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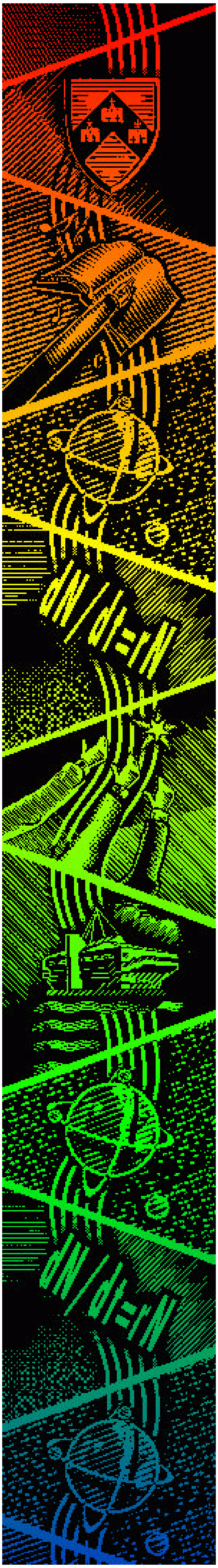

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On the trade balance response to monetary shocks: the Marshall-Lerner conditions reconsidered

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Abstract

This paper shows that, by disentangling the degree of monopolistic distortion from the elasticity of substitution between domestic and imported goods, we can obtain a negative response of the trade balance to positive monetary shocks, without introducing capital accumulation. This result could reconcile the class of models à la Obstfeld and Rogoff (1996, ch. 10) with the stylized fact of counter-cyclical trade balances.
Keywords: trade balance; Marshall-Lerner conditions; elasicity of substitution; monetary shocks; transfer problem
JEL classification: C6, E3, E4

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1 Introduction

One of the stylized facts of international business cycles is the counter-cyclical behaviour of the trade balance[1]. One strand of the recent literature on open economy dynamics resorts to imperfect competition and nominal rigidities to explain many of the observed "regularities" of international business cycles. This is true in particular for the models à la Obstfeld and Rogoff (1995 and 1996 ch. 10). However, one aspect of business cycles which has not been captured by the majority of these contributions is the counter-cyclicality of the trade balance[2]. Chari et al. (1997) build a quantitative model of exchange rate variation very close to the analytical framework of Obstfeld and Rogoff and reach the conclusion that the counter-cyclical dynamics of the trade balance can be matched only by considering capital accumulation[3]. Both the Obstfeld and Rogoff and the Chari et al models are concerned with demand side shocks: i.e. monetary as well as fiscal shocks.

In general we can say that, given a demand shock (e.g. a positive money supply shock) and keeping all prices constant (the exchange rate included), we expect the trade balance to deteriorate. The fact that Obstfeld and

[1] There is a wide literature that confirms this fact. See for example Danthine and Donaldson (1993), Backus et al. (1994a,b), Baxter and Crucini (1993), Kollmann (1997). As for Chari et al. (1997, 1998) they refer to this regularity in their 1997 version although the tables reported in the second version show the opposite: a positive correlation between output and net export (over output) for 8 out of 10 countries (one is aggregate Europe). Surprisingly among those with a negative correlation they list Austria which is the only one displaying a positive correlation in the list provided by Danthine and Donaldson (1993) (the other country is Norway not reported by the latter authors). Mendoza (1995) also reports a positive correlation between net export (over output) and output for G7 countries except for the U.S.A. which shows a negative correlation. The other groups of countries listed by Mendoza (25 countries) show only 5 coutries with a positive correlation.

[2] We refer here to two-country dynamic general equilibrium models. Different approaches to dynamic open economy issues do not necessarily share this shortcoming. For example, Kollmann (1997) builds a quantitative model of a "semi-small" open economy with nominal rigidities (of prices and wages) addressed at explaining the volatility of nominal and real exchange rates. With this framework, Kollmann is able to reproduce the counter cyclical dynamics of the trade balance. His model shows a unitary elasticity of substitution between domestic and imported goods (due to the Cobb-Douglas aggregation function) and an elasticity of aggregate demand for export left to calibration. As will be clear later, under these respects his economy crucially differs from ours.

[3] In a recent revised version of their paper, Chari et al. (1998) drop altogether the argument on the countercyclicality of the current account focusing only on the volatility of the real exchange rate.

Rogo¤ type models produce an improvement of the trade balance following a demand shock must then result from a change in relative prices. The study of the relation between relative prices and the trade balance can be traced back at least to the works of Marshall and Lerner (from which the well known Marshall-Lerner conditions are derived)[4]. Nevertheless, many recent contributions to the literature on imperfect competition in open economies have neglected this traditional approach and instead stress the "absorption approach" explanations for the missing stylized fact (e.g. Chari et al. 1997 emphasise capital accumulation).

Backus et al. (1994) in an open economy macro model with perfect competition, address the issue of relative price movement and trade balance responses from the "elasticity-approach" point of view, alongside the "absorption-approach". We partially follow these authors. By disentangling the degree of domestic goods market competition from the elasticity of substitution between domestic and imported goods we provide appropriate "extended Marshall-Lerner" conditions (henceforth EML) which govern the response of the trade balance to a monetary shock.

