DT
DECON

DOCUMENTO DE TRABAJO

Nº 477

THE MUNDELL-FLEMING MODEL: A DIRTY FLOAT VERSION

Waldo Mendoza Bellido

DEPARTAMENTO DE ECONOMÍA
PUCP

DOCUMENTO DE TRABAJO N° 477

The Mundell-Fleming Model: A Dirty Float Version

Waldo Mendoza Bellido

Marzo, 2019

DEPARTAMENTO
DE **ECONOMÍA**

DOCUMENTO DE TRABAJO 477
http://files.pucp.edu.pe/departamento/economia/DDD477.pdf

The Mundell-Fleming Model: A Dirty Float Version
Documento de Trabajo 477

Editado e Impreso:
© Departamento de Economía – Pontificia Universidad Católica del Perú,
Av. Universitaria 1801, Lima 32 – Perú.
Teléfono: (51-1) 626-2000 anexos 4950 - 4951
econo@pucp.edu.pe
http://departamento.pucp.edu.pe/economia/publicaciones/documentos-de-trabajo/

Encargado de la Serie: Jorge Rojas Rojas
Departamento de Economía – Pontificia Universidad Católica del Perú,
jorge.rojas@pucp.edu.pe
Primera edición – Abril, 2019.
Tiraje: 50 ejemplares

Hecho el Depósito Legal en la Biblioteca Nacional del Perú Nº 2019-06308.
ISSN 2079-8466 (Impresa)
ISSN 2079-8474 (En línea)

Se terminó de imprimir en mayo de 2019.

THE MUNDELL-FLEMING MODEL: A DIRTY FLOAT VERSION

Waldo Mendoza Bellido

ABSTRACT

A popular model in the teaching of macroeconomics of open economies at the undergraduate level is the Mundell-Fleming (MF). This model assumes that there is free capital mobility and takes into account two extreme exchange rate regimes: fixed and freely floating.

But there is a third regime, currently of relevance to many central banks, which is not addressed in the MF: one in which the central bank sets the short-term interest rate and maintains a dirty-float exchange-rate regime.

In this paper, an MF with these characteristics is presented. It is a simple, practical and user-friendly model that can be used to address contemporary issues, making it suitable for central banks or the teaching of macroeconomics at undergraduate level as a complement —or even a substitute— for the traditional MF.

JEL code: F41, E42, E52 and E58
Keywords: Mundell-Fleming, dirty float, imperfect capital mobility.

RESUMEN

Un modelo popular en la enseñanza de la Macroeconomía de las economías abiertas en el pre grado es el Mundell-Fleming (MF). El modelo supone que hay libre movilidad de capitales y considera dos regímenes de tipo de cambio extremos: fijo y flotante.

Pero hay un tercer régimen, relevante en la actualidad para muchos bancos centrales, que no es tratado en el MF. Es el de los bancos que fijan la tasa de interés de corto plazo y mantienen un régimen cambiario de flotación sucia.

En este documento se presenta un MF con estas características. Por su sencillez y por tratar temas contemporáneos, es un modelo amigable y práctico, y puede ser usado por los bancos centrales o en la enseñanza de Macroeconomía en el pre grado como un complemento, o quizá sustituto, del MF tradicional.

Código JEL: F41, E42, E52 y E58
Palabras clave: Mundell-Fleming, flotación sucia, movilidad imperfecta de capitales.

THE MUNDELL-FLEMING MODEL: A DIRTY FLOAT VERSION

Waldo Mendoza Bellido[1]

INTRODUCTION

One of the most popular models in the teaching of the macroeconomics of open economies at undergraduate level is the Mundell-Fleming (MF, Mundell, 1963 and Fleming, 1962). The model assumes free movement of capital, because the local asset and the external asset are perfect substitutes, and because there is no interference with the movement of financial capital. In this way, the balance of payments equation is reduced to the uncovered interest rate parity equation.

The MF takes into account two extreme exchange rate regimes. In the fixed exchange rate version, the central bank administers the exchange rate and in so doing loses control over international reserves, while the money supply is endogenous. In the floating exchange rate version, the bank sets the volume of international reserves and in so doing loses control over the exchange rate, while the money supply is exogenous. In both regimes, the interest rate is endogenous.

But there is a third regime, pertinent to evaluating the behavior of many central banks around the world, that is not dealt with in the MF. It concerns banks that, on the one hand, set a short-term interest rate as part of an inflation targeting scheme; and on the other, maintain a dirty float regime. In this regime, although the exchange rate is determined to a large extent by the foreign exchange market, the central bank intervenes in this market to moderate fluctuations. According to the IMF (2018), 27 countries currently employ such regimes,[2] and well-known past cases include those of Germany (1975-1981) and Japan (April 1991-March 2001).

How does a model of this type —in which central banks set the short-term interest rate and maintain a dirty-float foreign exchange regime— work?

To construct this new MF, first it is necessary to remove the assumption of free movement of capital, which renders foreign exchange intervention ineffective, and replace it with that of the imperfect movement of capital, in which foreign exchange intervention is effective. Second, we must propose for the monetary authority a foreign-exchange intervention rule that seeks to moderate exchange-rate movements. Third, we must assume that the central bank controls the short-term interest rate as part of its inflation-targeting schemes.

---

[1] Department of Economics, Pontificia Universidad Católica del Perú (PUCP). The author thanks Oscar Dancourt for his influential comments, and Yuliño Anastacio for his faultless assistance.

[2] For the IMF (2018) floating regimes can be either floating or free-floating. Conceptually, the term “dirty float” as utilized in this text equates to the IMF’s concept of flotation.

With these innovations, both the exchange rate and the volume of international reserves come to be endogenous variables in the model. Conversely, in the MF, only one of them is endogenous: the volume of international reserves under a fixed exchange rate, or the exchange rate when the regime is floating. Moreover, in this variant, the money supply is endogenous since the interest rate is fixed.

In this paper we present a MF with these characteristics, to which we add a simple fiscal rule —one employed by many countries around the world— that imposes a limit on the primary structural deficit.

The model is simple and practical as it uses the language of the MF but allows contemporary issues, such as foreign-exchange intervention or the interest-rate policy, to be dealt with in a way that would not be possible using the traditional model.

The paper has four sections. Section 1 describes foreign-exchange intervention based on a clear-cut example of a country with a dirty-float regime: Peru. Section 2 sets out the theoretical model. Section 3 provides comparative statics regarding the effects that changes in international conditions and the monetary policy have on production, the exchange rate, and international reserves. Finally, Section 4 presents some conclusions.

1. THE DIRTY-FLOAT REGIME

The dirty-float regime is nothing new. Countries such as Germany (1975-1981) and Germany (April 1991-March 2001) have also put this regime into practice, as reported by Obstfeld (1982) and Takatoshi (2002), respectively.

