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**TERMS OF TRADE AND LABOUR SUPPLY: A REVISION OF THE  
LAURSEN-METZLER EFFECT**

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*Terms of Trade and Labour Supply: A Revision of the  
Laursen-Metzler Effect\**

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### *Introduction*

The study of the mechanisms of transmission of economic cycles between economies is one of the main recurrent topics in the macroeconomics analysis of open economies.

Among these mechanisms can be found the one attributed to the terms of trade by the so-called *Laursen-Metzler Effect* (Harberger 1950, Laursen and Metzler 1950), which states that a fall in the terms of trade reduces national income and private savings, causing a deficit in the current account of the balance of payments.

It is well known that this effect was obtained using an adhoc consumption function. With the paper by Obstfeld [1982], a systematic revision of this effect within a neoclassical analysis framework (using optimizing agents, rational expectations, and markets equilibriums) appeared in contemporary literature. Among these versions, the papers by Svensson and Razin [1983], and Sen and Turnovsky [1989] can be considered important contributions.

Obstfeld studies the problem using a small economy model, with two goods, a financial asset, no production and with agents having preferences *a-la-Uzawa* [1968]. In this model an *Inverse Laursen-Metzler Effect* is observed since a permanent and non-anticipated fall in the terms of trade

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generates a surplus in the current account of the economy<sup>1</sup>. Svensson and Razin [1983] analyze this effect using a model that is more general than the one by Obstfeld. Their results are generally ambiguous, but coincide with Obstfeld when they use a similar structure of preferences.

In contrast with Obstfeld and Svensson and Razin, Sen and Turnovsky study this problem with the standard exogenous growth model of an open economy. In this paper, the domestic production of an exportable good is introduced, and also capital accumulation and the decision between leisure and work. Their results are ambiguous.

This paper analyzes the *Laurson-Metzler Effect* with a neoclassical model for a small economy, with two consumption goods, the domestic production of an exportable good, and agents that use their time endowment to consume leisure or to work. This model is different from that of Sen and Turnovsky, because it assumes that the agents' preferences with respect to leisure consumption *are not additively separable in time*, and because it excludes capital accumulation.

In this model the effect of a permanent and sudden fall of the terms of trade in the current account is generally ambiguous. The sign of this effect is determined by the impact of this perturbation on the labour supply curve of a representative agent: if it leads the agents to substitute work for leisure, the current account has a deficit according to the *Laurson-Metzler Effect*. In

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<sup>1</sup>This result is obtained when it is assumed that the initial amount of financial assets held by the economy is zero.

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contrast, the current account will present a positive balance according to the *Inverse Laursen-Metzler Effect* from Obstfeld's model.

This document is organized as follows. The first section shows the theoretical framework.. The second part analyzes the macroeconomic equilibrium, and section three constitutes a revision of the *Laursen-Metzler Effect*. Finally, the main conclusions are stated.

### *I. The Model*

We assume the existence of an economy composed of a large number of identical firms and households, which have an infinite horizon and perfect foresight.

The families possess the firms, consume an imported good ( $c_t^f$ ), a domestic good ( $c_t^h$ ), and the services derived from past and present leisure ( $l_t$ ); they sell labour to the firms, have a positive or negative savings balance by accumulating an international financial asset or bond ( $b_t$ ). The firms produce the domestic good ( $q_t$ ).

It is assumed that the economy is small, and thus, the terms of trade between the domestic and the imported good ( $p$ ), and the interest rate for the bond ( $r$ ) are given. The agents have perfect foresight, and unless otherwise indicated, it is assumed that these prices remain constant.

Finally, there is perfect competition in the labour market.