The class of models we refer to in the present paper is that of two-country general equilibrium models with nominal rigidities (à la Obstfeld and Rogo¤ (1995), henceforth OR models). These models generally use a consumption index aggregating over the di¤erent varieties of goods produced at home and abroad. This aggregation turns out to be crucial for the de…nition of the elasticity of substitution (and thus for the EML conditions). In this class of models each variety of good is produced by a single monopolistic producer. Hence, to be consistent with optimality conditions for monopolistic pricing, the elasticity between di¤erent varieties of goods must be greater than unity. Seminal works in this stream of research, namely Obstfeld and Rogo¤ (1995) and Betts and Devereux (1996b) do not allow for di¤erent parameters measuring the substitutability among goods produced within a country and the substitutability among domestic and imported goods. By doing this the elasticity of substitution between domestic and imported goods is unnecessarily constrained to be bigger than one. Corsetti and Pesenti (1997) make a similar point in relation to this issue, but then prefer to use a Cobb-Douglas aggregation function among domestic and imported goods, so that the elasticity of substitution between domestic and imported goods

[4] See any undergraduate level International Macroeconomics textbook, e.g. (Krugman and Obstfeld, 1997).

is unity. This serves pretty well their purpose of extending Obstfeld and Rogo¤'s (1995) welfare results to a non approximated model, alas at the expenses of a more general treatment of the issue.

In Obstfeld and Rogo¤ (1996, p. 232-235) a negative response of the trade balance to monetary shocks is shown to be obtainable in a model similar to our model but with tradable and non-tradable goods. Contrary to our model, there the relative magnitude of the intra-temporal elasticity of substitution as compared with the inter-temporal elasticity of substitution determines the response of the trade balance. Furthermore no distinction is made between degree of monopolistic distortion and elasticity of substitution between domestic and imported goods.

Chari et al. (1997) do distinguish the two types of elasticities at hand (indeed inspiring this work) but since they are interested in a calibration of this type of model, they do not exploit the potential of their nested aggregation function and hence they reach the previously mentioned conclusion that capital accumulation is a necessary element in generating a counter cyclical response of the trade balance[5].

The paper is organized as follows. In section 2 we highlight the general issue of the Marshall-Lerner conditions and present and discuss the nested CES aggregation function. In section 3 we re-write the original Obstfeld and Rogo¤ (1995) model using the nested CES function to derive, in section 3.4.3 the conditions for a negative response of the current account. Some remarks and conclusion follow in section 4.

2 Elasticity of substitution and degree of competition

2.1 The Marshall-Lerner conditions

Traditionally, and in a static context, the relation between the real exchange rate and the trade balance is described by the Marshall-Lerner condition. This states that if the sum of the elasticity of exports with respect to the real exchange rate and the elasticity of imports is bigger than one, then we should expect a real depreciation of the exchange rate to produce an improvement of

[5] See footnote 3

the trade balance (and the current account)[6] (Krugman and Obstfeld, 1997, p. 483).

Ethier (1988, p. A-17), shows that when two countries have equal tastes the Marshall-Lerner conditions are always satisfied[7]: this seems a very typical case in theoretical economies. General equilibrium models of the current account typically make use of homothetic preferences over consumption goods which are identical across countries. This means that the ratio between the demand of two different goods is independent of income and the marginal propensity to consume a specific good is constant in income and identical across goods. In the formulation of the Marshall-Lerner conditions used by Ethier, this fact implies that the conditions are always satisfied. Thus the standard Marshall-Lerner conditions are not useful in this class of models. Hence the need to derive extended conditions.

2.2 Degree of competition disentangled

The typical consumption index used by OR models is the homothetic aggregation function yielding constant elasticity of substitution (CES) i.e.

$$C = \left(\int_0^1 c_i^{\mu} di \right)^{\frac{1}{\mu}}$$

where the range of the variety is normalized to the continuous segment (0,1).

In a two country model it is then assumed that n goods are produced at home and $(1 - n)$ abroad, where $n \in (0;1)$. Thus the index can be rewritten as follows

$$C = \left(\int_0^n c_i^{\mu} di + \int_n^1 c_j^{\mu} dj \right)^{\frac{1}{\mu}}$$

with the associated demands for individual goods

$$c_i = \left(\frac{p_i}{P} \right)^{\frac{1}{\mu - 1}} C$$

$$c_j = \left(\frac{p_j}{P} \right)^{\frac{1}{\mu - 1}} C$$

[6] For small shocks around a balanced current account.

[7] This point is highlighted in these terms by Backus et al. (1994)

where $p_i; p_j$ are the home currency prices for good i and j respectively and P is the price index which we do not define for the moment.

Clearly, since $\frac{1}{1-\theta}$ is the elasticity of the demand faced by the monopolistic firm, it must be $\frac{1}{1-\theta} > 1$. But since this measure is also the elasticity of substitution between domestic and imported goods, namely

$$-\frac{d\log\frac{c_i}{c_j}}{d\log\frac{p_i}{p_j}} = \frac{1}{1-\theta}$$

we are unnecessarily restricting the elasticity of inter-country substitution.

