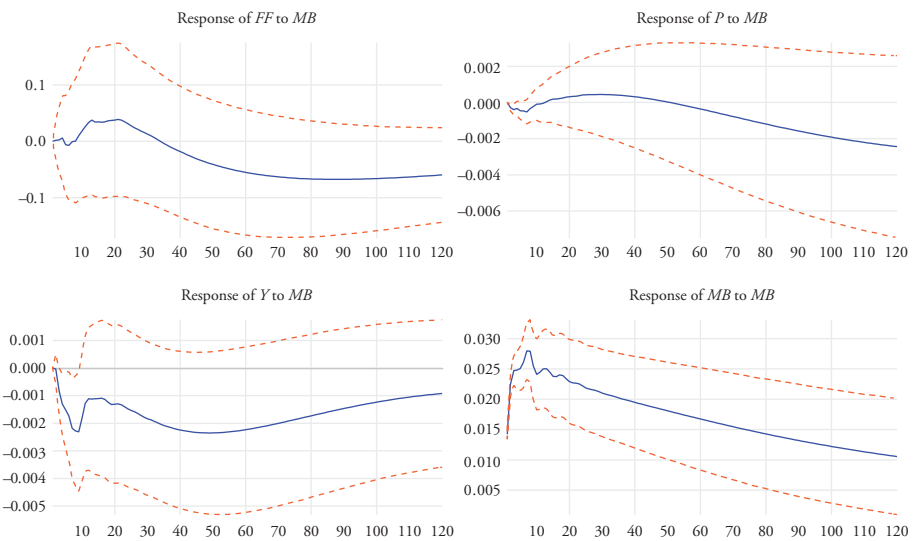
The identification strategy is based on Cholesky factorisation and variables have been ordered as follows: [FF_t; P_t; Y_t; MB_t]. In line with the post-Keynesian endogenous

7. The covariance matrix of structural errors is normalised: $\mathrm{E}(w_t w_t') = \sum_w = I_K$ (Lütkepohl 2005).

money theory (Lavoie 1996; 2020; Rochon 1999; 2001; Deleidi 2020), its empirical validation (Deleidi/Fontana 2019; Deleidi/Levrero 2019), and with the identification strategy used in Deleidi (2019), we assume an exogenous interest rate controlled by the Fed and endogenous monetary base (*MB*). As *MB* is ordered as the last variable, we are assuming that change in *FF*, *P* and *Y* can affect the monetary base within the monthly observation.[8] The model is estimated for all the available periods (1959M01–2019M11) and for the pre-financial crisis 'interval' (1959M01–2007M12).

Findings are reported in Figure 1 and 2 and – for the sake of simplicity – we discuss the effect of an increase in the monetary base (*MB*) on the level of prices (*P*). As shown in Figure 1, an exogenous increase in the monetary base *MB* (response of *MB* to *MB*) does not produce any positive effect on prices (response of *P* to *MB*). The same picture is confirmed in Figure 2 where the 1959M01–2007M12 interval is considered. Again, an increase in the monetary base does not trigger any positive pressure on prices. Therefore, our findings confirm the theoretical intuition of MMT-ers.

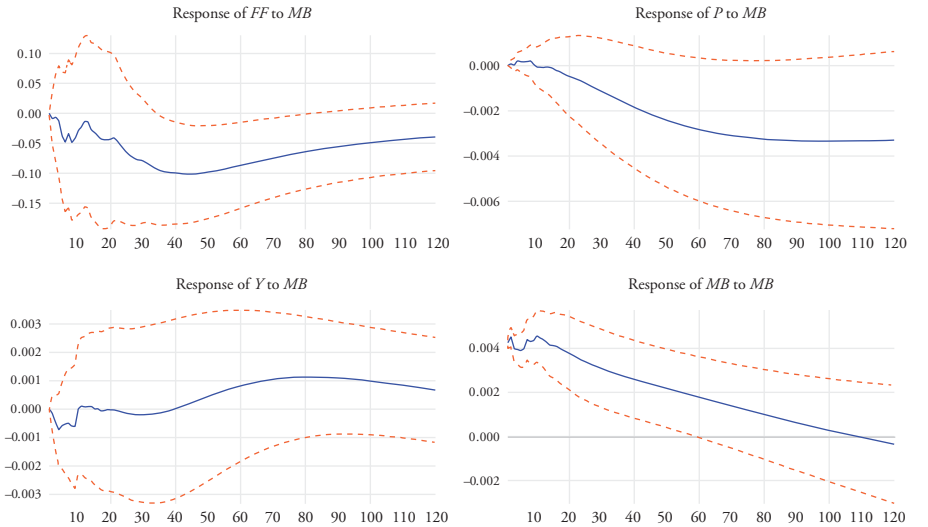
As mentioned at the end of Section 4, the exercise aims to test the hypothesis that is most commonly used to warn against the 'hyperinflationary consequences' of the MMT policy prescription. A 'direct' econometric test to measure the impact of the implementation of a JG programme on price levels cannot be conducted, since no country has ever introduced a similar measure. However, the model presented in Section 7 will shed further light on the complex relationship between public expenditure, monetary creation, and price level. Despite the fact that the JG will be initially funded directly by the (UK) central bank via



Notes: Solid lines are point estimates and dotted lines are the computed error bands. 95 per cent confidence interval bands estimated through a Monte Carlo procedure (1000 repetitions).

Figure 1 Impulse response functions (IRFs), 1959M01–2019M11

8. As a robustness check, we assume a second identification strategy where FF is ordered last, namely it is considered as an endogenous variable. Findings can be provided upon request and are in line with the ones obtained with our main identification strategy.



Notes: Solid lines are point estimates and dotted lines are the computed error bands. 95 per cent confidence interval bands estimated through a Monte Carlo procedure (1000 repetitions).

Figure 2 Impulse response functions (IRFs), 1959M01–2007M12

purchases of government bonds in the primary market, the *ex post* money creation will ultimately be decided by the independent decisions of the agents (commercial banks, households, regulators who set the legal requirements for the reserves-to-deposits ratio). That's why the model can perfectly adapt to simulating an institutional environment in which purchases of bonds by the central bank in the primary market are not allowed. Furthermore, in Section 8 it will be shown how different policy scenarios can generate different inflationary outcomes despite the same level of *ex post* monetary creation.

6 MMT AND THE OPEN ECONOMY

The inflation mechanisms explained in Section 3 do not consider problems related to the degree of openness of an economic system to the international trade of goods and financial assets. This is partly related to the fact that MMT analysis of open-economy issues is relatively scarce. MMT-ers think that a floating exchange-rate regime is necessary for a currency to be sovereign. That is why they promote the adoption of this kind of institutional arrangement. But once this condition is held, the theory seems to suggest that there is no external constraint on the economic policy of a country apart from self-imposed limitations (Vergnhanini/De Conti 2018).

The first reason for this kind of attitude is that there is no clear, 'official' MMT theory on exchange-rate determination. In chapter 24 of the MMT 'handbook' ('Policy in an open economy: exchange rates, balance of payments and competitiveness') it is presented as a simple model for exchange-rate determination based on the trade balance. Yet the model is dismissed by the authors themselves when they state that 'the simple supply and demand approach presented in this section really cannot explain exchange rate determination in the real world. The most important flaw in this approach is the focus on

international trade in goods and services. In reality, financial transactions are many orders of magnitude greater' (Mitchell et al. 2019: 381). Strangely, this approach is even attributed to 'mainstream economists', while 'the alternative approach follows Keynes's theory, which focuses on asset market' (ibid.: 382). Then the covered interest parity theory is presented as the 'Keynesian approach'.

This classification is at least arguable. Economists who follow the Keynesian school often disagree on exchange-rate determination theories. The so-called Harrodian open-economy tradition 'puts a substantial amount of weight on the trade flows' in the determination of exchange rates (Lavoie 2015: 493). The model presented in the present paper follows the Harrodian tradition in modelling the external position of a country and assessing the impact of a current-account deficit (surplus) on the value of a currency.[9] It borrows from the well-known OPENFLEX model featured in Godley/Lavoie (2007), the mechanism for the determination of the exchange rate. While both trade and financial flows contribute to the determination of the value of a currency, the absence of the traditional assumption of perfect substitutability of financial assets implies that the long-run trend of the exchange rate is mainly driven by the position of the current account (for a detailed analysis of this mechanism, see Carnevali 2021). However, as will become clearer by the end of Section 7, the results of the simulations conducted via this model are *not* inconsistent with the conclusions one could draw from the assumption that financial transactions play a major role in the determination of exchange rates.

The second reason why no external constraints seem to be assumed by MMT theorists lies in their confidence towards the liquidity of foreign-exchange markets. This is quite a brave hypothesis for countries and currencies low in the hierarchical international monetary and financial system. In the case of a current-account deficit,

> the 'virtue' of flexible exchange rates seems to be predicated on the notion that the foreign exchange market will quickly find a new lower clearing price as demand for a currency falls, but in many DEC [developing and emerging countries] quantity constraints might prove tremendous: if foreigners and domestic agents [of a DEC running an external deficit] want to exchange domestic currency for US dollars, it will take a mighty fall in the price of domestic currency to stimulate any actor to buy it. (Bonizzi et al. 2019: 47)

Moreover, in most extreme cases, both foreign nationals and domestic agents can refuse to accept the domestic currency (Bonizzi et al. 2019).