### I.1 The Families

Given the trajectory  $\{(w_t, \pi_t)\}_0^\infty$  for the wage rate and for the firms' benefits expressed in terms of the domestic good, a representative consumer chooses a trajectory  $\{(c_t^f, c_t^h, l_t)\}_0^\infty$  for his consumption vector that

$$\max \int_0^\infty e^{-\rho t} (U(c_t^f, c_t^h) + H(l_t)) dt, \quad (1)$$

subject to the budget restraint

$$\int_0^\infty e^{-\rho t} (c_t^f + p c_t^h) dt \leq b_0 + \int_0^\infty e^{-\rho t} p (w_t n_t + \pi_t) dt, \quad (2)$$

where  $\rho$  is the temporal preference rate,  $\pi_t$  is the firm's profit, and  $b_0$  is the previous accumulation of the bond. According to Kydland and Prescott [1982] the services derived from leisure consumption are defined as:  $l_t = \hat{T} - \eta_t > 0$ , where  $\hat{T}$  is time endowment, and

$$\eta_t \equiv \theta \int_{-\infty}^t e^{-\theta(t-\tau)} n_\tau d\tau, \quad \theta > 0, \quad (3)$$

is the *effective amount of hours worked* of a typical household, which is defined as a weighted average of the time devoted to work in the present and in the past<sup>2</sup>.

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<sup>2</sup> Equation (3) is Loannides and Taub's [1992] representation of Kydland and Prescott's [1982] utility function in continuous time.

Equations (1) and (3) define the household's preferences. We assume separability between the consumption of goods and the consumption derived from leisure<sup>3</sup> services. Leisure however, is not additively separable with respect to time.  $U()$  and  $H()$  are increasing, differentiable, and strictly concave functions in their arguments.

This kind of behaviour for leisure consumption has been interpreted in two different ways. Barro and King [1984] see it as evidence of the *fatigue* due to intense work during periods in the past, whereas Kydland [1984] says this *tiredness* takes place because the agents use leisure in order to increase a non-observable stock of capital.

In order to simplify the analysis of problem (1,3) we define the indirect utility function of a representative household as follows:

$$V(p, z_t) = \max_{(c_t^f, c_t^h)} \{ (U(c_t^f, c_t^h) \mid c_t^f + p c_t^h = z_t) \}, \quad (4)$$

where  $z_t$  is the expenditure in goods consumption<sup>4</sup>. Function  $V()$  is strictly concave<sup>5</sup> in  $z_t$ .

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<sup>3</sup> This assumption permits a graphic analysis of the response of the economy to large perturbations in the terms of trade. This analysis is extended to the general case only locally.

<sup>4</sup> The consumption of the domestic and imported good is obtained from Roy identities and from the expenditure definition:  $c_t^h = -\frac{V_p(p, z_t)}{V_c(p, z_t)}$ ,  $c_t^f = z_t - p c_t^h$ .

<sup>5</sup> Let us have  $V(p, z') = U(z' - p c', c')$  and  $V(p, z'') = U(z'' - p c'', c'')$ , and  $\lambda \in (0, 1)$ . Given the fact that  $U()$  is strictly concave in its arguments:

Equating the temporal preference rate to the interest rate of the bond, it can be shown that the optimality conditions of problem (1,3) are (see Appendix A):

$$\dot{\eta}_t = \theta (n_t - \eta_t), \quad \eta_0 = \bar{\eta}, \quad (5)$$

$$(\theta + r)w_t = \theta \frac{H_t(\hat{T} - \eta_t)}{pV_z(p, z_t)} + w_t r, \quad \lim_{t \rightarrow \infty} w_t \eta_t = 0, \quad (6)$$

$$z_{t+s} = z_t = r \left( b_t + p \int_t^{\infty} e^{-r(\tau-t)} (w_\tau n_\tau + \Pi_\tau) d\tau \right), \quad s > 0, \quad (7)$$

Here, equation (5) is an alternate form of expressing equation (3), and equations (5,6) determine the optimal trajectory of labour supply and of the agent's expenditure.