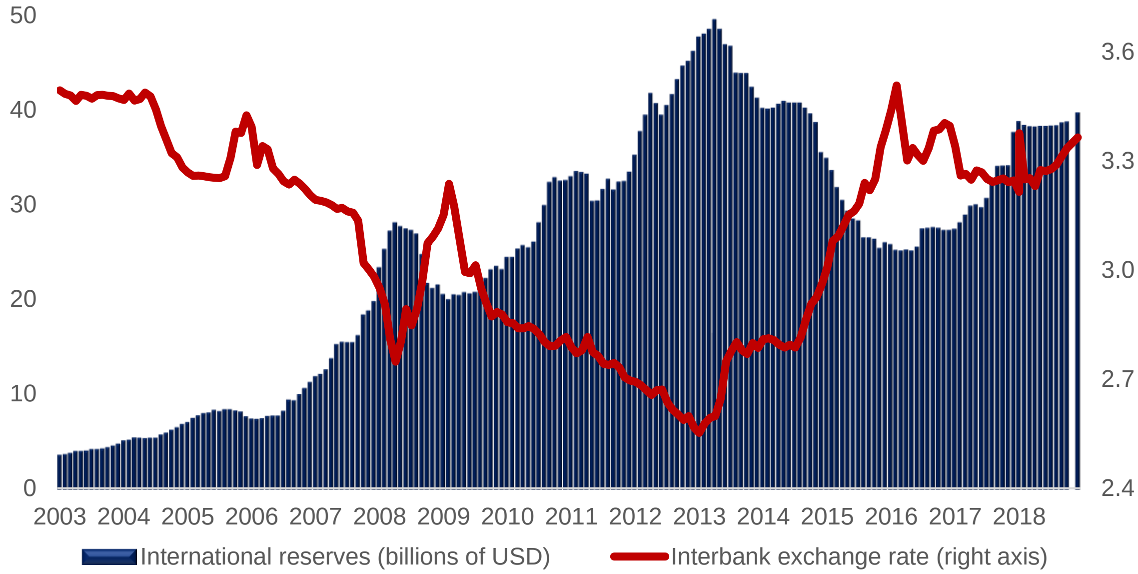
Currently, according to the IMF (2019), several countries in Latin America set the short-term interest rate and maintain a dirty floating exchange rate regime, within the framework of the inflation targeting scheme. Peru is the representative example of the dirty flotation regime.

In this hybrid foreign-exchange regime, the central bank has an intervention rule that leans against the wind. The bank tends to buy dollars when their price falls in relation to an implicit, unannounced exchange-rate target; and tends to sell when their price rises above this target. With this intervention rule, the central bank steers clear of excessive local-currency appreciations and depreciations in relation to its target value.

Graph 1 shows the dirty-float regime applied by the Peruvian Central Reserve Bank (BCRP) over the period 2003-2018.

As can be seen, the BCRP patently leans against the wind in the foreign-exchange market: it buys dollars when the exchange rate is going down, and sells when it is going up. The periods of decreases in the exchange rate, from the start of 2003 to April 2008 and from February 2009 to January 2013, correspond to periods of accumulation of foreign exchange reserves. In turn, the periods of increases in the exchange rate, from April 2008 to February 2009 and from January 2013 to February 2016, correspond to periods of reduction of foreign exchange reserves.[3]

Graph 1
Peru: exchange rate and international reserves



Source: BCRP

This hybrid dirty-float foreign-exchange regime will be a central part of the macroeconomic model to be presented in the following section: an MF with a fixed interest rate and dirty float of the exchange rate.

2. THE MUNDELL-FLEMING MODEL WITH DIRTY FLOAT OF THE EXCHANGE RATE

The model presented in this section is an MF for an economy in which the central bank sets the short-term interest rate and in which there is a dirty-float foreign-exchange scheme, in a world with imperfect capital movement. The model is an adapted and simplified version of Dancourt and Mendoza (2014) and Mendoza (2017), retaining the basic structure of the textbook MF.

The economy studied is small, open and dependent on external financing. Unlike the textbook model, capital movement is imperfect in the sense that local and external assets are not perfect substitutes.

---

3 The description and Graph 1 employ the exchange position (the portion of international reserves that belong to the central bank) rather than international reserves given the partial dollarization of the Peruvian economy. In Peru, international reserves are composed of the foreign-exchange position, the reserve requirements in dollars of the commercial banks, and the government's deposits in dollars.

On the other hand, the model reproduces a different macroeconomic policy regime than that assumed by the textbook MF. On the monetary policy front, in a world of imperfect capital movement, the central bank employs a monetary scheme with two instruments: the short-term interest rate (to control inflation) and exchange rate intervention, the dirty float (to avoid extreme exchange-rate volatility).

In the sphere of fiscal policy, the corresponding authority is guided by a structural primary deficit rule, which renders public spending endogenous. In the MF, public spending is exogenous, which assumes an economy with an infinite borrowing capacity.

The goods market equilibrium is Keynesian as production adapts to the level of demand, which comes from consumption, investment, public spending, and net exports. The external balance comes from the balance of payments equation, and the foreign-exchange intervention rule from the central bank. By combining the goods market equilibrium with the external balance, the equilibrium value of the exchange rate and production can be obtained. In turn, the volume of international reserves can be obtained by way of the intervention rule equation. Production, the exchange rate and the international reserves are the endogenous variables in this model.

Meanwhile, combining the goods market equilibrium and the external balance allows the economy's aggregate demand to be obtained. In this short-term model, on the aggregate supply side, the price level is assumed to be exogenous. As with the MF, it is not the purpose of this paper to explain the behavior of the price level.

2.1 Aggregate demand

a. The goods market

The goods market operates with idle capacity and production is intended for the local market and export, competing against imported substitute goods. Given the status of open economy, the international price, international GDP, and international interest rate are exogenous variables.

The adjustment mechanism is Keynesian. Production (Y) is adjusted to demand (D), which comes from consumption (C), private investment (I), public spending (G) and net exports (XN).

$$Y = D = C + I + G + XN \qquad (1)$$

Consumption is associated with disposable income and real wealth. Disposable income (Y_d) is the difference between income or production (Y) and taxes (T), and these are a proportion of the level of economic activity ($T = tY$). Only one kind of tax, income tax, is taken into account, at a rate of t. Thus, disposable income is defined as $Y_d = Y - T = (1 - t)Y$. Real wealth is equal to nominal wealth deflated by the local price level ($\frac{Q}{P}$). To maintain the linear character of the model, we utilize the approximation $\left(\frac{Q}{P} \cong Q - P\right)$. Consequently, private consumption is represented in equation (2).

$$= C_0 + c_1(1-t)Y + c_2(Q-P); 0 < t < 1, 0 < c_1 < 1, 0 < c_2 < 1. \quad (2)$$

Where c_1 and c_2 are the marginal propensities to consume with respect to disposable income and wealth, respectively.