We agree with Bonizzi et al. that this represents a fairly solid constraint for DECs. Indeed, as pointed out by Prates (2020: 503), 'currencies are hierarchically positioned according to their degree of liquidity' and therefore illiquidity of foreign-exchange markets for peripheral currencies issued by DECs is *by definition* a policy constraint these economies face. According to Prates, currency sovereignty should be considered together with the position of the currency in the international hierarchy to define the real policy space enjoyed by a country even in the context of flexible exchange rates. Two additional caveats should be taken into account: (i) both currency sovereignty and the position in the

9. Since economists who follow the Keynesian school often disagree on exchange-rate determination theories, we acknowledge this is not the only possible approach. Many (post-)Keynesian scholars follow the tradition developed in particular by Harvey (1991; 2012; 2021), according to whom 'currency-prices are driven by short capital flows. Those flows are in turn a function of agents' expectations' (Harvey 2012: 187). For a comparison between the Harrodian models of the open economy and Harvey's model, see Lavoie (2015: ch. 12).

hierarchy are defined through different incremental levels (degrees of sovereignty and distance from the key currency), allowing for a wide spectrum of combinations of outcomes or policy constraints; and (ii) emerging economies very rarely adopt a pure floating exchange-rate regime: even without a fixed exchange-rate regime, the central banks of these countries often intervene to limit the volatility of the exchange rate (Prates 2020).

Similar criticism of MMT for its disregard of external constraints with regard to emerging economies, even in the context of flexible exchange rates, is raised by Epstein (2020) and Vernengo/Pérez Caldentey (2020).

The model presented in the next section is based on the assumption that a relatively smooth adjustment of the exchange rate takes place.[10] Therefore, it is more appropriate to study the economic dynamics of the world's major currencies.[11] Yet, even in these cases, we agree with Sawyer (2019) that an external deficit position does pose some problems to the world's major currencies that are *not the dollar*, its inflationary consequences being the most relevant.

This should not discourage governments to make use of fiscal policy to achieve its aims. The model presented in the following section differs from most 'mainstream' approaches to open-economy models because it demonstrates the effectiveness of fiscal policy even in the context of a relatively open economy with flexible exchange rates. However, the viewpoint of MMT-ers, that inflation can actually be ruled out through measures like the JG programme, can be challenged if one considers the impact of exchange-rate devaluation on import prices and, via import prices, on domestic prices.

7 AN MMT 'FISCAL EXPANSION' IN AN OPEN-ECONOMY SFC MODEL

One of the most original and valuable characteristics of the MMT 'handbook' is that it explains the national accounts from a sectoral-balance perspective along with the work of the British economist Wynne Godley. MMT, as per many other post-Keynesian strands of research that are part of the so-called New Cambridge approach, recognises that flows feed stocks and the latter feed back into the dynamics of the flows of an economic system.

For this reason, a stock–flow consistent (SFC)[12] model seems the most appropriate framework to test fiscal policy conducted along with the prescriptions of MMT in an open-economy context.

10. External constraints are not the only reason why it is wise to limit the model we are presenting to advanced economies. The JG is supposed to guarantee 'the level of income necessary for a full-time worker to enjoy an adequate social and material existence' (Mitchell et al. 2019: 302). In DECs, large portions of workers in the private sector may well be below this threshold, meaning that the introduction of a JG programme would pose a major disruption to the private-sector wage structure. The analysis of the consequences of this kind of disruption for the feasibility of the JG programme goes beyond the scope of this paper.

11. In the monetary-sovereignty–currency-hierarchy taxonomy presented in Prates (2020), these currencies/countries would fall mainly in box 2 of fig. 3 (ibid.: sec. 5).

12. The attempts to 'translate' the tenets of MMT policy proposals into a fully formalised mathematical model are rare. One of the first was Aspromourgos (2000), while a more recent example is featured in Colacchio/Forges Davanzati (2020), where the authors use a Keynesian stock–flow closed-economy model to test the 'employer of last resort' hypothesis and to put forward a proposal of the state as 'innovator of first resort'. Other authors use SFC models to compare a JG plan with conventional government spending (Godin 2014; Sawyer/Veronese Passarella 2021).

The model presented here – the MTO[13] model – builds on the basic structure of the OPENFLEX model featured in Godley/Lavoie (2007). The latter constitutes the 'centre of gravity of the open economy SFC literature' (Nikiforos/Zezza 2017: 1220).

As per the OPENFLEX model, ours is a two-country SFC open-economy model with flexible exchange rates. We have seen in Section 2 that a floating exchange-rate regime is essential to qualify a currency as sovereign. For explanatory purposes, we have called the two countries/blocks the United Kingdom (UK) and the European Union (EU). The UK is for MMT-ers an example of a country with full monetary sovereignty. However, the pound sterling is not the dollar: its position in the international hierarchy of currencies is relatively high, but it has a very limited role as an international reserve and an international means of payment.

All the parameters,[14] the variables, the equations and the matrices of the MTO model are presented in Appendices 3–5.

Conversely to the OPENFLEX model, the MTO model includes a sector of commercial banks, which is essential to recreate the 'narrative' of a hypothetical 'MMT world' in which the (UK) government increases its expenditure to implement a JG programme and the treasury is initially funded directly by the (UK) central bank.[15]

At the beginning (period 0), all the stocks of the model are set at zero. The accumulation of income and wealth is triggered by the first act of spending by the two governments/blocks.[16] This is consistent with the MMT's contention that 'government must spend (or lend) the currency into the economy before taxpayers can pay taxes in the form of the currency. Spend first, tax later is the logical sequence' (Mitchell et al. 2019: 323).

Once that the model reaches the steady state, it is ready to be 'shocked' with a variation of UK government spending for the JG programme to test its inflationary effects.

13. 'MTO' is the acronym for **M**MT **T**est in an **O**pen-economy model. Its code can be provided upon request.

14. As the MTO is a theoretical model, most of its parameters are borrowed from the OPENFLEX model. 'Reasonable values' have been given to the parameters of the new equations. However, sensitivity tests have been conducted to check the robustness of the results of the simulations presented in the paper to changes in the values of parameters. From a 'quantitative' perspective, the key parameters that affect the results of the simulations (in terms of change in GDP, change in prices, devaluation of the currency, etc.) are: (i) the constants of import and export equations ($\varepsilon_0$and μ_0 in equations (A13) and (A14) in Appendix 5; the values of the constants have been set to obtain a volume of UK imports from the EU equal to 16 per cent of UK GDP, which approximates the actual average in recent years); (ii) the elasticities of the import and export volumes with respect to the GDP of the countries ($\varepsilon_2$and μ_2 in equations (A13) and (A14) in Appendix 5); and (iii) the coefficients of the exchange-rate pass-through to import and export prices ($v1$ and $u1$ in equations (A41) and (A42) in Appendix 5). From a 'qualitative perspective' (direction of change of the variables) the results of the simulations are independent from the values of these parameters (as far as they are kept into a 'realistic and reasonable range').

15. As we have seen in Section 2, nothing changes – in the outcome *ex post* – if we rule out a direct purchase of treasury bills by the central bank as far as we can assume a sufficient demand for treasury debt by the private sector (commercial banks and savers). In turn, this assumption can easily be made as far as the central bank intervenes in the secondary market. A strength of the MTO model is represented by the fact that different 'narratives' can be deployed with the *same* system of equations, because the latter captures the outcome *at the end* of each period.

16. For the sake of simplicity, in the MTO model the European governments are consolidated into a single entity.

Indeed, total government expenditure ($g^{£}$) is given by the sum of a conventional, 'base' component ($g^{£}_{base}$), a JG component ($g^{£}_{jg}$[17]), and a money transfer component ($gmt^{£}$):

$$g^{£} = g^{£}_{base} + g^{£}_{jg} + gmt^{£}. \quad \text{(A84)}^{18}$$

Let's assume the UK government wants to implement a project at a cost of £2 billion. It sells government bills to the UK central bank. The treasury's account at the central bank is credited by £2 billion. When the government hires JG workers, £2 billion are transferred to the (private) bank accounts of these workers and the reserves of the commercial banks at the central bank are credited by £2 billion. Some of these reserves are used to provide cash to bank-account holders. Some are assumed to be 'set aside' to respect the target of the reserves-to-deposits ratio (10 per cent in the model[19]). Even so, at this point there is an excess of reserves held by commercial banks. If the central bank wants to keep control of the interest-rate target it must drain the glut of reserves from the system by selling government bills to the commercial banks. In any case, banks are assumed to be always willing to invest reserves in purchases of government bills because of the differential between the yield of these securities and the deposit rate (which in the MTO model is zero). That is why the quantity of government bills held by the UK banking sector ($B^{£}_{bank}$) always ends up being the difference between the deposits of UK citizens ($DEP^{£}_{bank}$) and the reserves ($RES^{£}$):

$$B^{£}_{bank} = DEP^{£}_{bank} - RES^{£}. \quad \text{(A99)}$$

Obviously, in the case of the £2 billion project, the increase of government bills held by the UK banking sector ($\Delta B^{£}_{bank}$) is nothing but the difference between the variation of UK citizens' deposits ($\Delta DEP^{£}_{bank}$) and the variation of reserves ($\Delta RES^{£}$).

The currency emission (monetary base) generated by the policy is not given by the £2 billion initially credited to the government account at the central bank, but by the *additional* monetary base ($\Delta H^{£}_{s}$) left in the system at the end of this cycle of operations:

$$\Delta H^{£}_{s} = \Delta H^{£}_{h} + \Delta RES^{£}. \quad \text{(A75)}$$

Both $\Delta H^{£}_{h}$ (additional cash held by UK citizens) and $\Delta RES^{£}$ are ultimately determined by the choices of UK households on how they want to allocate the additional saving generated in the system by the government deficit and its 'multiplier effect'.

