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Summary: The standard BRANSON model is modified in a way which allows one to focus on the short term dynamics of foreign bonds markets, the money market and the stock market – or alternatively the oil market. This allows us to explain the dynamics of the exchange rate and the oil price within a portfolio choice model; also we identify critical expectation dynamics in a more conventional pricing approach to the oil market – expectations determine whether or not the oil market equilibrium is compatible with a stationary price or with sustained oil price inflation. Moreover, a straightforward innovative way to combine a portfolio approach with a growth model is developed. New results are obtained – through multiplier analysis – about the long term effects of changes in the savings rate, the process innovation rate, the product innovation variable and the money supply on the exchange rate and the stock market price; this raises many empirical issues. Finally, the analysis presented sheds new light on the global asset price dynamics in the context of the banking crisis.

Zusammenfassung: Das Standard-Branson-Modell wird auf eine Weise modifiziert, die es erlaubt auf die kurzfristige Dynamik von Auslandsbondsmarkt, Geldmarkt und Aktienmarkt – oder alternative Ölmarkt – zu fokussieren. Dies erlaubt eine einfache Erklärung der Dynamik von Ölpreis und Wechselkurs in einem Portfoliomodell. Es wird zudem in einem alternativen konventionellen Preismodellierungsansatz eine kritische Höhe der Ölinflationsdynamik hergeleitet, ab der kein stationärer Ölpreis im Steady-state zustande kommt. Darüber hinaus wird hier eine neue Verbindung von Portfoliomodell und Wachstumsmodell entwickelt. Es gibt zahlreiche neue Ergebnisse – u.a. im Kontext der Multiplikatoranalyse -, wobei Änderungen der Sparquote, der Prozessinnovationsrate, der Produktinnovationsintensität und des Geldangebots auf Wechselkurs und Aktienkurs untersucht werden, was zahlreiche empirisch interessante Fragen aufwirft. Die hier präsentierte Analyse kann auch konsistent zahlreiche Facetten der globalen Aktiva-Preisdynamik im Kontext der US-Bankenkrise erklären.

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To the memory of Edward Graham, Petersen Institute for International Economics, Washington D.C.

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1. Introduction

Open economy Macroeconomics has made considerable progress in recent years – e.g., with the analysis of output, inflation and trade in the context of DSGE models. As regards exchange rate analysis, there has been limited progress: The standard workhorse for the analysis of short-run dynamics is the BRANSON (1977) portfolio model – with money (M), domestic bonds (B) and foreign bonds (F*) which jointly explains the exchange rate (e: in price notation) and the nominal interest rate (i). Net wealth of the private sector is $A' = M/P + B/P + eF^*/P$ and the desired share of assets are assumed to be proportionate to A' (P is the output price level). In a system of flexible exchange rates the portfolio model determines e and i on the basis of given stocks M, B and F* (denominated in foreign currency); F* will rise if there is a current account surplus. A simple, long term approach to exchange rate determination is the purchasing power parity $P=\Omega eP^*$, where $\Omega \neq 1$ for the case of heterogeneous tradable goods (* denotes foreign variables). A useful intermediate model for exchange rate determination is the model of DORNBUSCH (1976), which explains overshooting of the exchange rate – the fact that the short-term reaction is higher than the long-run reaction – in the context of fast adjustment of the money market and slow adjustment of the goods market.

It is interesting to look for an analytical bridge between the short run and the long run, however the long term developments of the real economy cannot be considered without taking into account accumulation dynamics such as captured by the neoclassical growth model (or endogenous growth models). In this context it is useful to focus on a modified version of the BRANSON model, in which the domestic bonds market has been replaced by the stock market (WELFENS, 2007). The stock market price index is denoted by P", the number of stocks is assumed to be equal to the number of capital units K. Such a modified portfolio approach is a useful starting point for combining the portfolio model with a long run neoclassical growth model. As regards the growth model, we assume that knowledge A(t) grows at a constant rate a, while the growth rate of labor (L) is equal to n. It will be assumed that output is produced according to a Cobb-Douglas function $Y=K^{ß}(AL)^{1-ß}$– with capital output elasticity ß in the interval (0,1). It will be useful to define $k':= K/(AL)$ and $y':=Y/(AL)$ where AL is labor in efficiency units. With respect to the portfolio model we will consider money, foreign bonds and a third asset which could be stocks or oil; in principle one could consider a model with N assets, but keeping the analytics tractable suggests focusing on only three assets (indeed, an explicit solution will be presented subsequently). As regards the link between innovation dynamics and stock market prices, one may point out that GRILICHES et al. (1991) have presented important empirical findings, however, the theoretical basis has remained somewhat opaque.