Private investment is inversely dependent on the local interest rate (r) and the international interest rate (r^*). The presence of two interest rates reflects the fact that local firms can finance their investments in the local market in local currency, or in the foreign market in foreign currency.

$$I = I_0 - br - b^*r^* \quad (3)$$

On the other hand, in the fiscal sphere, we will model the case in which there is a limit (α) on the structural primary deficit as a percentage of potential GDP. The primary structural deficit (DPE) is the difference between primary public spending (G) and total structural income in the public sector. Total structural income in the public sector depends on the tax rate (t) and on potential GDP $(\bar{Y})$.

$$DPE = G - t\bar{Y} = \alpha\bar{Y}$$

From the above expression, it can be discerned that primary public spending is endogenous and a direct function of the tax rate, the fiscal deficit limit, and potential GDP.

$$G = (t + \alpha)\bar{Y} \quad (4)$$

Finally, net exports, or the trade balance, are directly dependent on the international GDP (Y^*), given their influence on the volume of exports, and the real exchange rate $(E + P^* - P)$[4], which reflects the competitiveness of the economy; and are inversely dependent on disposable income, because of its effect on imports given a marginal propensity to import (m). E is the nominal exchange rate and P^* is the price in dollars of the foreign good, which is an imperfect substitute for the domestic good.

$$XN = a_0Y^* + a_1(E + P^* - P) - m(1-t)Y \quad (5)$$

By replacing the values of consumption, private investment, public spending, and net exports in equation (1), the equilibrium in the goods market is given by,

---

4 We use an approximation of the real exchange rate.

$$Y = k[A_0 + (t+\alpha)\bar{Y} - br - b^*r^* - (a_1 + c_2)P + a_1E] \quad (6)$$

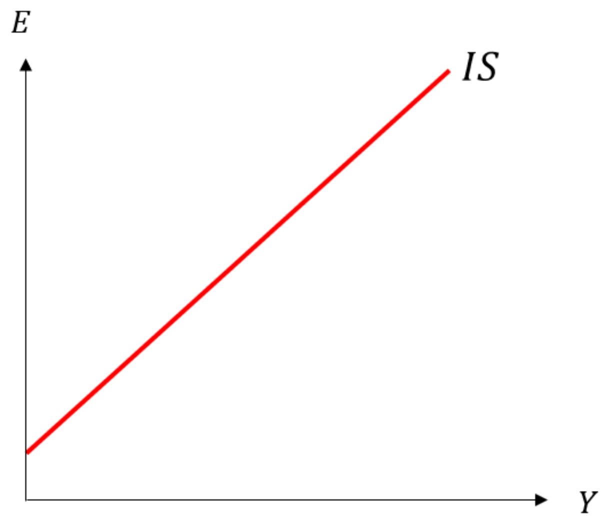
Where $k = \frac{1}{1-(c_1-m)(1-t)}$ is the Keynesian multiplier, whose value is greater than the unit, and $A_0 = C_0 + I_0 + a_0Y^* + a_1P^* + c_2Q$ is the autonomous component of demand.

Goods market equilibrium can be presented in the nominal exchange rate and production space. We use this in preference to the interest rate and production —more commonly employed in the MF— because in this model the interest rate is exogenous.

$$E = -\frac{A_0+(t+\alpha)\bar{Y}-br-b^*r^*-(a_1+c_2)P}{a_1} + \frac{Y}{ka_1} \quad (7)$$

This is the IS line, the combination of the exchange rate and production that keeps the goods market in equilibrium, and which we represent using Figure 1. Its slope is positive as an increase in the exchange rate pushes up production.

Figure 1
IS



b. The central-bank interest rate and the money market

In this model, the monetary policy instrument is the short-term interest rate, which is administered by the central bank. This is a substantive difference with the MF model.

$$r = r_0 \quad (8)$$

In the monetary market, in equilibrium, the real money supply that is, the nominal money supply (M^s) deflated by the price level (P), $M^s - P$[5], must be equal to the real demand for money. The nominal monetary supply[6] comes from the international reserves (B^{*bcr}) and the stock of domestic bonds held by the central bank, also known as internal credit (B^b). Real monetary demand is a direct function of production and an inverse function of the interest rate. In equilibrium,

$$M^s - P = B^{*bcr} + B^b - P = b_0 Y - b_1 r \tag{9}$$

Setting the interest rate changes the adjustment mechanism in the money market. In a regime with a floating exchange rate, the nominal money supply is traditionally exogenous and the interest rate is the adjustment variable to keep the money market in equilibrium. In this model the interest rate is exogenous, the money supply is endogenous, and the adjustment variable to keep the money market in equilibrium is internal credit. The central bank carries out open-market operations, buying or selling bonds, so that the interest rate stays the same. This is represented in equation (10).

$$B^b = -B^{*bcr} + P + b_0 Y - b_1 r \tag{10}$$

c. This equation serves only to determine an endogenous variable, the stock of bonds held by the central bank in local currency. This variable, however, is influenced by the other endogenous variables in the model, but does not exert an influence on them. That is, the model is recursive: once the value of production and the international reserves are determined, the stock of bonds in local currency can be determined, but there is no need to establish the bond stock to determine the other endogenous variables. Therefore, we keep this market isolated and do not take it into account in the general equilibrium analysis.

d. External equilibrium

When capital movement is imperfect, it is the balance of payments equation that best represents the external sector, rather than the uncovered interest rate parity equation, which reflect perfect capital movement. Our model assumes imperfect capital movement. The imperfection does not stem from the existence of controls on free capital movement, but reflects the fact that local and foreign assets are imperfect substitutes.

The balance of payments is composed of the current-account balance and the capital balance. We abstract all other components from the current-account balance, leaving only the trade balance, which is the same as for the case of the goods market.

---

5 Again, we use a linear approximation, $\frac{M^s}{P} \cong M^s - P$.

6 Strictly speaking, primary issuance or high-powered money, given that there are no banks in this model.

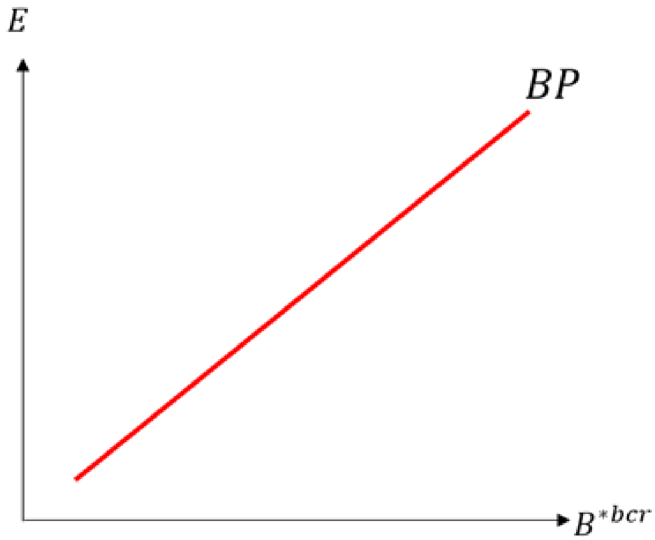
As regards the capital account, we look only at financial capital income, which are a direct function of the differential between the local interest rate (r) and the international interest rate(r^*), adjusted for expected depreciation $(E^e - E)$.[7]
The balance of payments equation is therefore given by,

$$B^{*bcr} - B^{*bcr}_{t-1} = a_0 Y^* + a_1(E + P^* - P) - m(1-t)Y + a_2(r - r^* - E^e + E) \tag{11}$$

Here, $B^{*bcr} - B^{*bcr}_{t-1}$ is the result of the balance of payments, which is equal to the variation between one period of the international reserves and another, where B^{*bcr} is the central bank's stock of international reserves for the current period and B^{*bcr}_{t-1} is the stock from the previous period. In the nominal exchange rate and international reserves space, the balance of payments is represented by equation 12) and Figure 2.

$$E = \left[\frac{m(1-t)Y - a_1 P^* + a_1 P - a_0 Y^* + a_2(r^* + E^e - r) - B^{*bcr}_{t-1}}{a_1 + a_2}\right] + \frac{B^{*bcr}}{a_1 + a_2} \tag{12}$$

Figure 2
The balance of payments



7 Again, here, to maintain the linear character of the model, we use an approximation for expected depreciation, $\frac{E^e - E}{E} \cong E^e - E$. E^e Is the expected exchange rate.