We can easily disentangle the two elasticities by nesting two levels of CES functions, namely

$$C = \left\{ n^{1-\theta} C_h^{\theta} + (1-n)^{1-\theta} C_f^{\theta} \right\}^{\frac{1}{\theta}} \tag{1}$$

where

$$C_h = \left(n^{\omega-1} \int_0^n c_i^{\omega} di \right)^{\frac{1}{\omega}} \tag{2}$$

and

$$C_f = \left((1-n)^{\omega-1} \int_0^n c_j^{\omega} dj \right)^{\frac{1}{\omega}} \tag{3}$$

where $c_i; c_j$ are goods produced at home and abroad, respectively. The weights given to home and foreign goods in equation (1) have an important and twofold meaning. To see this let us consider first equations (2) and (3). There the coefficient n and $(1-n)$ normalize the aggregation function to the variety of goods supplied by each country, furthermore it eliminates the "taste for variety" from the aggregation function. In equation (1) the same coefficients determine the bias of the consumption bundle towards a particular country: i.e. when $n = 0.5$ the two countries are equally represented in the aggregation function. Generally the two concepts, "love for variety" and country-bias are independent, so that consumers might prefer the goods produced in a specific country despite the smaller variety of goods supplied by that country as compared with the other country (e.g. rest of the world). As is typical in dynamic general equilibrium models, ours is solved by linearization around the symmetric steady state, i.e. where the current account is balanced. For this purpose, the bias needs to be reduced to the mere condition that all individuals consume all goods. This is to say that if all the goods of each country are consumed in equal quantity, each individual consumes n goods of the Home country and $(1-n)$ of the Foreign country, i.e. exactly equal to the variety offered by each country.

The demand functions associated with this consumption indexes are[8]

$$C_h = n\left(\frac{P_h}{P}\right)^{\frac{1}{\theta-1}} C$$

$$C_f = (1-n)\left(\frac{EP_f}{P}\right)^{\frac{1}{\theta-1}} C$$

$$c_i = \frac{1}{n}\left(\frac{p_i}{P_h}\right)^{\frac{1}{\omega-1}} C_h \tag{4}$$

$$c_j = \frac{1}{1-n}\left(\frac{q_j}{P_f}\right)^{\frac{1}{\omega-1}} C_f \tag{5}$$

Nesting the above functions we obtain

$$c_i = \left(\frac{p_i}{P_h}\right)^{\frac{1}{\omega-1}}\left(\frac{P_h}{P}\right)^{\frac{1}{\theta-1}} C \tag{6}$$

$$c_j = \left(\frac{q_j}{P_f}\right)^{\frac{1}{\omega-1}}\left(\frac{EP_f}{P}\right)^{\frac{1}{\theta-1}} C \tag{7}$$

where p_i is the price for the individual good i; q_j is the price of the foreign consumption good, E is the value of the foreign currency in terms of the home currency, whereas P_h P_f and P are the price indexes of home produced final goods, foreign produced final goods purchased at home and the general home price index of consumption goods, namely

$$P_h = \left(\frac{1}{n}\int_0^n p_i^{\frac{\omega}{\omega-1}} di\right)^{\frac{\omega-1}{\omega}} \tag{8}$$

$$P_f = \left(\frac{1}{1-n}\int_n^1 q_j^{\frac{\omega}{\omega-1}} dj\right)^{\frac{\omega-1}{\omega}} \tag{9}$$

$$P = \left(nP_h^{\frac{\theta}{\theta-1}} + (1-n)(EP_f)^{\frac{\theta}{\theta-1}}\right)^{\frac{\theta-1}{\theta}} \tag{10}$$

[8]Notice that $\frac{c_i}{c_j}$ is independent from income.

It is evident that the previous case of identical elasticities is just a particular case of this nested CES consumption index, i.e. where $\mu = \omega$:

Now, if we assume, as done in the existing literature, that imperfect competition takes the form of monopolistic competition[9] the elasticity of demand faced by each producer is $-\frac{1}{\omega - 1}$; so that the markup[10] is $\frac{1-\omega}{\omega}$:

The elasticity of substitution we are interested in is nevertheless that between consumption of domestic goods and foreign goods. This fact clearly affects the EML conditions. Furthermore, because of the symmetry imposed over domestic agents for computational reasons, the conflation of the two parameters limits the role of the monopolistic distortion to welfare aspects. It has been shown that our structure, where the two elasticities of substitution are distinguished, can imply that the degree of monopolistic distortion has a dynamic role[11].

In either case the relevant elasticity turns out to be

$$-\frac{d\log \frac{c_i}{c_j}}{d\log \frac{p_i}{p_j}} = -\frac{d\log \frac{C_h}{C_f}}{d\log \frac{P_h}{P_f}} = \frac{1}{1-\mu} \tag{11}$$

This elasticity does not have any prior constraint besides being positive if we allow for normal goods only[12].

Whereas the markup must still be positive, we might well have an elasticity of substitution between a domestic good and imported good smaller than one.

The importance of this specification is not at all exclusively theoretical. As reported in Krugman and Obstfeld (1997, p. 485) for most countries the elasticity of substitution in question is indeed smaller than one[13].