The mechanism captured by the equations above (together with the other equations of the MTO model) gives shape to the idea that there is no '*ex ante* decision of treasury to either borrow or print money' (Mitchell et al. 2019: 335). Rather, 'it is an *ex post* … outcome … determined by decisions made by households, firms, financial institutions, the central bank and even foreign investors' (ibid.: 335).

With respect to the structure of prices, the MTO model encompasses a slightly more advanced arrangement in comparison with the OPENFLEX model. Domestic inflation is

17. A similar way of modelling the JG programme is featured in Colacchio/Forges Davanzati (2020).
18. We are following the numbering of the equation in Appendix 5, where the whole list of equations is given.
19. This is an arbitrary value, since in the UK there is no legal reserve requirement. However, nothing changes in the dynamics of the model if a different value is used.

not measured via the GDP deflator any more. A mark-up ($\varphi^{£}$) rule on unit costs $UC^{£}$ is used for the price level of the goods 'made in Britain' ($p^{£}_{madeUK}$):

$$p^{£}_{madeUK} = \left(1 + \varphi^{£}\right) UC^{£}. \tag{A45}$$

Other equations set the price (index) of: UK import (equation (A39)), UK export (equation (A40)), UK total sales (equation (A45)), UK domestic sales (including import, equation (A47)).

One of the key assumptions behind the MMT representation of the labour market is that the intervention of the government as an employer of last resort does not put upward pressure on the wages of non-JG workers. First, 'there might be little perceived difference between unemployment and a JG job for a highly paid worker' (Mitchell et al. 2019: 304); second, 'JG workers would constitute a more credible threat to the current private sector employees than say, the long term unemployed' (ibid.: 304). This assumption is captured in equations (A51)–(A60) of the MTO model (see Appendix 5). The wage rate of the 'private' sector[20] ($W^{£}$) depends on a 'standard' component[J1] ($W^{£}_{s}$) and a rate of increase ($W^{£}_{inc}$). The latter is driven by a 'fictional' unemployment rate ($UN^{£}_{p}$) that does not count JG workers as 'employed'. When $UN^{£}_{p}$ goes below a certain threshold ($winf^{£}$[21]), the mechanism that fuels increments in the wage rate is triggered. This means that JG workers cannot *directly* impact the level of wages of the private sector. The JG programme can impact $W^{£}$ only as far as it contributes to a higher level of employment in the 'private' sector.

Now we can test the effects of a JG programme. In 2020 the government invests £2 billion in the $g^{£}_{jg}$ component, which was set at 0 in the baseline. Figure 3 shows the behaviour of the system of prices after the implementation of the policy and the level of employment. Note that in the baseline scenario (steady-state) inflation equals zero as all prices are constant.

As it is evident from Figure 3, all price indexes increase after the 'shock' and they continue to grow for several periods. The inflation phenomenon is first linked to the current-account deficit which is originated by the expansionary fiscal policy. The external deficit puts downward pressure on the pound, as the increase in the demand for euros is not matched by an equal increase in the demand for pounds. In turn, the depreciation of the sterling affects export and import prices. Domestic prices rise as import prices are a component of them. Note that the model tends to *underestimate* the impact of currency devaluation on domestic prices for two reasons: (i) For the sake of simplicity, the MTO is a pure 'labour economy'. There are no (imported) intermediate goods that enter the production process and therefore the increase of import prices in UK does not affect the price of UK 'home-made' merchandise. (ii) For the sake of realism, the model assumes a partial pass-through of the exchange rate to import (and export) prices as a certain degree of strategic behaviour by EU (and UK) exporters cannot be ruled out. A partial pass-through is a necessary condition for the stability of SFC open-economy models too (Carnevali et al. 2020).

Table A3 in Appendix 2 reports different levels of increase of domestic prices 20 periods after the fiscal expansion, given different sets of parameters. In every case, the JG programme's implementation is followed by a long-lasting depreciation of the currency and domestic inflation.

20. We have used the expression 'private' sector for the sake of simplicity. In more advanced versions of the model, a distinction could be made between workers hired by private firms and public employees/civil servants, meaning workers hired by the government *not* within the JG programme.
21. $winf^{£}$ has been initially set at 5.5 per cent. Of course, the lower $winf^{£}$ is, the lower will be the wage inflationary pressure.

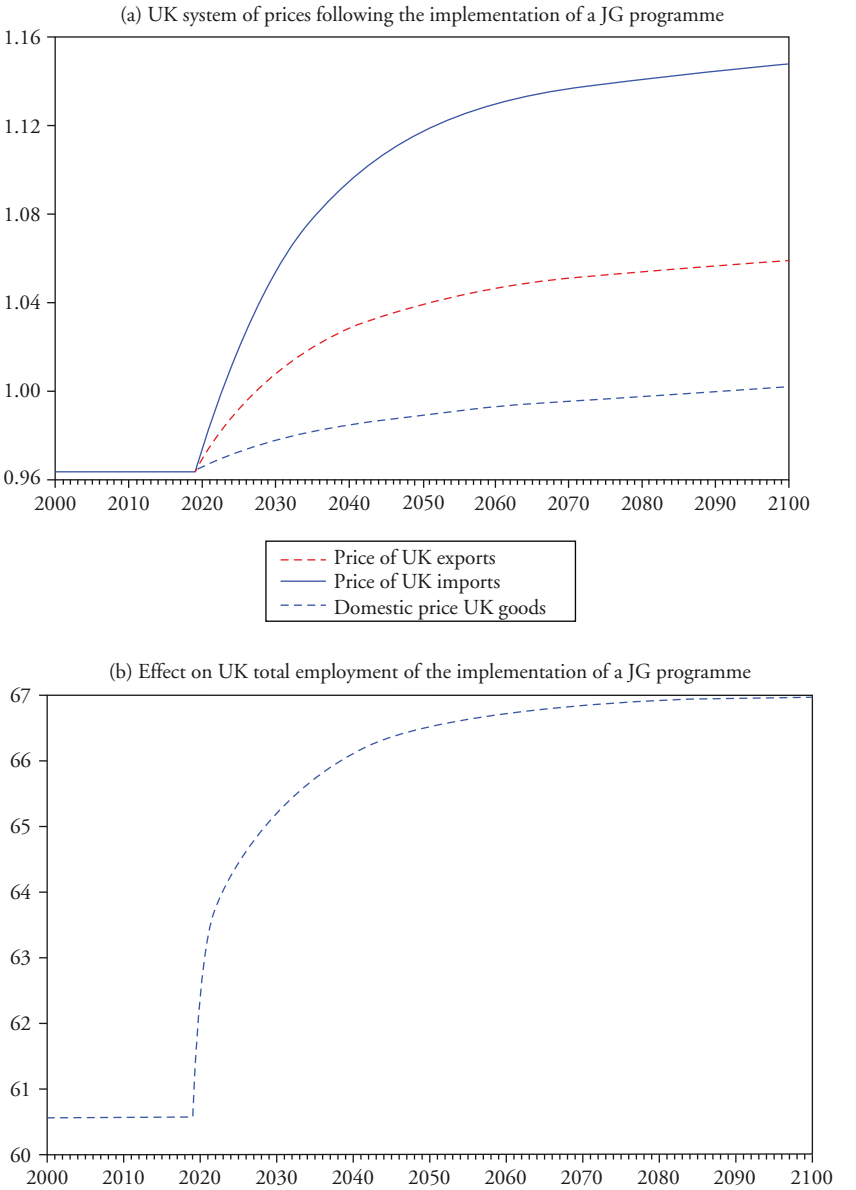


Figure 3 UK prices and UK employment following the implementation of a JG programme

There is also a second component which contributes to the rise of prices. Although we have seen that wage inflation is only linked to a 'fictional' unemployment rate ($UN_p^{£}$) which does not count JG workers as 'employed', the implementation of a JG programme put money in the pockets of formerly unemployed people. These people, in turn, spend the money in the

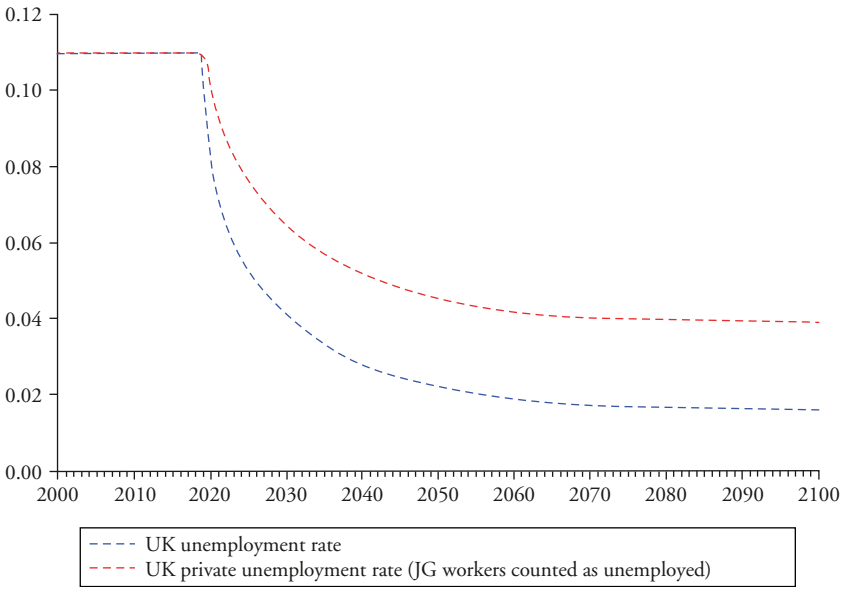


Figure 4 UK unemployment rate following the implementation of a JG programme

'private' sector, which has to hire more workers to keep up with the level of higher demand. Therefore, unemployment in the 'private' sector decreases, as shown in Figure 4.