This presentation of the balance of payments has many advantages over the uncovered interest rate parity version of the MF with free capital movement. With perfect movement, the exchange rate depends only on the international interest rate and expected depreciation; while with imperfect capital movement, the exchange rate is also influenced by the price of exports, international GDP, and local GDP. Second, and most important, with the parity equation it is only possible to deal with fixed and floating exchange-rate schemes. However, our dirty-float foreign-exchange regime can only be tackled with imperfect capital movement, which is the method we employ next.

The central bank in this economy has neither a fixed nor a floating exchange rate. It has a hybrid system with limited exchange-rate flexibility, since foreign-exchange intervention is based on some notion of what an "adequate" exchange rate is. In this hybrid dirty-float regime, the central bank has an intervention rule that leans against the wind. The bank tends to buy dollars when their price falls in relation to an implicit, unannounced exchange-rate target (E^m); and tends to sell when their price rises above this target. One simple intervention rule that this dirty-float regime reproduces well is that proposed by Dancourt (1989, 2012),

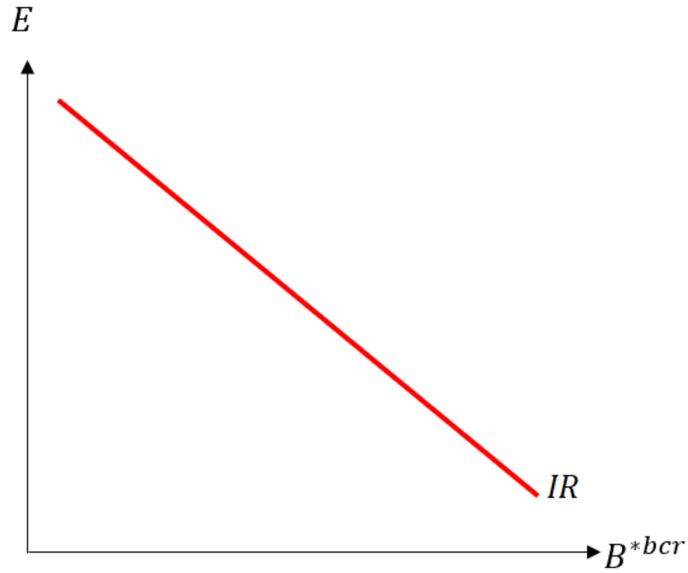
$$B^{*bcr} = B^{*bcr}_{t-1} + \beta_0(E^m - E) \tag{13}$$

In this rule, when the market exchange rate is positioned below the target rate $E < E^m$ (above the target rate, $E > E^m$), the central bank buys dollars, $B^{*bcr} - B^{*bcr}_{t-1} > 0$ (the central bank sells dollars, $B^{*bcr} - B^{*bcr}_{t-1} < 0$) and thereby raises (lowers) the price of the foreign currency. When the market exchange rate equals the target exchange rate$E = E^m$, in line with equation (13), the central bank does not intervene, $B^{*bcr} - B^{*bcr}_{t-1} = 0.$. With this intervention rule, the central bank avoids excessive local-currency appreciations and depreciations in relation to the target value.

The intervention rule may be plotted in the exchange rate and international reserves space. We refer to this line of foreign-exchange intervention as IR. It is equation (14) and is represented in Figure 3.

$$E = E^m + \frac{B^{*bcr}_{t-1}}{\beta_0} - \frac{B^{*bcr}}{\beta_0} \tag{14}$$

Figure 3
The intervention rule



The dirty-float regime is therefore an intermediate regime between the fixed (in which the stock of international reserves is an endogenous variable) and the floating (in which the endogenous variable is the exchange rate). In this intermediate regime, where the exchange rate is kept from fluctuating to any great degree, both the stock of reserves and the exchange rate are the endogenous variables. It is not common to find models where both the exchange rate and the international reserves are endogenous variables.

Combining equations (12) and (14), for the balance of payments and exchange-rate intervention, respectively, we obtain equations (15) and (16), which are the determining equations for the international reserves and the exchange rate, respectively.

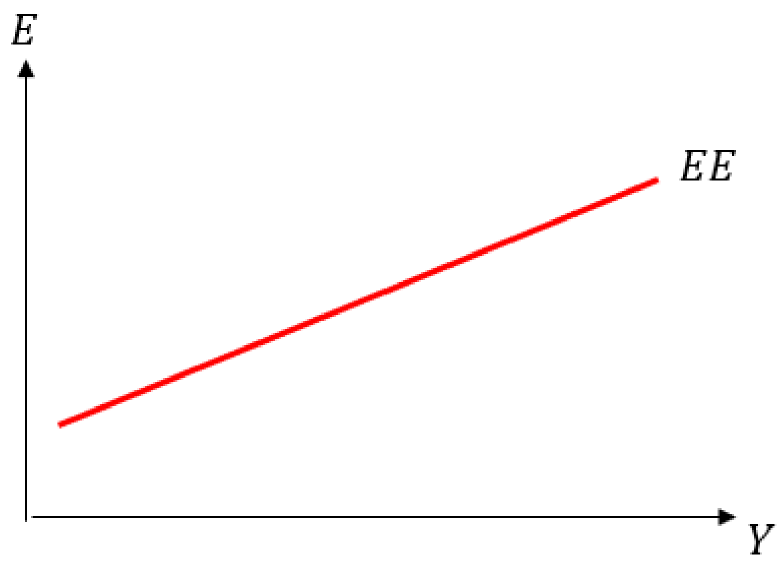
$$B^{*bcr} = B^{*bcr}_{t-1} + \beta_0 \left(\frac{a_1 + a_2}{\mu}\right) E^m + \frac{\beta_0}{\mu}[a_0 Y^* - a_2(r^* + E^e - r) - a_1(P - P^*) - m(1-t)Y] \tag{15}$$

$$E = \frac{1}{\mu}[\beta_0 E^m - a_0 Y^* + a_1(P - P^*) + a_2(r^* + E^e - r)] + \frac{m(1-t)Y}{\mu} \tag{16}$$

Where $\mu = a_1 + a_2 + \beta_0$.

We refer to equation (16) as the external equilibrium (EE) equation, because it results from the combination of the balance of payments equation and the foreign-exchange intervention rule. It is the geometric position of all combinations of the exchange rate and production that keep the balance of payments in equilibrium. We represent it with Figure 4. Its slope is positive because an increase in production pushes up imports and, in so doing, the exchange rate.