Equation (6) can have a familiar interpretation if we assume that individuals consider leisure as an asset for which the price is the wage rate. Thus, the expression seen in the left side of this equation is the normal return of this asset, calculated with  $(\theta+r)$  as the discount factor. The right side of the equation shows the return or dividend of the asset plus its capital gains or losses. Note that the

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$$\begin{aligned} \lambda V(p, z') + (1-\lambda) V(p, z'') &< U(\lambda(z' - pc') + (1-\lambda)(z'' - pc''), \lambda c' + (1-\lambda)c'') \\ &\leq \max_c U(\lambda z' + (1-\lambda)z'' - pc, c) = V(p, \lambda z' + (1-\lambda)z''), \end{aligned}$$

$V()$  is therefore strictly concave.

return of leisure (asset) is the marginal rate of substitution between leisure consumption and the consumption of the imported good.

Equation (7) assumes that the planned expenditure is constant and equal to a fraction of the household's total wealth.

### ***1.2 The Firms***

Given the trajectory of the wage rate  $\{w_t\}_0^\infty$ , a *typical firm* chooses a trajectory for the domestic good supply and labour demand  $\{q_t, n_t^d\}_0^\infty$  such that

$$\max \int_0^\infty e^{-rt} \pi_t dt, \quad (8)$$

where  $\pi_t = q_t - w_t n_t^d$ , and  $q_t = f(n)$  is a strictly concave production function. The solution to this problem is obtained  $f_n(n_t^d) = w_t$ , when the firm equals the marginal productivity of labour with the market's wage rate.

That is how the firm's labour demand curve is obtained:

$$n_t^d = \psi(w_t), \quad (9)$$

and its supply of the domestic good:

$$q_t = \phi(w_t), \quad (10)$$

where  $\psi()$  and  $\phi()$  are decreasing and strictly convex functions of the wage rate.

## *II Macroeconomic Equilibrium*

A *competitive equilibrium* is a trajectory of the wage rate  $\{w_t\}_0^\infty$ , an allocation  $\{(z_t, n_t)\}_0^\infty$  from the representative family, and an allocation  $\{(q_t, n_t^d)\}_0^\infty$  from the typical firm, with the following properties:

- $\{(z_t, n_t)\}_0^\infty$  solves problem (1)-(3) with the given wage rate,
- $\{(q_t, n_t^d)\}_0^\infty$  solves problem (8) with the given wage rate,
- the labour market clears  $n_t = n_t^d, \forall t$ .

The equations defining this equilibrium are<sup>6</sup>:

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<sup>6</sup> The dynamics of this model are similar to those in the model by Matsuyama [1990].

$$\dot{\eta}_t = \theta (\psi(w_t) - \eta_t), \quad \eta_0 = \bar{\eta}, \quad (11)$$

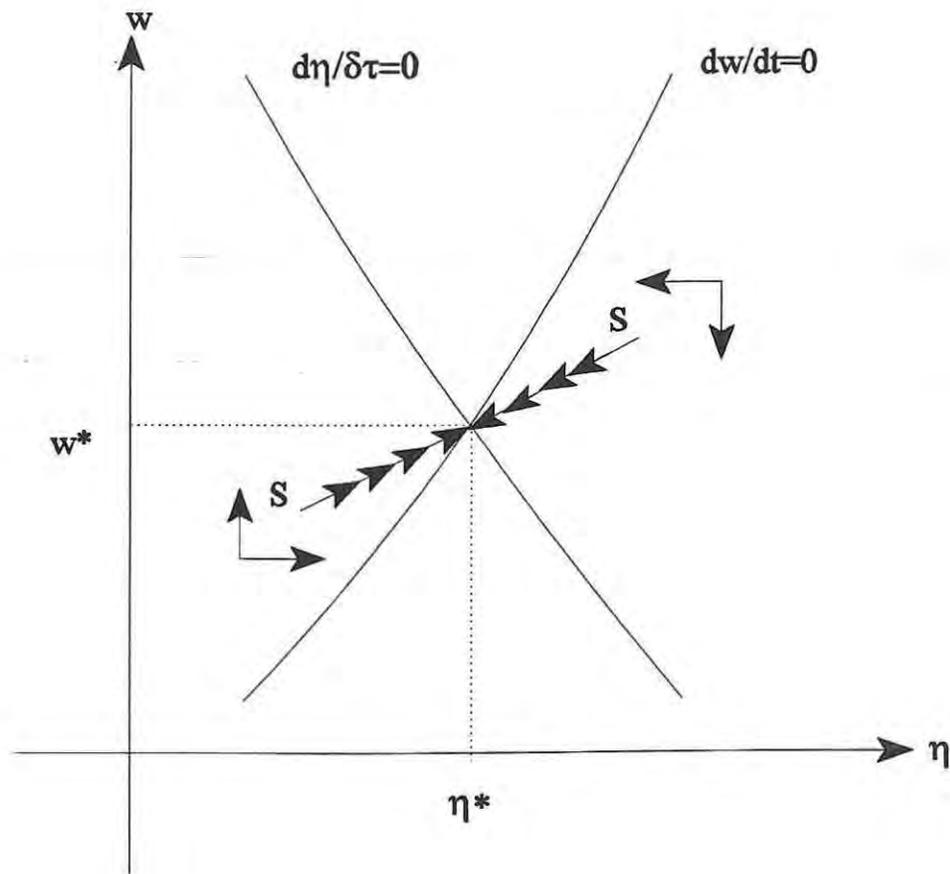
$$\dot{w}_t = -\theta \frac{H_t(\hat{T} - \eta_t)}{pV_z(p, z_t)} + (\theta + r)w_t, \quad \lim_{t \rightarrow \infty} w_t \eta_t = 0, \quad (12)$$