Subsequently, we first look at the modified BRANSON model (section 2). In Section (3) the BRANSON model is combined with the neoclassical growth model. Moreover, it is shown that the portfolio model is useful for analyzing asset market dynamics, including a setup with oil as one of the assets considered – and one also can show some similarity with the Hotelling pricing rule for non-renewables. Section (4) presents the multiplier analysis and section (5) draws key conclusions.

2. Combining the Portfolio Model and Growth Analysis

A useful point of departure is growth theory, namely the neoclassical model which we will consider for the case of a given savings rate, zero capital depreciation, a constant growth rate (n) of the population and a constant growth (a) rate of knowledge. Combining the equilibrium condition for the goods market – in a closed economy (and in the absence of foreign bonds) – dK/dt = sY, one can determine the steady state solution for the capital intensity K/(AL) as (JONES, 2002):

(1) $k'\# = [s/(a+n)]^{1/(1-ß)}$

Here # denotes the steady state. The production function then implies for output relative to labor in efficiency units:

(2) $y'\#= [s/(a+n)]^{ß/(1-ß)}$

In the steady state, the growth rate of output Y will be equal to the sum of a+n. For the case of an open economy, the growth model will have to be modified.

The standard BRANSON model assumes that the demand for each asset is proportionate to real wealth (A') of the private sector, and the desired shares of each asset (j=1,2,3) depends on the domestic interest rate (i) and the foreign interest rate as well as the expected depreciation rate (i*+a"). Due to the budget constraint, it must hold that the shares of the assets add up to unity. As regards the portfolio bloc, a modified BRANSON model is proposed here. It is assumed that the demand for each asset X_j (j = 1,2,3 refers to real money balances M/P, real value of foreign bonds eF*/P and a third asset, e.g. the real value of stocks: P"K/P) can be expressed as follows (with α>0)

(3) $X_j = x_j(\ldots)A'^{\alpha}Y^{1-\alpha}$

For a given ratio A'/Y, the demand for each asset is proprotionate to real income. With respect to empirical issues, an important question concerns the question whether α>1. Hence, one could express the demand for each asset as follows:

(4) $X_j/(AL) = x_j(\ldots)\{[A'/(AL)]/y'\}^{\alpha} [Y/(AL)]$.

Before the combined approach of the portfolio model and the growth model is considered in broader detail – including the multiplier analysis –, we take a brief look at an augmented three asset model with money, foreign bonds and oil (quantity is denoted as V"; we also define i'*= i*+a" and denote the expected growth of the oil price by π"; a" is the expected devaluation rate). In a long term perspective, the basic portfolio-growth model of a closed economy – with money (M), short-term bonds (B) and oil (V") - reads:

(5) $A' = M/P + eF^*/P + P"V"/P$

(6) $(M/P)/(AL) = v(i, i'^*, \pi") [A'/(AL)]^{\alpha} (s/(a+n))^{ß/(1-ß)}$

(7) $(B/P)/(AL) = b(i, i'^*, \pi")[A'/(AL)]^{\alpha} (s/(a+n))^{ß/(1-ß)}$

(8) $(P"V"/P)/(AL) = u(i, i'^*, \pi") [A'/(AL)]^{\alpha}(s/(a+n))^{ß/(1-ß)}$

The desired ratio of real money balances in total assets is $v(Y/A')^{1-\alpha}$ and a similar reasoning holds for the other assets. There is a long term restriction, namely $1=[v+b+u]]\{[Y/(AL)]/[A'/(AL)]\}^{1-\alpha}$ where long term stationarity of y', (M/P)/(AL), (B/P)/(AL) and (P"V"/P)/(AL) implies that only two of the three equilibrium conditions for the asset markets are independent.