The precise impact of lower 'private' unemployment on wages, and on prices, will depend on the parameters chosen in equations (A51)–(A60). When $winf^{£}$ is chosen to be low enough (for example, 0.035) to avoid wage increases due to low 'private' unemployment, the MTO model can show the 'pure' effect of the currency devaluation channel (see Figure 5).

Simulations conducted with the MTO model show that even in a relatively open economy with flexible exchange rates, expansionary fiscal policy that takes the form of a JG programme can be very effective in boosting the level of employment as far as there is spare production capacity in the system. The JG is supposed to buy labour off the bottom and therefore it should not put pressure on wages even when the economy approaches full employment. However, it seems that the trade-off between inflation and employment cannot be completely bypassed. First of all, inflation is imported via the external channel. That's not necessarily bad news. The depreciation of the currency is at the core of the rebalancing mechanism that allows the UK to stabilise the trade deficit and close the current-account deficit in the medium–long run despite the permanent higher level of income and employment. Second, the JG programme boosts employment even in the 'private' (non-JG) sector, and this can be a second channel of inflation transmission through higher wages.

The Phillips curve, which in an 'MMT world' was thought to be tamed into a flat line thanks to the JG programme, still looms in its very original form of a 'policy menu'.

It is worth noting that, as anticipated, it is possible to come to similar conclusions from a theoretical approach, which attributes a major role to financial transactions in the determination of the exchange rate. Even if a large current-account deficit does not *directly* generate a depreciation of the currency, no country (other than the United States) can sustain a large current-account deficit indefinitely. The readjustment can be conducted via

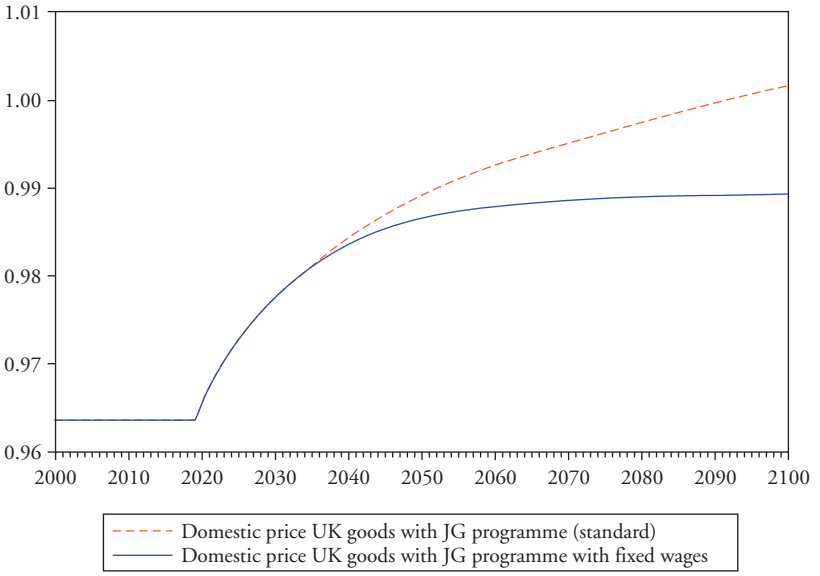


Figure 5 UK system of prices following the implementation of a JG programme: standard wage inflation parameter (0.055) vs low wage inflation parameter (0.035), which brings about fixed wages since the 'fictional' unemployment rate never goes below 3.5 per cent in the simulations

different means. Once those austerity measures are taken off the table, a depreciation of the currency is necessary. It could come through lower interest rates, or it could be ushered in 'spontaneously' by market expectations, which position the nominal exchange rate where they think it would have been positioned by monetary policy, in an active attempt to close the current-account deficit. Either way, inflationary pressures are likely to follow.

8 JOB GUARANTEE VS UNIVERSAL CREDIT

In the UK – as in other advanced economies[22] – people who are out of work can rely on a series of income-support benefits. The first 'layer' is made up of unemployment insurance proportional to the national insurance contributions that were paid (the more you paid when you were employed, the more you receive when you are unemployed; this is the logic behind the so-called 'New Style Job Seeking Allowance' in the UK). The second 'layer' provides a 'safety net' for people who are not protected by the first 'layer'. Universal Credit (UC) was introduced with the Welfare Reform Act in 2012 to replace six different benefits[23] for working-age, low-income citizens. It is by far the most important benefit of

22. The following examples are focused on the UK because, for explanatory purposes, the first block/country of the model presented in the previous section was the UK. Obviously, analogous conclusions apply to other welfare systems with a similar structure.
23. Income-Based Employment and Support Allowance, Income-Based Jobseeker's Allowance, Income Support, Child Tax Credit, Working Tax Credit, and Housing Benefit.

the British welfare system (as of June 2021, 5 966 262[24] individuals were receiving it, according to Stat-Xplore). It has superseded the old 'Income-Based Jobseeker's Allowance' which provided a basic money transfer for unemployed people who could not claim the 'Contributory-Based Job Seeking Allowance' (the antecedent of the 'New Style Job Seeking Allowance'). The standard monthly allowance for single claimants aged over 25 is £324.84.[25] UC is subject to a series of conditions, one of the most stringent being that a household's savings cannot exceed £16 000.

Within the British welfare system, the JG programme can be considered an alternative to this second layer of income: 'the government may offer workers the choice between the JG wage and the unemployment benefit, with the latter being lower' (Mitchell et al. 2019: 302). Under the hypothesis that the JG jobs are paid at the minimum wage, claimants involved in the JG programme could get a salary that would most of the time[26] be higher than the UC.

In the following simulation we compare three scenarios: (i) the JG programme tested in Section 7; (ii) a Keynesian stimulus that would achieve the same level of unemployment reduction as the JG programme, but would be concentrated on traditional sectors such as defence, energy, education and research;[27] and (iii) A UC 'additional programme' directed to the same number of individuals involved in the JG programme (we can assume these are people with savings above the £16 000 threshold who cannot receive standard UC). The cost of the UC 'additional programme' is supposed to be 3/4 of the cost of the JG, as the money transfer for each claimant is smaller than the minimum-wage monthly salary. The results of the simulation are shown in Figure 6.

Figure 6 shows that unemployment falls much more steeply in scenarios 1 and 2, as these are policies directly targeted to hire unemployed people. The reduction of unemployment under the UC 'additional programme' is due to the 'indirect' effect of the increase in public expenditure. We have already seen in Section 7 that the JG programme comes with an inflation phenomenon in the periods following its implementation. However, the increase in the level of domestic prices is lower with the JG programme than with a traditional Keynesian stimulus (see Figure 6a). This gap reflects different impacts of the two policies on the labour market and the wage increase. The UC 'additional programme' carries the least significant effect in terms of inflation.

Having said that, supporters of the JG programme would certainly point out that the preferability of this approach with respect to a traditional UC-style money transfer should be found also in the 'self-esteem' that the working condition generates in individuals. The reinforcement of the 'community ties' and of the 'social contract' is also considered a desirable effect of the JG.

Lastly, it is worth noting that despite the fact that scenarios 1 and 2 are linked to different outcomes in terms of price levels, they generate the same level of *ex post* monetary creation. This provides further evidence to the arguments presented in Section 5.

24. Before the COVID-19 pandemic there were 2 915 508 recipients of UC (per Stat-Xplore), but the transition from the legacy system had just started. It is forecast that just under 7 million households are expected to receive UC when it is fully rolled out (Kennedy/Keen 2018).
25. On top of this first component, the claimant can receive additional support via the housing element, the child element of the benefit, or due to individual disabilities. The allowance is different for claimants who apply as a couple.
26. As stated in the previous footnote, the exact amount of UC depends on individual circumstances, meaning on the components the claimant is eligible to receive.
27. As far as the expenditure is concentrated in these sectors, we can regard it as a 'hire off the top' approach.