$$z_{t+s} = z_t = r \left( b_t + p \int_t^\infty e^{-r(\tau-t)} \phi(w_\tau) d\tau \right), \quad s > 0. \quad (13)$$

Figure 1 shows an analysis of this equilibrium in plane  $(w, \eta)$ .

The negative slope curve  $\left(\frac{d\eta}{dt} = 0\right)$  is the firm's labour demand function. In the points found above, the amount of hours of current work of an agent is smaller than its historical average  $(\eta_t)$ . That is how in this region, a decrease of  $\eta_t$  is observed, as showed by the horizontal arrows.

The positive slope curve  $\left(\frac{dw}{dt} = 0\right)$  is the long run labour supply. In the region below this curve, the marginal utility of leisure is higher than the wage rate. Thus, according to equation (12) a decrease in  $w_t$  is observed, as suggested by the vertical arrows.



**Figure 1**  
*Dynamics of the wage rate and of the labour supply*

$E$  is the only long run equilibrium point, and  $SS$  is the only trajectory that satisfies simultaneously equations (11,13).  $SS$  is a *saddle path* trajectory. Note that this trajectory corresponds to an equilibrium level for the households' expenditure.

Appendix B shows that given the equilibrium trajectory of the wage rate  $SS$ , the trajectory of the current account is:

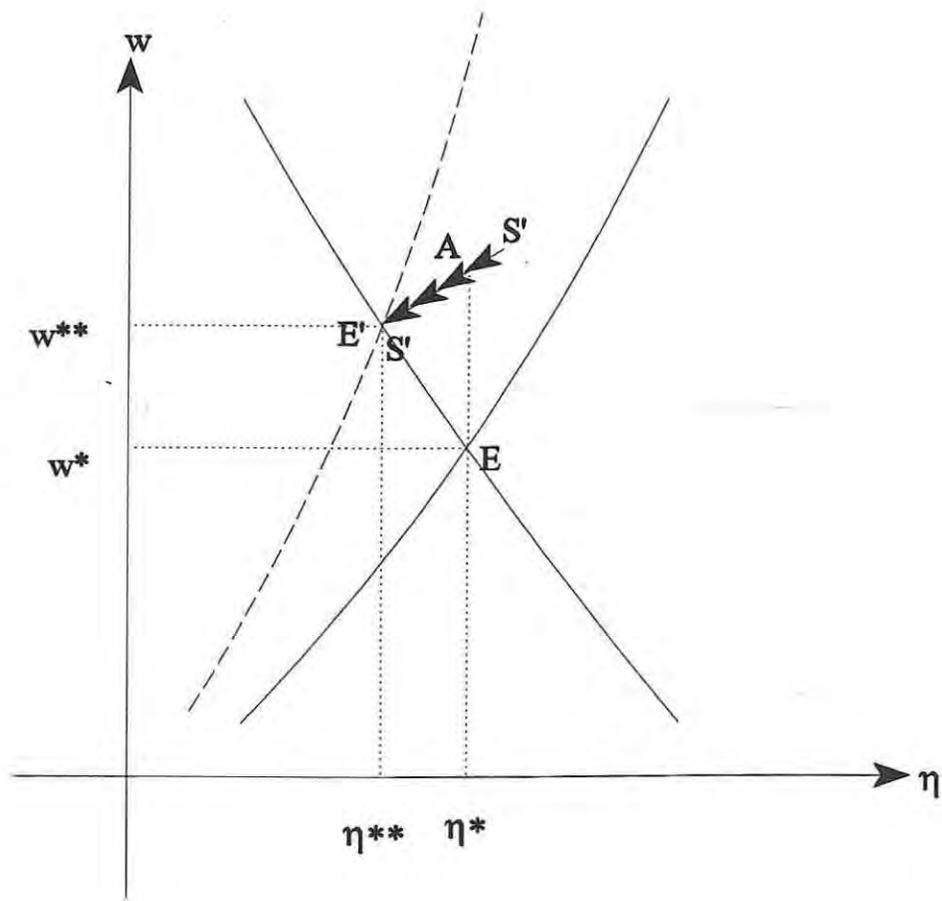
$$b_t^o = -p \int_t^\infty e^{-r(\tau-t)} \phi_w(w_\tau) w_\tau^p d\tau. \quad (14)$$

This equation establishes that the evolution of the current account is entirely determined by the initial situation of the economy, since if  $\eta_0 < \eta^*$ , the economy will accumulate deficits in its current account during the transition towards the long run equilibrium and viceversa.

### *III. Terms of Trade, Labour Supply and the Current Account*

This section shows the analysis of the effects of a permanent non-anticipated deterioration of the terms of trade, for the labour supply and the current account, when the economy is in a long run equilibrium situation.

A fall in the terms of trade reduces the wage rate in terms of the imported good. This generates a *substitution effect* towards leisure, which shifts the labour supply curve above point  $E$  in Figure 1. The perturbation also alters directly (*income effect*) and indirectly (*wealth effect*) the marginal utility of expenditure  $V_x^0$ .



**Figure 2**

Effects of an adverse terms of trade shock on the wage rate and the labour supply when  $\chi(p, z) < 0$ .

The result of these effects on the position of the labour supply curve in Figure 1 depends on the sign of the following expression (see Appendix C):

$$\chi(p, z) = \left( \frac{1}{\sigma(p, z)} \right) \Gamma_0 + \gamma(p, z) - 1, \quad (15, a)$$

where  $\sigma(p, z) = -V_z / (V_{zz} z)$  is the intertemporal substitution of expenditure,  $\gamma(p, z) = -V_{zp} p / V_z$  is the terms of trade elasticity of the marginal utility of expenditure, and  $\Gamma_0 = \int_0^\infty e^{-rt} \dot{\phi}(w_t) dt / \left( b_0 / p + \int_0^\infty e^{-rt} \phi(w_t) dt \right)$  is the initial effect of a change in the terms of trade in the households' wealth.

In this expression  $(1/\sigma)\Gamma_0 > 0$  is the wealth effect, and  $\gamma$  is the income effect for which the sign is undetermined.

When  $\chi(p, z)$  is negative, the supply labour curve shifts over point  $E$  as in Figure 2<sup>7</sup>. The wage rate moves from  $E$  to  $A$  following trajectory  $S'S'$ , and converges towards the new long run equilibrium situated on point  $E'$ .