[9]Goods are differentiated under physical characteristics and there is a large number of producers: one per good. This implies that the effects of each single producer on aggregate variables is negligible.

[10]Let us define the markup as $\frac{p_i - Mc_i}{Mc_i}$ where Mc_i = marginal cost of the i-th producer.

[11]See Lombardo (1998a,b) for an analysis of the dynamic role of imperfect competition in the OR models.

[12]Note that keeping prices fixed, the elasticity of substitution between domestic and imported goods is $\frac{1}{1-\mu}$; even without imposing symmetry.

[13]For precision, the elasticity we are presenting here is the impact elasticity in the terminology of Krugman and Obstfeld. They show in fact that the elasticity changes overtime and indeed that the elasticity of imports and of exports do differ. According to Backus et al. (1994b), this elasticity of substitution is between 1 and 2 for U.S.A., and smaller for European countries.

3 The model

We consider here the original Obstfeld and Rogoff (1995) model amended with the nested CES function described above.

Notice that since the two countries are symmetric, here we show mainly the expressions for the Home country. Variables of the Foreign country are those with a $*$ suffix.

3.1 Households

There are n households in the Home country and (1-n) in the Foreign country. Within each country, households own equal shares of the firms. These households have identical preferences and, since there is no uncertainty, they choose consumption, real money balances and labour supply so as to solve the following problem

$$\max_{C;\frac{M}{P};l} \sum_{s=t}^{\infty} \beta^{t-s} \left[\frac{C_s^{1-\sigma}}{1-\sigma} + \frac{\chi}{1-\varepsilon} \left(\frac{M_s}{P_s} \right)^{1-\varepsilon} - \frac{l_s^{\mu}}{\mu} \right] \tag{12}$$

$$\begin{aligned} s.t.:\ M_s + P_s B_{s+1} &= w_s l_s + \Pi_s + (1+i_s) P_s B_s + M_{s-1} - P_s C_s - \tau_s \\ s &= t ... \infty \end{aligned} \tag{13}$$

where, all variables are in nominal terms except consumption bonds and labour supply. C is the consumption index defined in equation (1) M is money, B is a real bond, P is the consumption price index as defined by equation (10) w is the nominal wage, l is labour, Π is profit share, τ is tax paid by the individual, i is the nominal interest rate. It is assumed that $\varepsilon; \sigma > 0$ and $\mu > 1$. Finally $\beta = (1+\delta)^{-1}$, where δ (bounded between zero and one) is the rate of time preference.

From the first order condition of utility maximization the following functions are derived:

$$\frac{M_t}{P_t} = C_t^{\frac{\sigma}{\varepsilon}} \left(\chi \frac{1+i_{t+1}}{i_{t+1}} \right)^{\frac{1}{\varepsilon}} \tag{14}$$

$$l_t = \left(\frac{w_t}{P_t} C^{-\sigma} \right)^{\frac{1}{\mu-1}} \tag{15}$$

$$C_{t+1} = [\beta(1+\nu_{t+1})]^{\frac{1}{\sigma}} C_t \tag{16}$$

which represent respectively, money demand, labour supply and the consumption Euler equation. ν denotes the real interest rate.

3.2 Firms

The production function has constant return to scale in labour and is identical across firms.

$$y_i = \frac{1}{n}\int_0^n l_i di = l \tag{17}$$

Profit maximization in monopolistic competition implies that prices are set as a markup over marginal costs, i.e.

$$p = \frac{w}{\omega}$$

We assume here that firms set prices for one period. That is to say that prices are fixed in the short run. We don't give any further explanations for this than those given in the related literature: mainly menu-costs arguments.

3.3 Money supply

Henceforth it is assumed that the following government's balanced budget holds:

$$M_t - M_{t-1} + \tau = 0 \tag{18}$$

In what follows we will consider only a permanent monetary shock, i.e. a permanent unexpected change in money supply.

3.4 Monetary shocks and current account dynamics

To obtain the correlation between monetary shocks and the current account we simply follow Obstfeld and Rogoff (1996, ch. 10) and solve for differences between home and foreign log-linearized expressions.

Let us start with the consumption Euler equation. Since purchasing power parity (PPP) holds in this model, domestic and foreign real interest rate are identical so that we have

$$\hat{C}_{t+1} - \hat{C}^*_{t+1} = \hat{C}_t - \hat{C}^*_t \tag{19}$$

where $\hat{C} = d\log C$.

From the labour supply equation (15) and making use of the production function and the oligopoly pricing rule we obtain the output supply equation

$$\hat{y}_t = \frac{1}{\mu - 1}\left(\hat{p}_t - \hat{P}_t - \sigma\hat{C}_t\right) \tag{20}$$

and the foreign counterpart

$$\hat{y}^*_t = \frac{1}{\mu - 1}\left(\hat{q}_t - \hat{P}^*_t - \sigma \hat{C}^*_t\right) \tag{21}$$

where q is the price of a typical foreign good.