Figure 4
EE



The IS and EE slopes are positive. It can be noted that the IS slope is greater than that of the EE.[8]

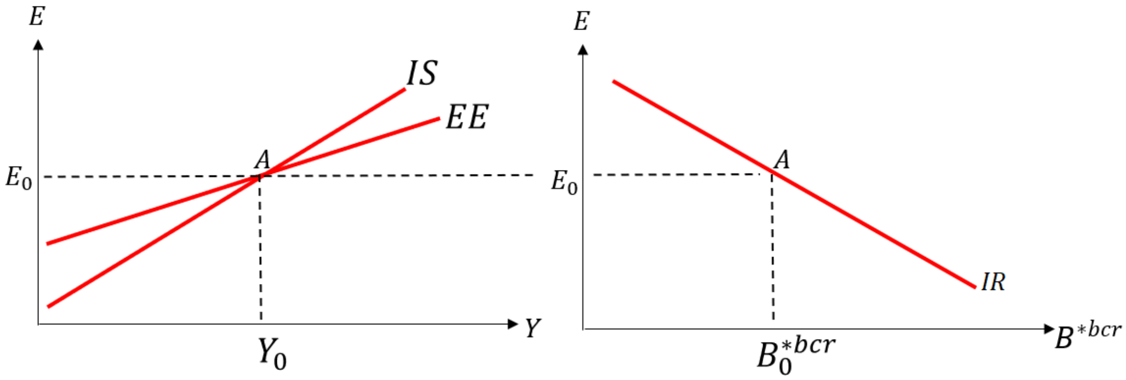
$$\left.\frac{dE}{dY}\right|_{IS} = \frac{1}{ka_1} > \left.\frac{dy}{dx}\right|_{EE} = \frac{m(1-t)}{u}$$

d. General equilibrium

General equilibrium is achieved when there is equilibrium in the goods market (IS) and the external sector (EE), which contains the balance of payments and the central bank's intervention rule. In graphic terms, the IS and the EE determine production and the exchange rate. With the exchange rate established, the stock of international reserves can be determined in the IR, as shown in Figure 5.

8 Since $1 > m(1-t)$ and $[1-(c_1-m)(1-t)]a_1 < a_1 + a_2 + \beta_o$

Figure 5
General equilibrium and aggregate demand



To arrive at the model in its reduced form and obtain the equilibrium values of production, the exchange rate, and the international reserves, we take the following steps. First, by combining equations (6) and (16) we obtain the equilibrium values of production and the exchange rate – equations (17) and (18), respectively. To obtain the international reserves in equilibrium, we replace the equilibrium value of the exchange rate, equation (18), in the intervention rule, equation (13), thus arriving at equation (19).

$$ {}^{eq} = D_0 \left\{ A_0 + (t+\alpha)\bar{Y} - \frac{a_1 a_0 Y^* + a_1 a_1 P^* - a_1 a_2 E^e + (ub + a_1 a_2) r + (ub^* - a_1 a_2) r^* + [u(a_1 + a_2) - a_1 a_1] P - a_1 B_0 E^m}{u} \right\} \quad (17)$$

$$\begin{aligned} E^{eq} = & \left[\frac{u + m(1-t) D_0 a_1}{u^2}\right] (B_0 E^m - a_0 Y^* - a_1 P^* + a_2 E^e) \\ & - \left[\frac{a_2 u + m(1-t) D_0 (ub + a_1 a_2)}{u^2}\right] r \\ & + \left[\frac{a_2 u - m(1-t) D_o (ub^* - a_1 a_2)}{u^2}\right] r^* + \frac{m(1-t) D_0}{u} [A_0 + (t+\alpha)\bar{Y}] \\ & + \left|\frac{a_1 u - m(1-t) D_0 [u(a_1 + a_2) - a_1 a_1]}{u^2}\right| P \end{aligned} \quad (18)$$

$$
\begin{aligned}
B^{*bcr^{eq}} = {} & B^{*bcr}_{t-1} + B_0\left[\frac{u(u-1) - m(1-t)D_0a_1}{u^2}\right]E^m \\
& - B_o\left\{\left[\frac{u + m(1-t)D_0a_1}{u^2}\right](-a_0Y^* - a_1P^* + a_2E^e) \right. \\
& - \left[\frac{a_2u + m(1-t)D_0(ub + a_1a_2)}{u^2}\right]r \\
& + \left[\frac{a_2u - m(1-t)D_o(ub^* - a_1a_2)}{u^2}\right]r^* \\
& + \frac{m(1-t)D_0}{u}[A_0 + (t+\alpha)\bar{Y}] \\
& \left. + \left|\frac{a_1u - m(1-t)D_0[u(a_1+a_2) - a_1a_1]}{u^2}\right|P\right\}
\end{aligned}
\qquad (19)
$$

Where $A_0 = C_0 + I_0 + a_0Y^* + a_1P^* + c_2Q,$ $\mu = a_1 + a_2 + \beta_0$ and $D_0 = \frac{uk}{a_1[1-c_1(1-t)]k + a_2 + B_0}$

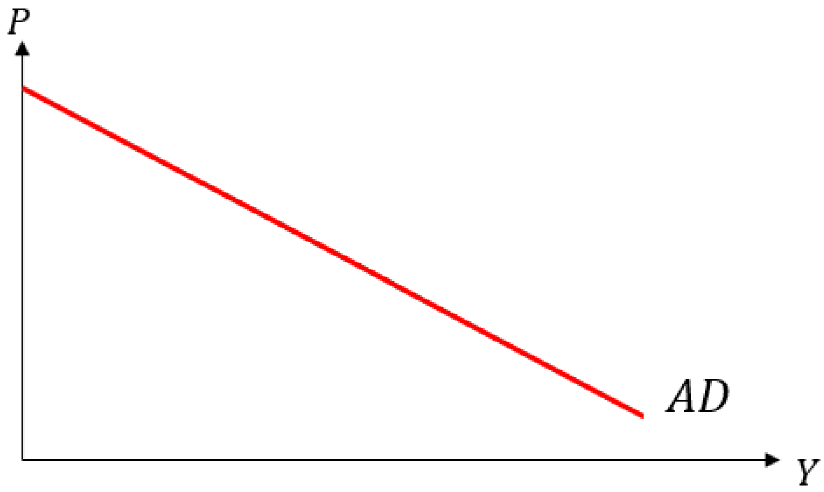
In this reduced form of the model, there are three endogenous variables. Production, which is determined in the goods market; the exchange rate, determined in the balance of payments; and the international reserves, in the intervention rule.

Meanwhile, equation (17) can be used to obtain the aggregate demand curve (AD) of this economy, represented by equation (20) and Figure 6. AD has a negative slope because wealth and the real exchange rate fall as the price level rises, pushing down consumption and new exports, demand, and production.[9]

$$
\begin{aligned}
P & \\
= {} & \frac{u[A_0 + (t+u)\bar{Y} - a_1(a_0Y^* + a_1P^* - a_2E^e - B_0E^m) - (ub + a_1a_2)r - (ub^* - a_1a_2)r^*]}{u(a_1+a_2) - a_1a_1} \\
& - \frac{u}{D_0[u(a_1+a_2) - a_1a_1]}Y
\end{aligned}
\qquad (20)
$$

[9] In equation (20), $u(a_1 + a_2) - a_1a_1 > 0$.