In this new trajectory, the agents reduce their expenditure in goods, and also the time they allocate to work in the short and long run. This reduction is larger in the short run since it has been assumed that working causes *fatigue*. According to equation (14), the economy will accumulate *deficits* ( $\Delta b_t < 0$ ) in its current account during the transition to the new equilibrium ( $\Delta w_t < 0$ ), as assumed by the *Laursen-Metzler Effect*.

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<sup>7</sup> Note that in this case, the slope for the supply curve increases.

Figure 3 shows the opposite case. Here, the supply curve shifts below point  $E$ <sup>8</sup>. This is because the income and wealth effects, when  $\gamma < 0$  result in a reduction of expenditure<sup>9</sup>. An *inverse Laursen-Metzler effect* will be observed. This effect will not depend on the cause of this shift.

If the substitution, income and wealth effects were mutually canceled ( $\chi = 0$ ) a fall in the terms of trade would not have any effect in the current account.

Finally, some special cases of expression (15,a) are analyzed. For this purpose, an iso-elastic utility function is assumed:  $U(c^f, c^h) = \left(\frac{v}{v-1}\right) (c^f c^{h(1-\alpha)})^{(v-1)/v}$ ,  $\alpha > 0, v > 0$ . Thus

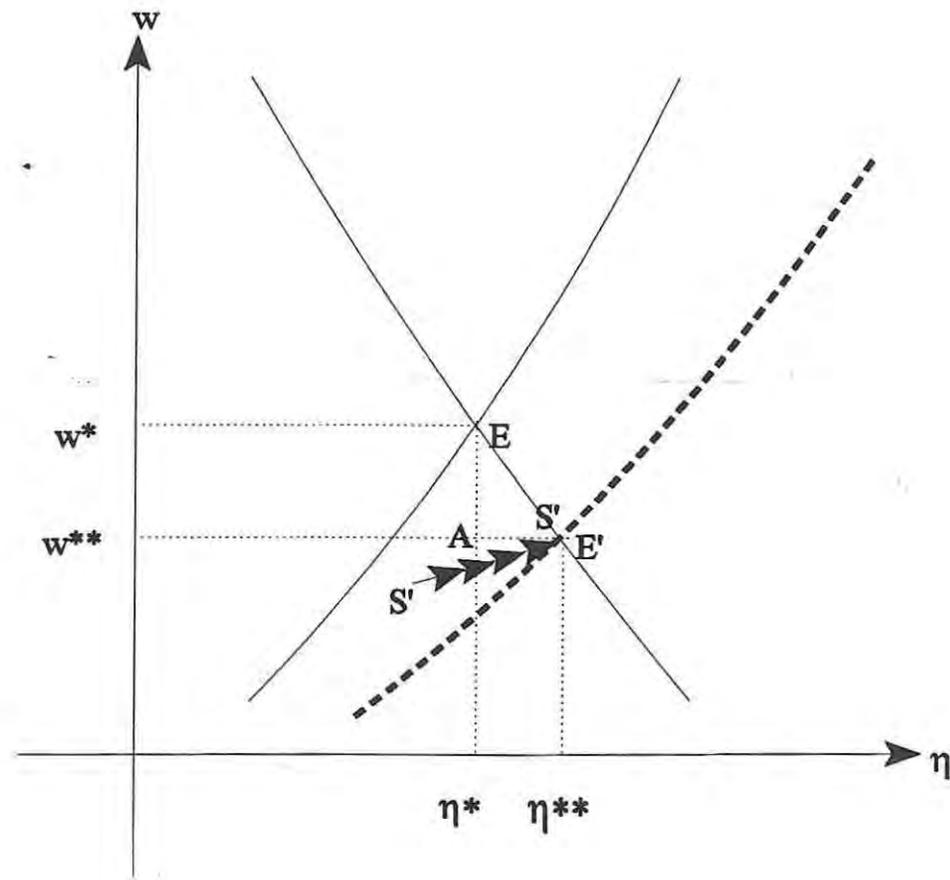
$$\chi = \frac{\Gamma_0}{v} - \left( 1 - \left( \frac{v-1}{v} \right) (1-\alpha) \right), \quad (15, b)$$

$v$  is the intertemporal elasticity of substitution for expenditure,  $\alpha$  is the proportion of expenditure allocated to the consumption of the imported good. Here,  $\chi$  is a decreasing function of the intertemporal elasticity of substitution and of the previous accumulation of the bond, whereas the sign of the effect of  $\alpha$  on  $\chi$  depends on the elasticity of substitution, being positive when it is above one, and negative when it is below one.