Taking the difference between the last two equations we obtain

$$\hat{y}_t - \hat{y}^*_t = \frac{1}{\mu - 1}\left\{\hat{p}_t - \hat{q}_t - \hat{e}_t - \sigma\left(\hat{C}_t - \hat{C}^*_t\right)\right\} \tag{22}$$

which represents the difference in the (log-deviation) supply of goods, and where $e = d \log E$.

The corresponding difference in demand for goods is obtained by taking a weighed sum of equation (6) and the foreign counterpart (not shown) where weights are represented by the size of the population. Since $P = eP^*$ the demand for the i-th domestic good is

$$y = c \equiv \left(\frac{p}{P}\right)^{\frac{1}{\theta - 1}} C^W$$

where $C^W = (nC + (1-n)C^*)$.

Consequently our log-linearized expression becomes

$$\hat{y}_t - \hat{y}^*_t = \frac{1}{\theta - 1}\left(\hat{p}_t - \hat{q}_t - \hat{e}_t\right) \tag{23}$$

Market clearing requires equation (22) and (23) to be equal, which yields

$$\hat{p}_t - \hat{q}_t - \hat{e}_t = \frac{1 - \theta}{\mu - \theta}\sigma\left(\hat{C}_t - \hat{C}^*_t\right) \tag{24}$$

Notice that the left hand side of the last equation represents the log-deviation of the terms of trade from the initial steady state.

As for the budget constraint, applying the following identity $w_t l_t + \Pi_t \equiv p y_t$ together with the market clearing condition we obtain

$$b_{t+1} = (1+\delta) b_t + \frac{\theta}{\theta - 1}\left(\hat{p}_t - \hat{P}_t\right) + \hat{C}^W_t - \hat{C}_t \tag{25}$$

and the foreign counterpart

$$b^*_{t+1} = (1+\delta) b^*_t + \frac{\theta}{\theta - 1}\left(\hat{q}_t - \hat{P}^*_t\right) + \hat{C}^W_t - \hat{C}^*_t \tag{26}$$

where $b = \frac{B}{C_{ss}}$. Since the initial steady state bond holding, B_{ss}, is zero we use steady state consumption as the unit of measure for the change in bonds holdings.

Once it is noted that $b^* = -\frac{n}{1-n} b$; we can subtract the foreign budget constraint from the home one to obtain

$$\frac{1}{1-n} b_{t+1} = \frac{1+\delta}{1-n} b_t + \frac{\theta}{\theta-1}(p_t - q_t - e_t) - (C_t - C_t^*) \tag{27}$$

Finally from money demand we get

$$m_t - \hat{P}_t = \frac{\sigma}{\varepsilon}\hat{C}_t - \frac{1}{\varepsilon}\left(\frac{\hat{P}_{t+1} - \hat{P}_t}{\delta} + \frac{\hat{r}_{t+1}}{1+\delta}\right) \tag{28}$$

where $m = d\log M$ and for which we have made use of the Fisher equation[14].

Subtracting the foreign counterpart (not shown) from (28), we obtain

$$m_t - m_t^* = e_t + \frac{\sigma}{\varepsilon}\left(\hat{C}_t - \hat{C}_t^*\right) - \frac{1}{\varepsilon}\left(\frac{e_{t+1} - e_t}{\delta}\right)$$

As shown by Obstfeld and Rogoff (1996, ch. 10), with PPP holding through time, there is no overshooting of the exchange rate[15], so that the last term in the last equation disappears implying

$$m_t - m_t^* = e_t + \frac{\sigma}{\varepsilon}\left(\hat{C}_t - \hat{C}_t^*\right) \tag{29}$$

3.4.1 Long run solution: flexible prices

Since prices are fixed only for one period, the long run coincides with period t+1. We can thus reconsider all our previous relations starting with the budget constraint. Since the only change in bond holdings derives from the short run shock, i.e. $b_{t+1} = b_t$, we get

$$\frac{\delta}{1-n} b_t = \frac{\theta}{1-\theta}(\hat{p}_{t+1} - \hat{q}_{t+1} - e_{t+1}) + \left(\hat{C}_{t+1} - \hat{C}_{t+1}^*\right)$$

[14] i.e. $\frac{\delta}{1+\delta}\hat{i}_{t+1} = \frac{\delta}{1+\delta}\hat{r}_{t+1} + \hat{P}_{t+1} - \hat{P}_t$

[15] This could be easily shown with our equation by resorting to the permanency of the monetary shock so that $m_{t+1} - m_{t+1}^* = m_t - m_t^*$

which by equation (24) reduces to

$$\frac{\delta}{1-n} b_t = \frac{\theta(\sigma-1)+\mu}{\mu-\theta}\left(\hat{C}_{t+1}-\hat{C}^*_{t+1}\right) \tag{30}$$

or

$$\frac{\delta}{1-n} b_t = \frac{\theta(\sigma-1)+\mu}{(1-\theta)\sigma}\left(\hat{p}_{t+1}-\hat{q}_{t+1}-e_{t+1}\right) \tag{31}$$

The transfer problem

This last relation shows already the effects of our specification of the elasticities as compared with the results obtained by the original specification. At least in theory, it is possible now to obtain a negative correlation between the terms of trade $(\hat{p}-\hat{q}-e)$ and the current account: just set $\theta < 0$ and $\sigma > 1-\frac{\mu}{\theta}$.[16] In Obstfeld and Rogoff (1996, ch. 10) the positive correlation between the current account and the terms of trade is interpreted as confirming the argument of Keynes (1929) in support of the "transfer problem". Our finding shows that the conclusion drawn by Obstfeld and Rogoff is due to their restrictive assumptions on elasticities.