Figure 6
Aggregate demand

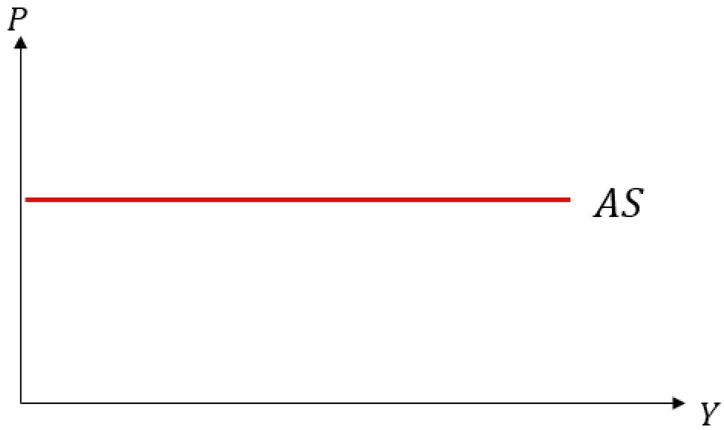


Aggregate supply

In this short-term model, it is assumed that the prices are given. Explaining their determinants is not the aim here. Equation (21) is aggregate supply, and is shown in Figure 7.

$$P = P_0 \tag{21}$$

Figure 7
Aggregate supply



In sum, the model is represented by the following system of equations, made up of IS, EE, AD, AS and IR. These equations, which constitute the general equilibrium of aggregate supply and demand, are represented with Figure 8.

$$E = -\frac{A_0 + (t+\alpha)\bar{Y} - br - b^*r^* - (a_1 + c_2)P}{a_1} + \frac{Y}{ka_1} \tag{7}$$

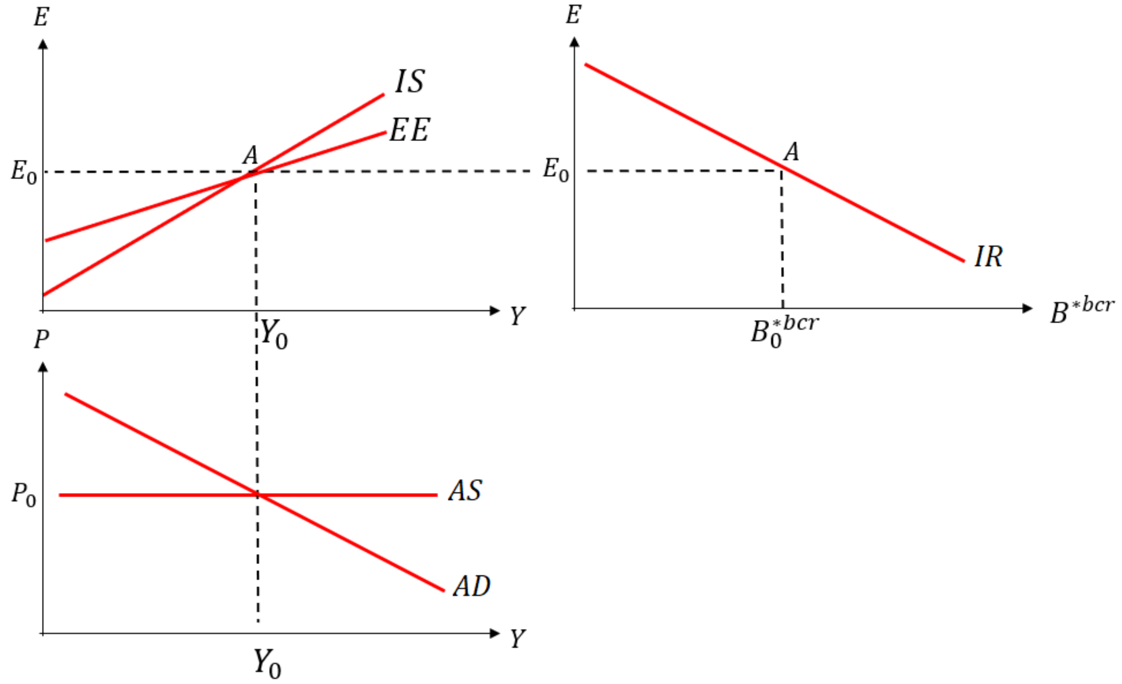
$$E = \frac{1}{\mu}[\beta_0 E^m - a_0 Y^* + a_1(P - P^*) + a_2(r^* + E^e - r)] + \frac{m(1-t)Y}{\mu} \tag{16}$$

$$P = \frac{u[A_0 + (t+u)\bar{Y} - a_1(a_0Y^* + a_1P^* - a_2E^e - B_0E^m) - (ub + a_1a_2)r - (ub^* - a_1a_2)r^*]}{u(a_1 + a_2) - a_1a_1} - \frac{u}{D_0[u(a_1 + a_2) - a_1a_1]}Y \tag{20}$$

$$P = P_0 \tag{21}$$

$$E = E^m + \frac{B_{t-1}^{*bcr}}{\beta_0} - \frac{B^{*bcr}}{\beta_0} \tag{14}$$

Figure 8
General equilibrium of aggregate supply and demand



With the complete model, we can now carry out some comparative static exercises to obtain the main predictions of this contemporary version of MF.

3. EXTERNAL SHOCK, MONETARY POLICY AND INTERVENTION RULE

In each of our exercises, we start with general equilibrium. Production is equal to demand, there is equilibrium in the balance of payments, and the target exchange rate is the same as the observed rate.

We will now perform two exercises to evaluate the effects on production, the exchange rate, and international reserves of an adverse external shock, a drop in the price of foreign goods, and a contractionary monetary policy (raising the policy interest rate).

i) The decrease in the price of the foreign good ($dP^* < 0$)

The decrease in the price of the foreign good causes the real exchange rate to fall, which deteriorates the trade balance or net exports. In the goods market, the deterioration of the trade balance causes demand, and therefore production, to fall. The deterioration in trade, for its part, is conducive to a balance of payments deficit, which pushes up the exchange rate —an effect that is weakened, but not negated, by the fall in imports due to lower production.

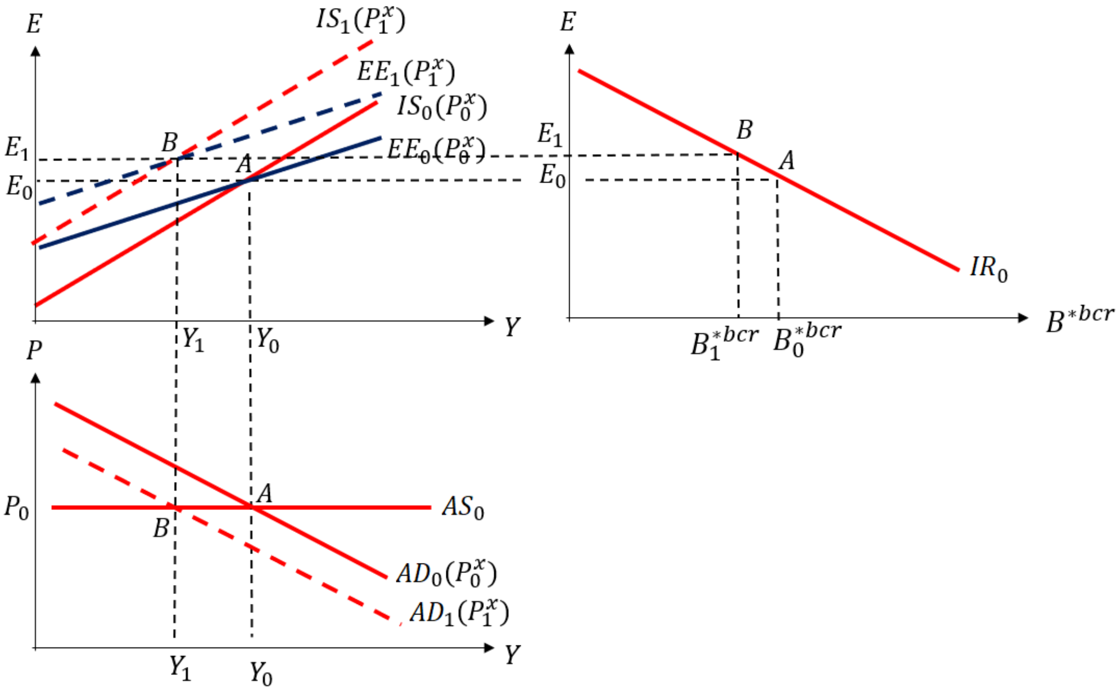
Finally, given the rise in the exchange rate (to above the target rate), the central bank intervenes by selling dollars, attenuating the rise in the exchange rate, and reducing its holdings of international reserves.