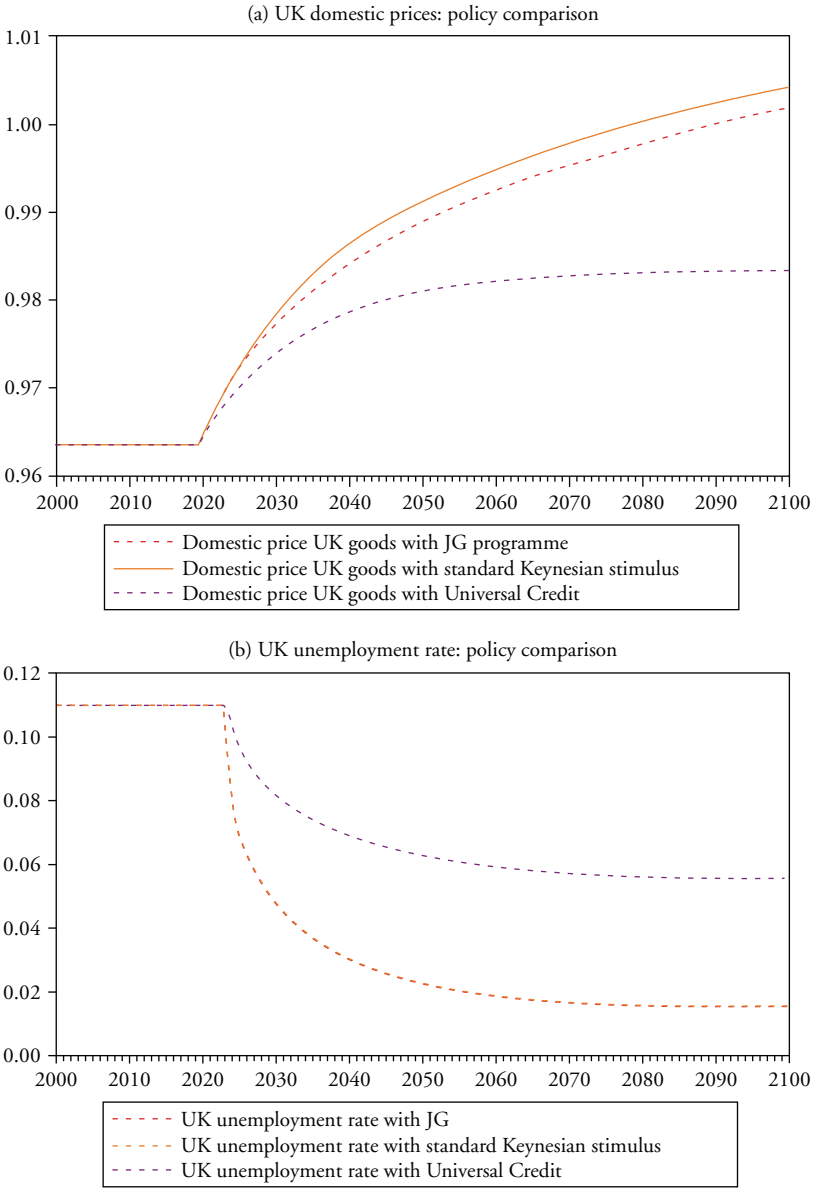


Figure 6 UK prices and UK unemployment following three policy scenarios: JG programme, standard Keynesian stimulus, and UC programme

9 CONCLUSIONS

In 2013 Marc Lavoie published a paper entitled 'The monetary and fiscal nexus of Neo-Chartalism: *a friendly critique*' (emphasis added). Our paper shares the same purpose of developing a 'friendly critique'. This time the critique is directed at the neo-Chartalist

theory of inflation from *an open-economy perspective*. We appreciate the role played by the MMT 'project' – especially in the US – to relaunch the debate on the use of fiscal policy to fight against unnecessary unemployment. We also think that MMT theorists' efforts also to address non-specialist readers should be credited for improving the pluralism of democratic public debate, too often dominated by unquestioned 'mainstream neoclassical' economic dogmas. We agree with MMT theorists that fears of a hyper-inflation, Weimar-style tragedy that are put forward by some of their critics are often misplaced. And we have provided empirical evidence in support of this counter-criticism.

However, from an open-economy perspective, the 'inflation challenge' cannot be overlooked even in an ideal 'MMT world', where a JG programme is assumed to be implemented with the support of an active central bank.

With the use of an SFC open-economy model we have tested the claim of MMT that it is possible to obtain simultaneously a dramatic increase in employment and a flat Phillips curve, as far as we deal with a country whose currency is fully sovereign. Our simulations show that some degree of trade-off between inflation and (un)employment is unavoidable in a flexible exchange regime. We have also compared the effect of the JG programme with a traditional money transfer directed to unemployed citizens. Again, a similar trade-off emerges.

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APPENDIX 1 LIST OF VARIABLES OF THE SVAR MODEL (SECTION 5)

St. Louis Adjusted Monetary Base, Billions of Dollars, Monthly, Seasonally Adjusted, URL: https://fred.stlouisfed.org/series/AMBSL (*MB*).

Consumer Price Index for All Urban Consumers: All Items in U.S. City Average, Index 1982-1984=100, Monthly, Seasonally Adjusted, URL:
https://fred.stlouisfed.org/series/CPIAUCSL (*P*).

Effective Federal Funds Rate, Percent, Monthly, Not Seasonally Adjusted, URL:
https://fred.stlouisfed.org/series/FEDFUNDS (*FF*).

Industrial Production Index, Index 2012=100, Monthly, Seasonally Adjusted, URL:
https://fred.stlouisfed.org/series/INDPRO (*Y*).

Table A1 Lag order selection and Akaike information criterion (AIC)

Lag	AIC
0	6.47645
1	−19.96895
2	−20.71291
3	−20.80939
4	−20.81259
5	−20.81982
6	−20.81391
7	−20.79670
8	−20.81840
9	−20.83102
10	−20.84942[a]
11	−20.84583
12	−20.83322

Note: a. Minimum value.

Table A1 suggests that the optimum lag is 10 and, in Table A2, the estimated VAR satisfies the stability condition as no root lies outside the unit circle.

Table A2 Roots of the characteristic polynomial

Root	Modulus
0.997985 − 0.001705i	0.997986
0.997985 + 0.001705i	0.997986
0.977646 − 0.023229i	0.977922
0.977646 + 0.023229i	0.977922
0.878778	0.878778
0.875973 − 0.057994i	0.877891
0.875973 + 0.057994i	0.877891
0.695645 + 0.531504i	0.875453
0.695645 − 0.531504i	0.875453
0.168687 + 0.844703i	0.861382
0.168687 − 0.844703i	0.861382
0.287958 − 0.805013i	0.854965
0.287958 + 0.805013i	0.854965

(continues overleaf)

Table A2 (continued)

Root	Modulus
0.630568 + 0.567313i	0.848210
0.630568 − 0.567313i	0.848210
−0.501079 − 0.678946i	0.843830
−0.501079 + 0.678946i	0.843830
−0.780170 + 0.233542i	0.814375
−0.780170 − 0.233542i	0.814375
−0.340462 + 0.731774i	0.807098
−0.340462 − 0.731774i	0.807098
0.204251 − 0.754180i	0.781349
0.204251 + 0.754180i	0.781349
−0.779425	0.779425
−0.331816 − 0.701523i	0.776039
−0.331816 + 0.701523i	0.776039
0.672403 − 0.359066i	0.762269
0.672403 + 0.359066i	0.762269
−0.654727 − 0.338295i	0.736960
−0.654727 + 0.338295i	0.736960
0.496085 − 0.507795i	0.709899
0.496085 + 0.507795i	0.709899
−0.094214 + 0.701335i	0.707635
−0.094214 − 0.701335i	0.707635
−0.631798 − 0.134495i	0.645955
−0.631798 + 0.134495i	0.645955
−0.336958 + 0.523143i	0.622270
−0.336958 − 0.523143i	0.622270
0.580882	0.580882
0.139940	0.139940

APPENDIX 2 SENSITIVITY TESTS AND MATRICES OF THE MODEL

Table A3 Sensitivity test: change in UK domestic prices 20 periods after the implementation of the JG programme (results for different sets of parameters)

v_1	u_1	ε_0	μ_0	ε_2	μ_2	$winf^{£}$	% change in domestic prices
0.8	0.4	−1.800	−1.800	1.000	1.000	0.055	2.10%
0.8	0.4	−1.800	−1.800	**0.900**	**0.900**	0.055	1.03%
0.8	0.4	−1.800	−1.800	**1.100**	**1.100**	0.055	4.30%
0.8	0.4	−1.800	−1.800	**1.200**	**1.200**	0.055	9.64%
0.8	0.4	**−2.000**	**−2.000**	1.000	1.000	0.055	1.58%
0.8	0.4	**−1.600**	**−1.600**	1.000	1.000	0.055	2.77%
0.8	0.4	−1.800	−1.800	1.000	1.000	**0.035**	2.03%
0.8	0.4	−1.800	−1.800	1.000	1.000	**0.065**	2.22%
0.9	**0.3**	−1.800	−1.800	1.000	1.000	0.055	2.90%
0.7	**0.5**	−1.800	−1.800	1.000	1.000	0.055	1.49%

Note: The bold values are the ones that differ from the standard values used for the simulations shown in the paper.