Furthermore note again that the degree of monopolistic distortion does not play any role in this expression.

3.4.2 Short run sticky prices

To derive the short run responses to a monetary shock we just need to take account of the fact that $\hat{p}_t = \hat{q}_t = 0$ since prices can not deviate from the initial staedy state level in the short run.

Let us then start with the budget constraint. Equation (27) reduces now to

$$\frac{1}{1-n} b_{t+1} = -\frac{\theta}{\theta-1} e_t - \left(\hat{C}_t-\hat{C}^*_t\right) \tag{32}$$

Note that the change in bond holdings takes place exclusively in the short run and is permanent. In the long run prices adjust to clear the market and the current account returns to balance.

Equation (30) and (32) must be both true so that using equation (19) we obtain

$$\left(\hat{C}_t-\hat{C}^*_t\right) = \Delta e_t \tag{33}$$

[16] Admittedly, this case is very exceptional. Lombardo (1998) shows that including intermediate goods production makes this condition more plausible, albeit more complex.

where

$$\Delta = \frac{\theta}{1-\theta}\left[\frac{(\mu-\theta)\delta}{(\mu-\theta)(1+\delta)+\theta\sigma}\right]$$

We can now rearrange the monetary shock equation (29) using equation (33) to get

$$e_t = \left(\frac{\varepsilon}{\varepsilon+\sigma\Delta}\right)(m_t - m_t^*) \tag{34}$$

Finally using equation (32), (33) and (34) we find the correlation between money shocks and the trade balance/current account, namely

$$\frac{1}{1-n} b_t = \Omega\,(m_t - m_t^*) \tag{35}$$

where

$$\Omega = \frac{\theta\varepsilon\left[(\mu-\theta)+\theta\sigma\right]}{\varepsilon(1-\theta)\left[(\mu-\theta)(1+\delta)+\theta\sigma\right]+\sigma\theta\delta(\mu-\theta)} \tag{36}$$

3.4.3 Trade balance response

The problem of solving for the sign of the trade balance (current account) response to a monetary shock reduces to the following

$$\operatorname{sign}\left(\frac{db}{d(m-m^*)}\right) = \operatorname{sign}(\Omega)$$

Let us give the following definition

Definition 1 θ^* is the null root of Ω; i.e. $\Omega(0) = 0$; If a second root exists[17], it is $\theta^{**} = \frac{-\mu}{\sigma-1}$, i.e. $\Omega(\theta^{**}) = 0$: Let us also denote with $\hat{\theta}$ the value of θ such that denominator $\Omega\left(\hat{\theta}\right) = 0$; i.e. the discontinuity point of Ω in terms of θ[18]:

Then we can state the following proposition which holds for all plausible cases[19]

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[17]This second root does not exist if $\sigma = \frac{\varepsilon(\mu-1)}{1-\varepsilon}$: In this case the discontinuity and the root coincide, yielding a negative value of Ω: See the appendix for details.

[18]In the appendix it is proved that of the two discontinuity points only one lies within the admissible range. $\hat{\theta}$ refers clearly to the admissible value.

[19]As discussed in the appendix, extra qualifications would be needed if we admit as plausible the interval $\sigma \in \left(1, \frac{1+\delta}{1+\frac{\delta}{\varepsilon}}\right)$: Besides this interval being very narrow, it implies that θ^{**} is extremely big in absolute terms. Hence the non plausibility. In other words, if $\sigma \notin \left(1, \frac{1+\delta}{1+\frac{\delta}{\varepsilon}}\right)$; then $\Omega < 0$ for all plausible negative θ:

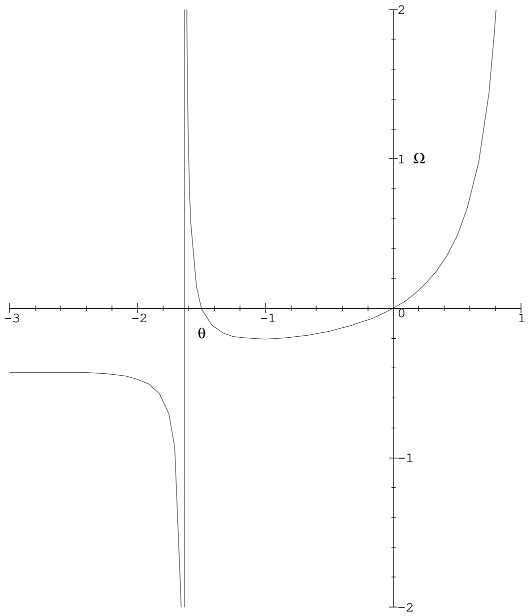
Proposition 1
1. if $\varepsilon > \mu$ or $\varepsilon < \mu$ and $\sigma < \frac{\mu - 1}{\varepsilon - 1}$ then
   - $\Omega > 0$ iff $\theta \in (0, \infty)$ or $\theta \in \left(\bar{\theta}, \theta^{**}\right)$
   - $\Omega < 0$ iff $\theta \in \left(-\infty, \bar{\theta}\right)$ or $\theta \in (\theta^{**}, 0)$
2. If $\mu > \varepsilon$ and $\sigma > \frac{\mu - 1}{\varepsilon - 1}$ then
   - $\Omega > 0$ iff $\theta \in (0, \infty)$ or $\theta \in \left(\theta^{**}, \bar{\theta}\right)$
   - $\Omega < 0$ iff $\theta \in (-\infty, \theta^{**})$ or $\theta \in \left(\bar{\theta}, 0\right)$
3. If $\theta^{**} = \bar{\theta}$ then $\Omega < 0$ iff $\theta < 0$.