In sum, a decrease in the price of a foreign good causes a downturn in the economy, a rise in the exchange rate, and a fall in the central bank's international reserves.

The decrease in the price of the foreign good is presented in Figure 9. In the sphere of aggregate supply and demand, this decrease is an adverse shock that shifts aggregate demand leftward, causing production to fall. In the exchange rate and production space, the adverse external shock shifts IS and EE leftward, increasing the exchange rate and reducing production. The shift in IS is stronger than that of EE, as can be seen in equations (7) and (16). Finally, in the exchange rate and international reserves space, because the exchange rate goes up, the international reserves go down.

Figure 9

The decrease in the price of the foreign good



The mathematical results are given by,

$$dY = D_o\left[\frac{(a_2+B_0)a_1}{u}\right]dP^* < 0$$

$$dE = \frac{a_1}{u}\left[\frac{m(1-t)D_0(a_2+B_0)}{u} - 1\right]dP^* = -a_1\left[\frac{[1-c_1(1-t)]k}{a_1[1-c_1(1-t)]k+a_2+\beta_0}\right]dP^* > 0$$

$$dB^{*bcr} = -B_0\frac{a_1}{u}\left[\frac{m(1-t)D_0(a_2+B_0)}{u} - 1\right]dP^* = -\beta_0 a_1\left[\frac{[1-c_1(1-t)]k}{a_1[1-c_1(1-t)]k+a_2+\beta_0}\right]dP^* < 0$$

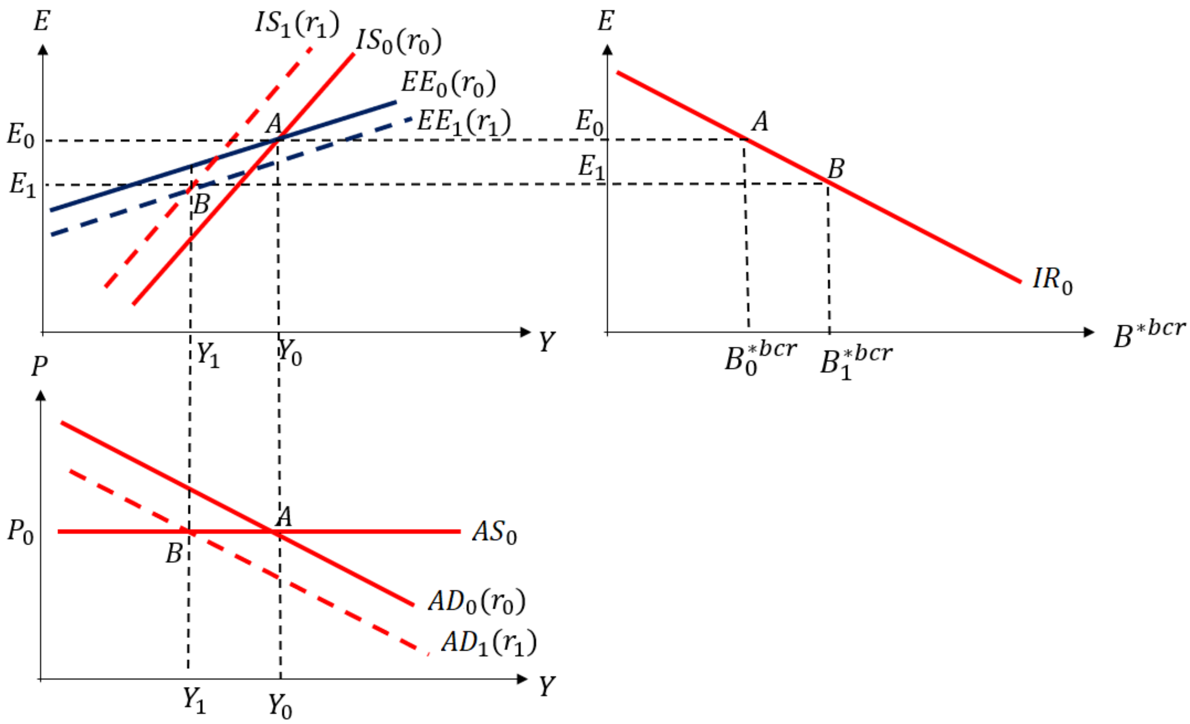
ii) The rise in the local interest rate $(dr > 0)$

The rise in the local interest rate, on the one hand, causes investment, demand, and production to fall. On the other hand, the increase in the relative profitability of local compared with foreign assets favors an influx of financial capital, causing a balance of payments surplus and a fall in the exchange rate. The lower production causes imports to fall, which accentuates the decrease in the exchange rate. The drop in the nominal exchange rate, which causes the real exchange rate to fall, brings about a balance of trade deficit that worsens the downturn. Given the drop in the exchange rate, the central bank intervenes in the foreign-exchange market by buying dollars, which increases the volume of its international reserves.

In sum, a contractionary monetary policy causes a downturn in the economy, a fall in the exchange rate, and a rise in the central bank's international reserves.

The increase in the local interest rate, a contractionary monetary policy, is presented in Figure 10. In the aggregate supply and demand space, the rise in the interest rate is an adverse domestic shock that shifts aggregate demand leftward, causing production to fall. In the exchange rate and production space, the rise in the exchange rate shifts IS leftward and EE rightward, lowering the exchange rate and production. Finally, in the exchange rate and international reserves space, because the exchange rate goes down, the international reserves go up.

Figure 10
The rise in the local interest rate



The mathematical results are given by,

$$dY = -\frac{D_0(ub + a_1 a_2)}{u} dr < 0$$

$$dE = -\left[\frac{a_2 u + m(1-t)D_0(ub + a_1 a_2)}{u^2}\right] dr < 0$$

$$dB^{*bcr} = B_0 \left[\frac{a_2 u + m(1-t)D_0(ub + a_1 a_2)}{u^2}\right] dr > 0$$

3. CONCLUSION

This paper has presented an MF for economies that set the interest rate and have a dirty-float foreign-exchange regime. The model can provide an understanding of the workings of central banks with this policy combination in the framework of an inflation targeting scheme, and allows for predictions regarding the effects of external shocks or macroeconomic policies on production, the exchange rate, and international reserves.

This is a simple, practical and user-friendly model that can be used to approach contemporary issues, making it suitable for central banks or the teaching of Macroeconomics at undergraduate level as a complement —or even a substitute— for the traditional MF.

REFERENCES

Dancourt, Oscar; Yong, Ivory y Koen Hendricks

1989 *Hiperinflación y política económica en el Perú: una interpretación*. Documento de trabajo 84, Departamento de Economía de la PUCP, Lima.