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<sup>8</sup> Note that in this case the slope for the supply curve decreases.

<sup>9</sup> If  $\gamma > 0$  the effect of a decrease of the terms of trade in expenditure is undetermined.



**Figura 3**

Effects of an adverse terms of trade shock on the wage rate and the labour supply when  $\chi(p, z) > 0$

If the initial stock of bonds is zero ( $b_0=0$ ) expression (15,b) is reduced to:  $\frac{\alpha(1-\nu)}{\nu}$ . Here, the intertemporal elasticity of substitution determines the kinds of effects generated by a fall in the terms of trade. This model generates a *Laursen-Metzler effect* when  $\nu > 1$ , and an *Inverse Laursen-Metzler Effect* when  $\nu < 1$ .

Another important case takes place when  $\nu = 1$ . Expression (15,b) becomes:  $\Gamma_0^{-1}$ . Now, the sign of the initial accumulation of bonds determines the kinds of effects produced by a reduction in the terms of trade. The *Laursen-Metzler Effect* takes place when  $b_0 > 0$ , and the *Inverse Laursen-Metzler Effect* is observed when  $b_0 < 0$ .

#### IV. Final Comments

In the model analyzed in this paper, it was proved that the result of a permanent and sudden fall of the terms of trade in the current account depends on the effect of this shock in the labour supply curve of the households.

The model generates a *Laursen-Metzler Effect* when the fall in the terms of trade causes a strong substitution effect against work, and produces an *Inverse Laursen-Metzler Effect* when the opposite happens.

*Appendix A: Obtention of the optimality conditions for the households*

Given the definition for the indirect utility function, the solution to problem (1,3) consists on the election of the trajectory for the expenditure and labour supply  $\{(z_t, n_t)\}_0^\infty$  such that

$$\max \int_0^\infty e^{-\rho t} (V(p, z_t) + H(\hat{T} - \eta_t)) dt. \quad (A, 1)$$

The Hamiltonian for this problem can be written as:

$$H_t = \left( V(p, z_t) + H(\hat{T} - \eta_t) \right) + \mu_t (rb_t + p(w_t n_t + \Pi_t) - z_t) + \lambda_t \theta (n_t - \eta_t) e^{-\rho t} \quad (A, 2)$$

where  $\lambda_t e^{-\rho t}$ , and  $\mu_t e^{-\rho t}$  are the costates variables of the budget restraint and of the evolution of  $\eta_t$ .

Optimality conditions are:

$$V_z(p, z) = \mu_t, \quad (H_z = 0), \quad (A, 3)$$

$$\mu_t p_t w_t + \theta \lambda_t = 0, \quad (H_n = 0), \quad (A, 4)$$

$$\dot{\mu}_t = \mu_t (\rho - r), \quad \lim_{t \rightarrow \infty} \mu_t e^{-rt} b_t = 0, \quad (A, 5)$$

$$\dot{\lambda}_t = H_\eta(\hat{T} - \eta_t) + (\theta + r) \lambda_t, \quad \lim_{t \rightarrow \infty} \lambda_t e^{-rt} \eta_t = 0. \quad (A, 6)$$

If the interest rate equals the intertemporal preference rate ( $r = \rho$ )<sup>10</sup>, and given that  $w_t = -\theta \frac{\lambda_t}{p\mu_t}$