The proof is given in the appendix.

This proposition includes the case analysed in Obstfeld and Rogoff (1995, 1996) where the elasticity of intra-temporal substitution is bigger than one and where there is a positive correlation between money and the current account.[20]. But it also shows that there are plausible values of the parameters for which the current account deteriorates after a positive monetary shock. A graphical example will show this point, which is the central result of this paper.

Let us assume the following values for the relevant parameters: $\mu = 1.5$; $\sigma = 2$; $\varepsilon = 9$; $\delta = 0.05$. The relation between the response of the trade balance to a monetary shock and θ is showed in figure 1. On the right side of the vertical axis we have the Obstfeld and Rogoff (1995) case: an elasticity of substitution bigger than one implies a positive response of the trade balance. The origin of the axes coincide with the formulation of Corsetti and Pesenti (1997). Finally, the left side of the vertical axis shows that an elasticity of substitution smaller than one ($\theta < 0$) can easily produce a negative response of the trade balance.

[20] There is a second interval for which the response is positive, i.e. $\left(\bar{\theta}, \theta^{**}\right)$. In principle it is possible to analyse its dimension in terms of θ, but the gain this would provide seems more than offset by the heaviness of the expressions involved. Just note that this interval shrinks as σ increases, so that $\Omega < 0$ for an increasing range of negative θ. For the root of Ω corresponding to $\theta = 0$ we have then an intuitive story based on consumption switching more or less than proportionally to the change in prices, which in a way is at the centre of the Marshall-Lerner conditions. However we lack a plausible interpretation for the behaviour of Ω around its "infinite discontinuity" point. Note that in that region Ω changes sign twice.



fi gure 1: Trade balance response

4 Conclusion

This paper has shown that disentangling the markup from the elasticity of substitution between domestic and imported goods, opens the way in general equilibrium models of open economies with imperfect competition and nominal rigidities, to a range of responses of the current account and terms of trade to monetary shocks. This improves the fitting of this class of models with respect to one of the stylized facts of international business cycles. Whether this occurs at the expenses of other aspects, namely permanency and international consumption and output correlation, is an issue for further research.

The conditions derived in this paper are clearly very sensitive to the specification of the model. Introducing international market segmentation, i.e. pricing to market, as in Betts and Devereux (1996) and also introducing a more complex market structure including intermediate goods, affects the critical values of the parameter for which the deterioration of the trade balance occurs, but does not alter the general finding of the present paper.

A Appendix

A.1 Proof of Proposition 1

Proof. Let us start by recalling the following expression

$$\Omega = \frac{\theta\varepsilon\left[(\mu - \theta) + \theta\sigma\right]}{\varepsilon(1-\theta)\left[(\mu-\theta)(1+\delta)+\theta\sigma\right]+\sigma\theta\delta(\mu-\theta)}$$

Ω is thus a rational function of our 5 parameters, which have the following admissible ranges:

$$\theta \in (-\infty; 1)\,;\ \varepsilon \in (1; \infty)\,;\ \sigma \in (0; \infty)\,;\ \mu \in (1; \infty)\,;\ \delta \in (0; 1)$$

Since we are mainly interested in the dynamics of the trade balance in relation to the intra-temporal elasticity of substitution, the two key parameters are θ and σ (the inverse of the intertemporal elasticity of substitution). For convenience we will then study Ω as a function of θ; the critical values of which will be considered at varying σ.

As for the first point of Proposition 1, it is self-evident that for $\theta \in (0; 1)$, Ω is positive.

Note then that the numerator of Ω, is a second degree polynomial in θ. The two roots can be easily derived as $\theta^{*} = 0$ and $\theta^{**} = \frac{-\mu}{\sigma - 1}$. Clearly θ^{**} exists only for $\sigma > 1$.

The denominator of Ω, Ω_D, is also a second degree polynomial in θ. Unfortunately the two roots of Ω_D are too cumbersome to be used to derive any conclusion about the dynamics. Nevertheless, we can easily rule out one of the roots of Ω_D by resorting to the upper bound of the range of θ together with the fact that $\Omega(\theta)\big|_{\theta \in (0;1)} > 0$.