Dancourt, Oscar

2012 *Reglas de política monetaria y choques externos en una economía semi-dolarizada.* Documento de trabajo 346, Departamento de Economía de la PUCP, Lima.

Dancourt Oscar and Waldo Mendoza

2016 *Intervención cambiaria y política monetaria en el Perú*. Documento de trabajo 422, Departamento de Economía de la PUCP, Lima.

Fleming, Marcus

1962 *Domestic Financial Policies Under Fixed and Under Floating Exchange Rates*. IMF Staff Papers, 9, 369-379.

International Monetary Fund (IMF)

2018 *Annual Report on Exchange Arrangements and Exchange Restrictions* 2017, Washington D.C.

2019 *Foreign Exchange Intervention in Inflation Targeters in Latin America.* Marcos Chamon, David Hofman, Nicolás E. Magud, and Alejandro Werner (Editors), Washington D.C.

Mendoza, Waldo

2017 *La macroeconomía de la flotación sucia en una economía primario exportadora: el caso del Perú.* Revista Economía de la PUCP, Vol. XL, N° 79, pp. 105-132.

Mundell, Robert

1963 *Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates*. Canadian Journal of Economics and Political Science, 29, 227-257

Obstfeld, Maurice

1982 Exchange Rates, Inflation and Sterilization Problem: Germany, 1975-1981. NBER Working Paper Series, 963.

Takatoshi, Ito

2002 *Is Foreign Exchange Intervention Effective?* NBER, Working Paper 8914.

ÚLTIMAS PUBLICACIONES DE LOS PROFESORES
DEL DEPARTAMENTO DE ECONOMÍA

- *Libros*

José D. Gallardo Ku
2019 *Notas de teoría para para la incertidumbre*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

Úrsula Aldana, Jhonatan Clausen, Angelo Cozzubo, Carolina Trivelli, Carlos Urrutia y Johanna Yancari
2018 *Desigualdad y pobreza en un contexto de crecimiento económico*. Lima, Instituto de Estudios Peruanos.

Séverine Deneulin, Jhonatan Clausen y Arelí Valencia (Eds.)
2018 *Introducción al enfoque de las capacidades: Aportes para el Desarrollo Humano en América Latina*. Flacso Argentina y Editorial Manantial. Fondo Editorial de la Pontificia Universidad Católica del Perú.

Mario Dammil, Oscar Dancourt y Roberto Frenkel (Eds.)
2018 *Dilemas de las políticas cambiarias y monetarias en América Latina*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

María Teresa Oré e Ismael Muñoz (Eds.)
2018 *Aguas en disputa. Ica y Huancavelica, entre el entrampamiento y el diálogo*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

Patricia Benavente, José Escaffi, José Távara y Alonso Segura
2017 *Las alianzas público-privadas (APP) en el Perú: Beneficios y riesgos*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

Waldo Mendoza
2017 *Macroeconomía Intermedia para América Latina. Tercera edición actualizada y Aumentada*. Lima, Fondo Editorial de la Pontificia Universidad Católica del Perú.

César Guadalupe, Juan León, José S. Rodríguez y Silvana Vargas
2017 *Estado de la educación en el Perú, Análisis y perspectivas de la educación*. Lima. GRADE. Fortalecimiento de la Gestión Educativa en el Perú, FORGE.

Adolfo Figueroa
2017 *Economics of the Anthropocene Age*. Cham, Suiza, Palgrave Macmillan.

Adolfo Figueroa y Richard Web
2017 *Distribución del ingreso en el Perú. Lima, Instituto de Estudios Peruanos*.

Alfredo Dammert y Raúl García
2017 *Economía de la energía*. Lima, Fondo Editorial, Pontificia Universidad Católica del Perú.

- *Documentos de Trabajo*

No. 476 "Políticas de estabilización vs Políticas de crecimiento en Perú 2011-2018". José A. Oscategui. Febrero, 2019.

No. 475 "El sector gastronómico en el Perú: encadenamientos y su potencial en crecimiento económico". Mario D. Tello. Febrero, 2019.

No. 474 "El sistema de Madrid y la reducción de los costos de transacción. Una evaluación econométrica". José A. Tavera y Angelo Cozzubo. Febrero, 2019.

No. 473 "El sistema de Madrid y la reducción de los costos de transacción. Una evaluación econométrica". José A. Tavera y Angelo Cozzubo. Febrero, 2019.

No. 472 "Oferta de trabajo del hogar remunerado en el Perú rural: 2015-2017". Cecilia Garavito. Enero, 2019.

No. 471 "Impact of In-Kind Social Transfer Programs on the Labor Supply: a Gender Perspective". Luis García y Erika Collantes. Diciembre, 2018.

No. 470 "Milking the Milkers: a Study on Buyer Power in the Dairy Market of Peru". Tilsa Oré Mónago y José A. Tavera. Diciembre, 2018.

No. 469 "Gobernanza y regulación del sistema universitario peruano: luces y sombras de una nueva reforma". José I. Távara. Diciembre, 2018.

No. 468 "Monetary and Fiscal History of Peru, 1960-2017: Radical Policy Experiments, Inflation and Stabilization". Cesar Martinelli y Marco Vega. Diciembre, 2018.

No. 467 "The Role of Loan Supply Shocks in Pacific Alliance Countries: A TVP-VAR-SV Approach". Carlos Guevara y Gabriel Rodríguez. Noviembre, 2018.

No. 466 "La apropiación de internet en adultos mayores: desafíos planteados por las economías informales en dos ciudades de América Latina". Roxana Barrantes y Daniela Ugarte. Octubre, 2018.

No. 465 "¿Semillas mejoradas como escape de la pobreza? Evidencia cualitativa y cuantitativa para la sierra sur del Perú". Victor Gamarra Echenique y Carmen Taipe Espinoza. Octubre, 2018.

No. 464 "Preferential Liberalization and Self-Enforcing Multilateral Cooperation: Evidence from Latin America's Use of Tariffs, Antidumping and Safeguards". Patricia Tovar. Agosto, 2018.

No. 463 "The determinants of private investment in a mining export economy. Peru: 1997-2017". Waldo Mendoza Bellido y Erika Collantes Goicochea. Julio, 2018.

No. 462 "El espacio importa para el desarrollo humano: el caso peruano". Efraín Gonzales de Olarte y Juan Manuel del Pozo. Junio, 2018.

No. 461 “El ecosistema digital y la economía regional peruana: heterogeneidad, dinámica y recomendaciones de política (2007- 2015)”. Roxana Barrantes y Paulo Matos. Mayo, 2018.

No. 460 “Private Investment in a Mining Export Economy: A Model for Peru”. Waldo Mendoza Bellido y Erika Collantes Goicochea. Abril, 2018.

- *Materiales de Enseñanza*

No. 3 “Economía Pública”. Roxana Barrantes, Silvana Manrique y Carla Glave. Marzo, 2018.

No. 2 “Macroeconomía: Enfoques y modelos. Ejercicios resueltos”. Felix Jiménez. Marzo, 2016.

No. 1 “Introducción a la teoría del Equilibrio General”. Alejandro Lugon. Octubre, 2015.

Departamento de Economía - Pontificia Universidad Católica del Perú
Av. Universitaria 1801, Lima 32 – Perú.
Telf. 626-2000 anexos 4950 - 4951
http://departamento.pucp.edu.pe/economia/