Table A4 MTO model transactions–flow matrix

	UK households	UK firms	UK banks	UK government	UK C. B.		EU households	EU firms	EU banks	EU government	EU C. B.	Sum
			all in £			Exch. rate			all in €			
Consumption	$-C^{£}$	$+C^{£}$	–	–	–	–	$-C^{€}$	$+C^{€}$	–	–	–	0
Gov. Expend.	–	$+G^{£}$	–	$-G^{£}$	–	–	–	$+G^{€}$	–	$-G^{€}$	–	0
Trade	–	$-IM^{£}$	–	–	–	$xr^{£}$	–	$-IM^{€}$	–	–	–	0
–	–	$+X^{£}$	–	–	–	$xr^{£}$	–	$+X^{€}$	–	–	–	0
GDP/Income	$+Y^{£}$	$-Y^{£}$	–	–	–	–	$+Y^{€}$	$-Y^{€}$	–	–	–	0
Taxes	$-T^{£}$	–	–	$+T^{£}$	–	–	$-T^{€}$	–	–	$+T^{€}$	–	0
Interest payments	$+r^{£}B^{£}_{£}$	–	$+r^{£}B^{£}_{bank}$	$-r^{£}B^{£}$	$+r^{£}B^{£}_{cb£}$	$xr^{£}$	$+r^{£}B^{£}_{€}xr^{€}$	–	$+r^{€}B^{€}_{bank}$	–	–	0
	$+r^{\$}B^{\$}_{\$}xr^{\$}$	–	–	–	–	$xr^{£}$	$+r^{€}B^{€}_{€}$	–	–	$-r^{€}B^{€}$	$+r^{€}B^{€}_{cb€}$	0
Bank profits	$+F^{£}_{bank}$	–	$-F^{£}_{bank}$	–	–	–	$+F^{€}_{bank}$	–	$-F^{€}_{bank}$	–	–	0
CB profits	–	–	–	$+F^{£}_{cb}$	$-F^{£}_{cb}$	–	–	–	–	$+F^{€}_{cb}$	$-F^{€}_{cb}$	0
Flows of funds (changes in assets)												
Money	$-\Delta H^{£}_{h}$	–	–	–	$+\Delta H^{£}_{h}$	–	$-\Delta H^{€}_{h}$	–	–	–	$+\Delta H^{€}_{h}$	0
£ Bills	$-\Delta B^{£}_{£}$	–	$-\Delta B^{£}_{bank}$	$+\Delta B^{£}$	$-\Delta B^{£}_{cb£}$	$xr^{£}$	$-\Delta B^{£}_{€}xr^{£}$	–	–	–	–	0
€ Bills	$-\Delta B^{€}_{£}xr^{€}$	–	–	–	–	$xr^{£}$	$-\Delta B^{€}_{€}$	–	$-\Delta B^{€}_{bank}$	$+\Delta B^{€}$	$-\Delta B^{€}_{cb€}$	0
Bank Deposits	$-\Delta DEP^{£}_{bankd}$	–	$+\Delta DEP^{£}_{bank}$	–	–	–	$-\Delta DEP^{€}_{bankd}$	–	$-\Delta DEP^{€}_{bank}$	–	–	0
Bank Reserves	–	–	$-RES^{£}$	–	$+RES^{£}$	–	–	–	$-RES^{€}$	–	$+RES^{€}$	0
Sum	0	0	0	0	0	–	–	0	0	0	0	0

Note: C. B. = central bank.

Table A5 MTO model balance-sheet matrix

	UK households	UK firms	UK banks	UK government	UK C. B.		EU households	EU firms	EU banks	EU government	EU C. B.	Sum
			all in £			Exch. rate			all in €			–
Money	$+H_h^{£}$	–	–	–	$-H_h^{£}$	–	$+H_h^{€}$	–	–	–	$-H_h^{€}$	0
£ Bills	$+B_{£}^{£}$	–	$+\Delta B_{bank}^{£}$	$-B^{£}$	$+B_{cb£}^{£}$	$xr^{£}$	$+B_{€}^{£}xr^{£}$	–	$+\Delta B_{bank}^{€}$	–	–	0
€ Bills	$+B_{£}^{\$}xr^{€}$	–	–	–	–	$xr^{£}$		–	–	$-B^{€}$	$+B_{cb€}^{€}$	0
Bank Deposits	$+\Delta DEP_{bank}^{£}$	–	$-\Delta DEP_{bank}^{£}$	–	–	–	$+B_{€}^{€}$	–	$-\Delta DEP_{bank}^{€}$	–	–	0
Bank Reserves		–	$+RES^{£}$	–	$-RES^{£}$	$xr^{£}$	$+\Delta DEP_{bank}^{€}$	–	$+RES^{€}$	–	$-RES^{€}$	0
Balance	$-V^{£}$	–	0	$-NW_g^{£}$	0	$xr^{£}$	$-V^{€}$	–	0	$-NW_g^{€}$	0	0
Sum	0		0	0	0		0		0	0	0	

Note: C. B. = central bank.

APPENDIX 3 VARIABLES OF THE MTO MODEL

$YD^{£}$ = Disposable income in the UK
$YD^{£}$ = Disposable income in the EU
$Y^{£}$ = Nominal UK income (GDP at current prices)
$Y^{€}$ = Nominal EU income (GDP at current prices)
$B^{£}_{£s}$ = UK bills held by UK households
$B^{€}_{£s}$ = EU bills held by UK households
$B^{€}_{€s}$ = EU bills held by EU households
$B^{£}_{€s}$ = UK bills held by EU households
$xr^{£}$ = UK exchange rate (value of the pound in euros)
$xr^{€}$ = EU exchange rate (value of the euro in pounds)
$F^{£}_{bank}$ = UK banks' profits
$F^{€}_{bank}$ = EU banks' profits
$YD^{£}_{hs}$ = UK households' Haig–Simons disposable income (nominal terms)
$YD^{€}_{hs}$ = EU households' Haig–Simons disposable income (nominal terms)
$V^{£}$ = UK households' private wealth
$V^{€}$ = EU households' private wealth
$C^{£}$ = Value of consumption in the UK
$C^{€}$ = Value of consumption in the EU
$v^{£}$ = UK households' private wealth (real terms)
$v^{€}$ = EU households' private wealth (real terms)
$p^{£}_{ds}$ = UK prices of domestic sales
$p^{€}_{ds}$ = EU prices of domestic sales
$yd^{£}_{hs}$ = UK households' Haig–Simons disposable income (real terms)
$yd^{€}_{hs}$ = EU households' Haig–Simons disposable income (real terms)
$yd^{£}_{hse}$ = UK households' Haig–Simons expected disposable income (real terms)
$yd^{€}_{hse}$ = UK households' Haig–Simons expected disposable income (real terms)
$p^{£}_{m}$ = UK import prices
$p^{£}_{x}$ = UK export prices
$p^{€}_{m}$ = EU import prices
$p^{€}_{x}$ = EU export prices
$p^{£}_{madeUK}$ = Original prices of goods made in Britain
$p^{€}_{madeEU}$ = Original prices of goods made in the EU
$X^{£}$ = UK exports (nominal terms)
$X^{€}$ = EU exports (nominal terms)
$IM^{£}$ = UK imports (nominal terms)
$IM^{€}$ = EU imports (nominal terms)
$x^{£}$ = UK exports (real terms)
$im^{£}$ = UK imports (real terms)
$x^{€}$ = EU exports (real terms)

$im^{€}$ = EU imports (real terms)
$c^{£}$ = UK real consumption
$c^{€}$ = EU real consumption
$S^{£}$ = Value of sales in UK
$S^{€}$ = Value of sales in EU
$s^{£}$ = Total volume of sales in the UK
$s^{€}$ = Total volume of sales in the EU
$DS^{£}$ = UK domestic sales value
$DS^{€}$ = EU domestic sales value
$ds^{£}$ = UK domestic sales volume
$ds^{€}$ = EU domestic sales volume
$y^{£}$ = Real UK GDP
$y^{€}$ = Real EU GDP
$y^{£}_{net}$ = Real UK GDP net of money transfers (national accounting definition)
$y^{€}_{net}$ = Real UK GDP net of money transfers (national accounting definition)
$N^{£}$ = Employment level in the UK
$N^{€}$ = Employment level in the EU
$N^{£}_{full}$ = UK full employment level
$N^{€}_{full}$ = EU full employment level
$JG^{£}_{n}$ = Workers employed in the UK JG programme
$JG^{€}_{n}$ = Workers employed in the EU JG programme
$p^{£}_{s}$ = Average price of all sales in the UK
$p^{€}_{s}$ = Average price of all sales in the EU
$INF^{£}$ = UK inflation rate
$INF^{€}$ = EU inflation rate
$W^{£}$ = Actual wage rate in the UK
$W^{€}$ = Actual wage rate in the EU
$W^{£}_{inc}$ = UK wage increase
$W^{€}_{inc}$ = EU wage increase
$F^{£}_{W}$ = UK wage increase factor
$F^{€}_{W}$ = EU wage increase factor
$W^{£}_{s}$ = Standard wage rate in the UK
$W^{€}_{s}$ = Standard wage rate in the EU
$UN^{£}_{p}$ = Private (non-JG) UK unemployment rate
$UN^{€}_{p}$ = Private (non-JG) EU unemployment rate
$UN^{£}$ = UK unemployment rate
$UN^{€}$ = EU unemployment rate
$W^{£}_{incmax}$ = Maximum UK wage increase factor
$W^{€}_{incmax}$ = Maximum UK wage increase factor

$B^{£}_{£d}$ = Demand for UK bills by UK households
$B^{€}_{£d}$ = Demand for EU bills by UK households
$B^{€}_{€d}$ = Demand for EU bills by EU households
$B^{£}_{€d}$ = Demand for UK bills by EU households
$H^{£}_{h}$ = Cash held by UK households
$H^{€}_{h}$ = Cash held by EU households
$DEP^{£}_{bankd}$ = Demand for bank deposits by UK households
$DEP^{€}_{bankd}$ = Demand for bank deposits by EU households
$H^{£}_{s}$ = UK monetary base
$H^{€}_{s}$ = EU monetary base
$B^{£}_{£s}$ = UK bills held by UK households
$B^{€}_{£s}$ = EU bills held by UK households
$B^{€}_{€s}$ = EU bills held by EU households
$B^{£}_{€s}$ = UK bills held by EU households
$G^{£}$ = UK total government expenditure (nominal terms)
$G^{€}$ = EU total government expenditure (nominal terms)
$g^{£}$ = UK total government expenditure (real terms)
$g^{€}$ = EU total government expenditure (real terms)
$g^{£}_{jg}$ = UK government expenditure for the JG programme (real terms)
$g^{€}_{jg}$ = UK government expenditure for the JG programme (real terms)
$g^{£}_{base}$ = UK base government expenditure (real terms, initial value = 22)
$g^{€}_{base}$ = UK base government expenditure (real terms, initial value = 22)
$gmt^{£}$ = UK government money transfer (real terms)
$gmt^{€}$ = EU government money transfer (real terms)
$T^{£}$ = Taxes paid by UK households
$T^{£}$ = Taxes paid by EU households
$B^{£}_{cb£s}$ = UK bills held by UK central bank
$B^{€}_{cb€s}$ = EU bills held by EU central bank
$F^{£}_{cb}$ = UK central bank's profits
$F^{€}_{cb}$ = EU central bank's profits
$B^{£}_{s}$ = UK public debt (total UK bills issued)
$B^{€}_{s}$ = EU public debt (total EU bills issued)
$DEP^{£}_{bank}$ = Bank deposits (supply) in the UK
$DEP^{€}_{bank}$ = Bank deposits (supply) in the EU
$B^{£}_{bank}$ = UK bills held by UK banks
$B^{€}_{bank}$ = EU bills held by EU banks
$RES^{£}$ = UK bank reserves at the UK central bank
$RES^{€}$ = EU bank reserves at the EU central bank
$PSBR^{£}$ = UK government deficit