Open Economy

In an open economy, the portfolio bloc will include in a simple set-up money, foreign bonds (F*, denominated in foreign currency; e is the exchange rate) and stocks – or oil or other additional assets. As (eF*/P)/(AL) is constant in the steady state, it must be also true that (eF*/P)/Y is constant in the steady state and hence [d(eF*/P)/dt]/(eF*/P) = n+a. This implies that there will be a permanent current account surplus and thus – strictly speaking – one must also make a distinction between GDP and GNP, where the latter is GDP plus net foreign profits (or interest payments) accruing from abroad. This distinction between GDP and GNP has indeed been made in recent analysis of open economies, in particular in the context of foreign direct investment (WELFENS, 2007). While we will neglect for simplicity the distinction between GDP and GNP, the more important aspect of stating the equilibrium condition for the goods markets must be fully considered: In the open economy the condition for goods market equilibrium must hold: sY= dK/dt + (edF/dt)/P and hence – with f":= F/(AL) – we can write (taking into account df"/dt = (dF/dt)/(AL) – f"(a+n)):

(8') $sk'^{ß} = dk'/dt + k'(a+n) + (e/P)[df''/dt + f''(a+n)]$

This is the differential equation for capital accumulation in an open economy with capital flows.

Later we will consider a portfolio model with stocks (instead of oil) so that the equilibrium condition for the stocks market will read (with P' for stock market price index; K is the number of stocks which equals the number of capital units K): $P'K/P= h(\ldots)[A'/(AL)]y'^{1-\alpha}$. Without considering the explicit solution of the above differential equation – there basically is no problem as one may assume that financial market equilibrium is relatively quickly established (compared to goods market equilibrium) – one may restate the above equation by taking into account the asset market equilibrium conditions for the stock market and the foreign bonds market which jointly imply [(eF*/P)/(AL)]/[P'K/(AL)] = f/h so that we have f'=(f/h)k'/(e/P) and hence the steady state conditions dk'/dt and df"/dt=0 imply

(8") $sk'^{ß} = k'(a+n) + k'(1+(f/h))(a+n)$

Thus the steady state solution k'# for the open economy – with foreign bonds held by domestic residents – is given by (with f/h:= φ"):

(8"') $k'\# = \{s/[(a+n)(1+\varphi'')]\}^{1/1-ß}$

The steady state solution y'# for the open economy is, of course, $y'\#=k'^{ß/(1-ß)}$. This condition must be considered for the subsequent multiplier analysis in the portfolio growth model. It should be emphasized that in the open economy – with a structural current account surplus (and ignoring for the moment the distinction between GDP and GNP) – the steady state solution for k' implies that the capital intensity k'# is smaller than in a closed economy. However, this should not be considered a problem since holding foreign bonds brings benefits in terms of risk diversification (explicit analysis could focus on this aspect in the framework of the standard approach CAPM and welfare analysis – with a utility function containing both per capita consumption and per capita wealth –could also be enriched by additional aspects as could be the traditional optimum growth approach); moreover, one might consider an endogenous growth approach, namely assuming that (with a_0 denoting the exogenous progress rate, Ω' is a positive parameter) the progress rate $a= a_0 + \Omega' f$ as international portfolio diversification allows for the raising of innovation intensity. In such a set-up, the reduction of the steady-state level of the growth path will be offset by a rise in the trend growth rate.

In a growing economy, the monetary policy variable is M/(AL). It will be interesting to consider supply-side parameter changes, including the savings rate s, the progress rate a and – in an enhanced approach –the product innovation rate V' as well.

3. Oil Price Dynamics in a Double Perspective

Modified Hotelling Rule: Critical Role of Oil Inflation Expectations

Before we consider the combination of portfolio approach and growth model, let us focus on a simple portfolio model which sheds new light on the well-established debate about the pricing of non-renewable natural resources (on that debate see e.g. STIGLITZ, 1974; DASGUPTA/HEAL, 1979; SINN, 1981; ROEGER, 2005). The basic insight of the traditional debate is an intertemporal decision rule, which says that there will be indifference between producing today – yielding cash flow expressed in \$, namely P" - H" (where H" is the unit price of producing oil in \$ units; P" is the oil price in \$) – and producing tomorrow. We assume that the producer of the natural resource – we will assume that this is oil – wants to invest the cash flow abroad. Producing today will bring (with i* denoting the world nominal interest rate; E stands for expectation, * for foreign variables) at the period's end a unit revenue of i*[P" - H"] if one assumes that the cash flow is invested abroad/in the US; producing tomorrow (we denote the expected oil price as $P"^{E}$) will generate a yield of ($dP^{E}"/dt$) per unit. Take the simple case of perfect foresight and we can derive from the equilibrium equation i*[P"- H"] = dP"/dt the equilibrium expression – after dividing by P": dlnP"/dt = i*[1 - H"/P"]. For the case of H"=0 this expression is the Hotelling rule, namely that the oil price inflation rate will be equal to nominal interest rate.