<sup>10</sup> Note that when  $r > \rho$  the agents would accumulate bonds indefinitely, violating the assumption of a small economy, and if  $r < \rho$  the households would

according to equation (A,4), these equations can be written as:

$$\left( (\theta+r) w_t - \dot{w}_t \right) p V_z(p, z_t) = \theta H_1(\hat{T} - \eta_t), \quad \lim_{t \rightarrow \infty} e^{-rt} w_t \eta_t = 0 \quad (\text{A, 7})$$

$$\dot{\mu}_t = 0, \quad \lim_{t \rightarrow \infty} e^{-rt} b_t = 0, \quad (\text{A, 8})$$

$$V_z(p, z) = \mu. \quad (\text{A, 9})$$

According to equations (A,8) and (A,9), the expenditure is constant in the optimal trajectory, from which it can be said that:

$$z_t = r \left( b_t + \int_t^{\infty} e^{-r(\tau-t)} p (w_{\tau} n_{\tau} + \Pi_{\tau}) d\tau \right). \quad (\text{A, 10})$$

### Appendix B: Obtention of equation (14).

Equation (13) in this model follows the *Bellman principle* of dynamic optimization, and thus, the private expenditure of the agents for period  $t + \Delta t$  can be written as:

$$z_{t+\Delta t} = r \left( b_{t+\Delta t} + \int_{t+\Delta t}^{\infty} e^{-r(\tau-t-\Delta t)} p \phi(w_{\tau}) d\tau \right), \quad (\text{B, 1})$$

and given that  $z_t = z_{t+\Delta t}$  it follows that:

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acquire debts without any limit, violating their budget restraints.

$$b_{t+\Delta t} - b_t = - \int_t^\infty e^{-r(\tau-t)} P \left( \phi(w_{\tau+\Delta t}) - \phi(w_\tau) \right) d\tau . \quad (B, 2)$$

Dividing this expression by  $\Delta t$  and establishing  $\Delta t \rightarrow 0$  gives:

$$\dot{b}_t = - \int_t^\infty e^{-r(\tau-t)} P \phi_w(w_\tau) \dot{w}_\tau d\tau . \quad (B, 3)$$

**Appendix C: Obtention of equation (15).**

From equations (11,12) the equation that determines the equilibrium wage rate in the steady state of the economy<sup>11</sup> is obtained:

$$w p V_z(p, z) = \hat{\theta} H_1(\hat{T} - \psi(w)) , \quad (C, 1)$$

where  $\hat{\theta} = \theta / (\theta + r)$ . Differentiating this expression, we obtain:

$$p V_z \partial w + w (V_z + p V_{zp}) \partial p + w p V_{zz} \partial z = - \hat{\theta} H_{11} \phi_w \partial w , \quad (C, 2)$$

$$\partial z = \xi_0 \partial p + p \left( \frac{\partial \xi_0}{\partial w} \right) \left( \frac{\partial w}{\partial p} \right) \partial p , \quad (C, 3)$$

where  $\xi_0 = \int_0^\infty e^{-rt} \phi(w_t) dt$  is the present value of domestic production, and  $\partial \xi_0 / \partial w$  is its derivative

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<sup>11</sup> Given the properties of  $V()$ ,  $H()$ , and  $\psi()$  this equation has a solution which is unique.

with respect to a rise in the long run wage rate. According to trajectory  $s's'$  in figure 2  $\partial \xi_0 / \partial w < 0$ .

Substituting expression (C,3) in equation (C,2) and joining terms, it can be obtained:

$$\frac{\partial w}{\partial p} = \Omega \left( \frac{\Gamma_0}{\sigma(p, z)} + \gamma(p, z) - 1 \right), \quad (C, 4)$$

where  $\Omega = \left( \frac{p}{w} + p \frac{V_{zz}}{V_z} \left( \frac{\partial \xi_0}{\partial p} \right) + \frac{\theta_{H_{11}} \phi_w}{w V_z} \right) > 0$  ,  $\sigma(p, z) = -\frac{V_z}{V_{zz} z} > 0$ ,  $\Gamma_0 = \xi_0 / \left( \frac{b_0}{p} + \xi_0 \right)$ , and  $\gamma(p, z) = -\frac{V_{zp} p}{V_z} > 0$ .

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