$PSBR^{€}$ = EU government deficit
$NAFA^{£}$ = UK households' net accumulation of financial assets
$NAFA^{€}$ = EU households' net accumulation of financial assets
$CAB^{£}$ = UK current account
$CAB^{€}$ = EU current account
$FIN^{£}$ = UK financial account
$FIN^{€}$ = EU current account

APPENDIX 4 PARAMETERS OF THE MTO MODEL

$\theta^{£}$ = UK tax rate (0.3)
$\theta^{€}$ = EU tax rate (0.3)
v_0 = First parameter of UK import prices equation (–0.00001)
v_1 = Second parameter of UK import prices equation (0.8)
u_0 = First parameter of UK export prices equation (–0.00001)
u_1 = Second parameter of UK export prices equation (0.4)
ε_0 = Constant of the UK export equation (–1.8)
ε_1 = Elasticity of UK exports with respect to EU import prices relative to prices of goods made in the EU (0.7)
ε_2 = Elasticity of UK export with respect to EU output (1)
μ_0 = Constant of UK import equation (–1.8)
μ_1 = Elasticity of UK imports with respect to UK import prices relative to prices of goods made in Britain (0.7)
μ_2 = Elasticity of UK imports with respect to UK output (1)
$\alpha_1^{£}$ = UK propensity to consume out of income (0.75)
$\alpha_1^{€}$ = EU propensity to consume out of income (0.75)
$\alpha_2^{£}$ = UK propensity to consume out of wealth (0.1333)
$\alpha_2^{€}$ = EU propensity to consume out of wealth (0.1333)
$\varphi^{£}$ = Mark-up on unit cost in the UK (0.2381)
$\varphi^{€}$ = Mark-up on unit cost in the EU (0.2381)
λ_{ij} = Portfolio equations parameters (10 = 0.6; 11 = 5; 12 = 5; 20 = 0.25; 21 = 5; 22 = 5; 40 = 0.6; 41 = 5; 42 = 5; 50 = 0.25; 51 = 5; 52 = 5)
$pr^{£}$ = UK productivity (output per worker) (1.285)
$pr^{€}$ = EU productivity (output per worker) (1.285)
$r^{£}$ = Interest rate on UK bills (0.02)
$r^{€}$ = Interest rate on EU bills (0.02)
$depsh^{£}$ = Percentage of money held as deposits in the UK (0.5)
$depsh^{€}$ = Percentage of money held as deposits in the UK (0.5)
$winf^{£}$ = UK wage inflation parameter (0.055)
$winf^{€}$ = UK wage inflation parameter (0.055)

APPENDIX 5 EQUATIONS OF THE MTO MODEL

$$YD^{£} = \left(Y^{£} + r^{£}_{-1}B^{£}_{£s-1} + r^{€}_{-1}B^{€}_{£s-1}xr^{€} + F^{£}_{bank}\right)\left(1-\theta^{£}\right) \tag{A1}$$

$$YD^{£}_{hs} = YD^{£} + \left(\Delta xr^{€}\right)B^{€}_{£s-1} \tag{A2}$$

$$\Delta V^{£} = YD^{£}_{hs} - C^{£} \tag{A3}$$

$$YD^{€} = \left(Y^{€} + r^{€}_{-1}B^{€}_{€s-1} + r^{£}_{-1}B^{£}_{€s-1}xr^{£} + F^{€}_{bank}\right)\left(1-\theta^{€}\right) \tag{A4}$$

$$YD^{€}_{hs} = YD^{€} + \left(\Delta xr^{£}\right)B^{£}_{€s-1} \tag{A5}$$

$$\Delta V^{€} = YD^{€}_{hs} - C^{€} \tag{A6}$$

$$v^{£} = \frac{V^{£}}{p^{£}_{ds}} \tag{A7}$$

$$v^{€} = \frac{V^{€}}{p^{€}_{ds}} \tag{A8}$$

$$yd^{£}_{hs} = \frac{YD^{£}}{p^{£}_{ds}} - \Delta p^{£}_{ds}\frac{V^{£}_{-1}}{p^{£}_{ds}} + \frac{\Delta xr^{€}B^{€}_{£s-1}}{p^{£}_{ds}} = \frac{YD^{£}_{hs}}{p^{£}_{ds}} - \Delta p^{£}_{ds}\frac{V^{£}_{-1}}{p^{£}_{ds}} \tag{A9}$$

$$yd^{€}_{hs} = \frac{YD^{€}}{p^{€}_{ds}} - \Delta p^{€}_{ds}\frac{V^{€}_{-1}}{p^{€}_{ds}} + \frac{\Delta xr^{£}B^{£}_{€s-1}}{p^{€}_{ds}} = \frac{YD^{€}_{hs}}{p^{€}_{ds}} - \Delta p^{€}_{ds}\frac{V^{€}_{-1}}{p^{€}_{ds}} \tag{A10}$$

$$yd^{£}_{hse} = \frac{\left(yd^{£}_{hs} + yd^{£}_{hs-1}\right)}{2} \tag{A11}$$

$$yd^{€}_{hse} = \frac{\left(yd^{€}_{hs} + yd^{€}_{hs-1}\right)}{2} \tag{A12}$$

$$\log\left(x^{£}\right) = \varepsilon_0 - \varepsilon_1\left(\log\left(p^{€}_{m-1}\right) - \log\left(p^{€}_{madeEU-1}\right)\right) + \varepsilon_2\log\left(y^{€}\right) \tag{A13}$$

$$\log\left(im^{£}\right) = \mu_0 - \mu_1\left(\log\left(p^{£}_{m-1}\right) - \log\left(p^{£}_{madeUK-1}\right)\right) + \mu_2\log\left(y^{£}\right) \tag{A14}$$

$$x^{€} = im^{£} \tag{A15}$$

$$im^{€} = x^{£} \tag{A16}$$

$$X^{£} = x^{£}p^{£}_{x} \tag{A17}$$

$$X^{€} = x^{€}p^{€}_{x} \tag{A18}$$

$$IM^{£} = im^{£}p^{£}_{m} \tag{A19}$$

$$IM^{€} = im^{€}p^{€}_{m} \tag{A20}$$

$$c^{£} = \alpha^{£}_{1}yd^{£}_{hse} + \alpha^{£}_{2}v^{£}_{-1} \tag{A21}$$

$$c^{€} = \alpha_1^{€} yd_{hse}^{€} + \alpha_2^{€} v_{-1}^{€} \tag{A22}$$

$$C^{£} = c^{£} p_{ds}^{£} \tag{A23}$$

$$C^{€} = c^{€} p_{ds}^{€} \tag{A24}$$

$$s^{£} = c^{£} + g^{£} + x^{£} \tag{A25}$$

$$s^{€} = c^{€} + g^{€} + x^{€} \tag{A26}$$

$$S^{£} = s^{£} p_s^{£} \tag{A27}$$

$$S^{€} = s^{€} p_s^{€} \tag{A28}$$

$$DS^{£} = S^{£} - X^{£} \tag{A29}$$

$$DS^{€} = S^{€} - X^{€} \tag{A30}$$

$$ds^{£} = s^{£} - x^{£} \tag{A31}$$

$$ds^{€} = s^{€} - x^{€} \tag{A32}$$

$$Y^{£} = S^{£} - IM^{£} \tag{A33}$$

$$Y^{€} = S^{€} - IM^{€} \tag{A34}$$

$$y^{£} = s^{£} - im^{£} \tag{A35}$$

$$y^{€} = s^{€} - im^{€} \tag{A36}$$

$$y_{net}^{£} = s^{£} - im^{£} - gmt^{£} \tag{A37}$$

$$y_{net}^{€} = s^{€} - im^{€} - gmt^{€} \tag{A38}$$

$$N^{£} = \frac{y_{net}^{£}}{pr^{£}} \tag{A39}$$

$$N^{€} = \frac{y_{net}^{€}}{pr^{€}} \tag{A40}$$

$$\log\left(p_m^{£}\right) = v_0 - v_1 * \log\left(xr^{£}\right) + (1 - v_1) log\left(p_{madeUK}^{£}\right) + v_1 \log\left(p_{madeEU}^{€}\right) \tag{A41}$$

$$\log\left(p_x^{£}\right) = u_0 - u_1 * \log\left(xr^{£}\right) + (1 - u_1) \log\left(p_{madeUK}^{£}\right) + u_1 \log\left(p_{madeEU}^{€}\right) \tag{A42}$$