For a general polynomial of second degree, say $y = (ax^2 + bx + c)$, we can in fact represent the roots of y as

$$x_{1;2} = \left(-\frac{b}{2a}\right) \pm \sqrt{\left(-\frac{b}{2a}\right)^2 - \frac{c}{a}}$$

Then we can easily see that

$$
\begin{aligned}
x_1 &> 0 \iff \sqrt{\left(-\frac{b}{2a}\right)^2 - \frac{c}{a}} > \frac{b}{2a} \\
x_2 &> 0 \iff -\frac{b}{2a} > \sqrt{\left(-\frac{b}{2a}\right)^2 - \frac{c}{a}}
\end{aligned}
$$

from which follows

$$
\begin{aligned}
\frac{b}{2a} &> 0 \Rightarrow x_1 > 0 \iff -\frac{c}{a} > 0 \\
\frac{b}{2a} &< 0 \Rightarrow x_1 > 0 \text{ always}
\end{aligned} \tag{37}
$$

and

$$
\begin{aligned}
-\frac{b}{2a} &> 0 \Rightarrow x_2 > 0 \iff -\frac{c}{a} < 0 \\
-\frac{b}{2a} &< 0 \Rightarrow x_2 > 0 \text{ never}
\end{aligned} \tag{38}
$$

Noting that our coefficients are as follows,

$$
\begin{aligned}
a &= \sigma(\delta + \varepsilon) - \varepsilon(\delta + 1) \\
b &= -\sigma(\delta\mu + \varepsilon) + \varepsilon(\mu + 1)(\delta + 1) \\
c &= -\varepsilon\mu(\delta + 1)
\end{aligned}
$$

we can derive the following conditions

$$
\begin{aligned}
a &> 0 \iff \sigma > \frac{1 + \delta}{1 + \frac{\delta}{\varepsilon}} \equiv \sigma_1 \\
-b &> 0 \iff \sigma > \frac{\varepsilon(\mu + 1)(\delta + 1)}{\varepsilon + \delta\mu} \equiv \sigma_2 \\
c &< 0 \text{ always}
\end{aligned} \tag{39}
$$

Moreover $\sigma_2 > \sigma_1$, so that $-\frac{b}{2a} < 0 \iff \sigma_1 < \sigma < \sigma_2$.
Finally it can be verified that

- $\bar\theta_1 > 0$ is always true, since by equations (37) $\bar\theta_1 < 0$ iff $a < 0$ and $b < 0$; i.e. $\sigma < \sigma_1$ and $\sigma > \sigma_2$ (by equations (39)), which is not possible. Moreover $\bar\theta_1 > 1$ which follows from the argument used above;

- $\bar\theta_2 < 0$ iff $\sigma > \sigma_1 \equiv \frac{1+\delta}{1+\frac{\delta}{\varepsilon}}$ since by equations (38) and (39) $\bar\theta_2 > 0$ if $a < 0$ and $b > 0$; i.e. if $\sigma < \sigma_1$ and $\sigma < \sigma_2$, in which case $\bar\theta_2 > 1$ which follows from the argument used above.

Since $\sigma_1 > 1$ we can say that except for the narrow interval $\sigma \in (1; \sigma_1)$; $\bar\theta_2 < 0$ exists only if θ^{**} exists (i.e. for $\sigma > 1$). Furthermore for $\sigma \in (1; \sigma_1)$ we have that θ^{**} is implausibly big in absolute terms, so that for all plausible negative values of θ we have $\Omega < 0$:

It can be verified that $\theta^{**} = \bar\theta_2$ occurs only for $\sigma = \frac{\varepsilon(\rho - 1)}{\rho - \varepsilon} \equiv \hat\sigma^{**}$; which in turn exists only if $\rho > \varepsilon$[21]. In this particular case it can be shown that

- $\lim_{\theta \to \theta^{**}} \Omega|_{\sigma = \hat\sigma^{**}} = -\frac{1}{(\rho - 1) + \sigma(\delta + 1)} < 0$

The last result together with the fact that[22] $\bar\theta_1 \neq \bar\theta_2$, implies in turn that Ω changes sign in $\bar\theta$ as long as $\bar\theta \neq \theta^{**}$: Although we cannot say a priory the direction of sign change for $\bar\theta$; we can resort to the following result:

- $\left.\frac{\partial \Omega}{\partial \theta}\right|_{\theta = \theta^{**}} = -\frac{\varepsilon(\sigma_1 - 1)^2}{\delta\sigma(\sigma(\varepsilon - \rho) + \varepsilon(\rho - 1))} > 0$ iff $\rho > \varepsilon$ and $\sigma > \hat\sigma^{**}$

This leads us to conclude that, if $\rho > \varepsilon$ then

- if $\sigma < \hat\sigma^{**}$ is true, then case 1) of Proposition 1 applies

- if $\sigma > \hat\sigma^{**}$ is true, then case 2) applies ■

[21] The literature is not unanimous on the size of the elasticity of money demand ($\frac{1}{\varepsilon}$): Sutherland (1996) borrows a value of $\varepsilon = 9$ from the literature cited therein. Betts and Devereux (1996) use a unitary elasticity of money demand. The latter case seems rather exceptional and more plausible for a long run money demand.

[22] This can be easily verified noting that $b^2 - 4ac \neq 0$:

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