$$p_x^{€} = p_m^{£} xr^{£} \tag{A43}$$

$$p_m^{€} = p_x^{£} xr^{£} \tag{A44}$$

$$p_{madeUK}^{£} = \left(1 + \varphi^{£}\right) UC^{£} = \left(1 + \varphi^{£}\right) \frac{W^{£} N^{£}}{y_{net}^{£}} \tag{A45}$$

$$p^{€}_{madeEU} = \left(1+\varphi^{€}\right)UC^{€} = \left(1+\varphi^{€}\right)\frac{W^{€}N^{€}}{y^{€}_{net}} \tag{A46}$$

$$p^{£}_{s} = p^{£}_{madeUK}\frac{s^{£}-im^{£}-x^{£}}{s^{£}} + p^{£}_{m}\frac{im^{£}}{s^{£}} + p^{£}_{x}\frac{x^{£}}{s^{£}} \tag{A47}$$

$$p^{€}_{s} = p^{€}_{madeUS}\frac{s^{€}-im^{€}-x^{€}}{s^{€}} + p^{€}_{m}\frac{im^{€}}{s^{€}} + p^{€}_{x}\frac{x^{€}}{s^{€}} \tag{A48}$$

$$p^{£}_{ds} = \left(S^{£}-X^{£}\right)/\left(s^{£}-x^{£}\right) \tag{A49}$$

$$p^{€}_{ds} = \left(S^{€}-X^{€}\right)/\left(s^{€}-x^{€}\right) \tag{A50}$$

$$INF^{£} = \left(p^{£}_{ds}-p^{£}_{ds-1}\right)/p^{£}_{ds-1} \tag{A51}$$

$$INF^{€} = \left(p^{€}_{ds}-p^{€}_{ds-1}\right)/p^{€}_{ds-1} \tag{A52}$$

$$W^{£} = W^{£}_{s}\left(1+W^{£}_{inc}\right) \tag{A53}$$

$$W^{€} = W^{€}_{s}\left(1+W^{€}_{inc}\right) \tag{A54}$$

$$F^{£}_{W} = 1iff\left(UN^{£}_{p} < winf^{£}\right) \tag{A55}$$

$$F^{€}_{W} = 1iff\left(UN^{€}_{p} < winf^{€}\right) \tag{A56}$$

$$W^{£}_{incmax} = 1iff\left(W^{£}_{inc} < 0.015\right) \tag{A57}$$

$$W^{€}_{incmax} = 1iff\left(W^{€}_{inc} < 0.015\right) \tag{A58}$$

$$W^{£}_{inc} = W^{£}_{inc-1} + \left(0.0002F^{£}_{W}W^{£}_{incmax}\right) \tag{A59}$$

$$W^{€}_{inc} = W^{€}_{inc-1} + \left(0.0002F^{€}_{W}W^{€}_{incmax}\right) \tag{A60}$$

$$UN^{£} = \left(N^{£}_{full}-N^{£}\right)/N^{£}_{full} \tag{A61}$$

$$UN^{€} = \left(N^{€}_{full}-N^{€}\right)/N^{€}_{full} \tag{A62}$$

$$UN^{£}_{p} = \left(N^{£}_{full}-N^{£}+JG^{£}_{n}\right)/N^{£}_{full} \tag{A63}$$

$$UN^{€}_{p} = \left(N^{€}_{full}-N^{€}+JG^{€}_{n}\right)/N^{€}_{full} \tag{A64}$$

$$JG^{£}_{n} = \frac{g^{£}_{jg}}{pr^{£}} \tag{A65}$$

$$JG^{€}_{n} = \frac{g^{€}_{jg}}{pr^{€}} \tag{A66}$$

$$B^{£}_{£d} = V^{£}\left(\lambda_{10} + \lambda_{11} r^{£} - \lambda_{12} r^{€}\right) \tag{A67}$$

$$B^{€}_{£d} = V^{£}\left(\lambda_{20} + \lambda_{21} r^{£} - \lambda_{22} r^{€}\right) \tag{A68}$$

$$H^{£}_{h} = V^{£} - B^{£}_{£s} - B^{€}_{£s} xr^{€} - DEP^{£}_{bankd} \tag{A69}$$

$$DEP^{£}_{bankd} = (V^{£} - B^{£}_{£s} - B^{€}_{£s} xr^{€}) deps h^{£} \tag{A70}$$

$$B^{€}_{€d} = V^{€}\left(\lambda_{40} + \lambda_{41} r^{€} - \lambda_{42} r^{£}\right) \tag{A71}$$

$$B^{£}_{€d} = V^{€}\left(\lambda_{50} - \lambda_{51} r^{€} + \lambda_{52} r^{£}\right) \tag{A72}$$

$$H^{€}_{h} = V^{€} - B^{€}_{€s} - B^{£}_{€s} xr^{£} - DEP^{€}_{bankd} \tag{A73}$$

$$DEP^{€}_{bankd} = (V^{€} - B^{€}_{€s} - B^{£}_{€s} xr^{£}) deps h^{€} \tag{A74}$$

$$H^{€}_{s} = H^{€}_{h} + RES^{€} \tag{A75}$$

$$B^{£}_{£s} = B^{£}_{£d} \tag{A76}$$

$$H^{£}_{s} = H^{£}_{h} + RES^{£} \tag{A77}$$

$$B^{€}_{€s} = B^{€}_{€d} \tag{A78}$$

$$B^{£}_{€s} = B^{£}_{€d} xr^{€} \tag{A79}$$

$$B^{€}_{£s} = B^{€}_{s} - B^{€}_{€s} - B^{£}_{bank} - B^{£}_{cb£s} \tag{A80}$$

$$xr^{£} = \frac{B^{€}_{£s}}{B^{€}_{£d}} \tag{A81}$$

$$xr^{€} = \frac{1}{xr^{£}} \tag{A82}$$

$$G^{£} = g^{£} p^{£}_{ds} \tag{A83}$$

$$g^{£} = g^{£}_{base} + g^{£}_{jg} + gmt^{£} \tag{A84}$$

$$G^{€} = g^{€} p^{€}_{ds} \tag{A85}$$

$$g^{€} = g^{€}_{base} + g^{€}_{jg} + gmt^{€} \tag{A86}$$

$$T^{£} = \theta^{£}(Y^{£} + r^{£}_{-1} B^{£}_{£s-1} + r^{€}_{-1} B^{€}_{£s-1} xr^{€} + F^{£}_{bank}) \tag{A87}$$

$$T^{€} = \theta^{€}\left(Y^{€} + r^{€}_{-1} B^{€}_{€s-1} + r^{£}_{-1} B^{£}_{€s-1} xr^{£} + F^{€}_{bank}\right) \tag{A88}$$

$$B^{£}_{cb£} = B^{£}_{s} - B^{£}_{£s} - B^{£}_{€s} - B^{£}_{bank} \tag{A89}$$

$$B^{€}_{cb} = H^{€}_{s} \tag{A90}$$

$$F_{cb}^{£} = r_{-1}^{£} B_{cb£s-1}^{£} \tag{A91}$$

$$F_{cb}^{€} = r_{-1}^{€} B_{cb€s-1}^{€} \tag{A92}$$

$$\Delta B_{s}^{£} = G^{£} - T^{£} + r_{-1}^{£} B_{s-1}^{£} - F_{cb}^{£} \tag{A93}$$

$$\Delta B_{s}^{€} = G^{€} - T^{€} + r_{-1}^{€} B_{s-1}^{€} - F_{cb}^{€} \tag{A94}$$

$$DEP_{bank}^{£} = DEP_{bankd}^{£} \tag{A95}$$

$$DEP_{bank}^{€} = DEP_{bankd}^{€} \tag{A96}$$

$$RES^{£} = 0.1(DEP_{bank}^{£}) \tag{A97}$$

$$RES^{€} = 0.1(DEP_{bank}^{€}) \tag{A98}$$

$$B_{bank}^{£} = DEP_{bank}^{£} - RES^{£} \tag{A99}$$

$$B_{bank}^{€} = DEP_{bank}^{€} - RES^{€} \tag{A100}$$

$$F_{bank}^{£} = r_{-1}^{£} B_{bank-1}^{£} \tag{A101}$$

$$F_{bank}^{€} = r_{-1}^{€} B_{bank-1}^{€} \tag{A102}$$

$$PSBR^{£} = \Delta B_{s}^{£} \tag{A103}$$

$$PSBR^{€} = \Delta B_{s}^{€} \tag{A104}$$

$$NAFA^{£} = CAB^{£} + PSBR^{£} \tag{A105}$$

$$NAFA^{€} = CAB^{€} + PSBR^{€} \tag{A106}$$

$$CAB^{£} = X^{£} - IM^{£} + r_{-1}^{€} B_{£s-1}^{€} xr^{€} - r_{-1}^{£} B_{€s-1}^{£} \tag{A107}$$

$$CAB^{€} = X^{€} - IM^{€} + r_{-1}^{£} B_{€s-1}^{£} xr^{£} - r_{-1}^{€} B_{£s-1}^{€} \tag{A108}$$

$$FIN^{£} = \Delta B_{€s}^{£} - \Delta B_{£s}^{€} xr^{€} \tag{A109}$$

$$FIN^{€} = \Delta B_{£s}^{€} - \Delta B_{€s}^{£} xr^{£} \tag{A110}$$

Redundant equation:

$$B_{cb€}^{€} = B_{s}^{€} - B_{€s}^{€} - B_{£s}^{€} - B_{bank}^{€} \tag{A111}$$