If the ratio H"/P" were constant over time, the implication simply is that the growth rate of oil prices will be equal to the world interest rate times [1 - H"/P"]. To the extent that monetary policy is expansionary, we should expect a short-term fall in the nominal interest rate, but a long term rise in the interest rate, provided that the expansionary policy course raises the expected inflation rate. Moreover, if (denoting the US inflation rate of non-oil products as π'* and the share of non-oil products on the price index by α'*), we assume that the world real interest rate i* in the long run will be equal to the real growth rate of global output (dlnY*/dt) and we have i* = dlnY/dt + α'*π'* + (1-α'*)π"*. Thus, we can indeed restate the equation as π"α'* [1-H"/P"].= [dlnY*/dt + α'*π'*] [1-H"/P"]. From this equation, the profit-maximizing growth rate of the oil price inflation is obtained as π" =[dlnY*/α'] +π'. Turning back to the fundamental equation, we can write dlnP"/dt = (dlnY*/dt + dlnP*/dt)[1-H"/P"] and assuming that H"/P" is constant (H':=H"/P") the integration of that equation – with C" denoting a constant to be determined from the initial period - yields

(8'"") lnP"(t) = [1 – H'] [lnY*(t) + lnP*(t)] + C"

From this we have that the elasticity of P" with respect to world output and to the global price level (read US price level), respectively, is [1- H'], which is smaller than unity. Therefore the growth rate of global oil price inflation should be influenced by global output growth and the global inflation rate. Note that our fundamental equation could be modified to include technological progress in the sense that over time a higher share of the oil reservoir in a given resource site can be extracted. If the relevant progress rate – which must not be confused with a reduction of H" in real terms – is denoted as a', we can write $i^*[P"- H"] = dP"^E/dt[1+a']$; Assuming that $H"=ß"R$ (R is resource extraction) and using the approximation $1/[1+a'] \approx 1-a'$, we can state the equation $i^*(1-a')(1- ß"R/P") = (dP"^E/dt)/P"$. Let us assume for simplicity that ß"R/P" is close to zero (close to reality for the case of Quwait); we thus can take logarithms and use the approximation that $\ln(1+x) \approx x$ so that we get the crucial equation $\ln i^* - a' - ß"R/P" = \ln\pi"^E$, where $\ln\pi"^E$ denotes the logarithm of the expected oil price inflation rate (taking logarithms requires to impose the assumption that the oil price inflation rate is positive). Thus in a supply-side perspective, we have for a given R in the short run the optimum price $P" = ß"R/(\ln i^*-a'- \ln\pi"^E)$. In P"-R space the supply curve is a ray through the origin. Hence the current oil price will be higher, the lower the interest rate i* (read: the US interest rate), the higher the rate of technological progress a', and the higher $\pi"^E$ are. This is a simple supply-side perspective of the oil market and suggests that expansionary US monetary policy – reducing i* – will raise the oil price. Obviously, the best policy to reduce the oil price in the short run is to try to raise the progress rate on the side of energy users and thus to start policy activities which reduce the expected oil price inflation rate (e.g. an OECD initiative which would encourage substitution of oil through other energy sources or a global program to improve energy efficiency through more intensive research and development could be useful here.)

The above equation can also be rearranged in a way that the medium term optimum supply is determined, namely as a function of P", the world interest rate, the growth rate of technological progress in terms of "site deepening" and the expected oil inflation rate: Hence $R = P"(\ln i^* - a' - \ln\pi"^E)/ß"$. We will assume (with the parameter $\zeta>0$) that the change in the oil price is a positive function of the excess demand: $dP"/dt = \zeta(R^d - R^s)$. If one assumes that the current demand R^d for oil is a negative function of the oil price P" and a positive function of wealth [A':= M/P + eF*/P + P'K/P], we can write $R^d = -\Omega"P"+ \Omega"'A'+ R_0$ (Ω" and Ω"' are positive parameters, R_0 is autonomous demand for oil, e' is the Euler number, t the time index; C' a constant to be determined from the initial conditions); and we get:

(9) $dP"/dt = \zeta[-\Omega"P"+ \Omega"'(M/P + eF^*/P + P'K/P) +R_0 - P"(\ln i^* - a' - \ln\pi"^E)/ß"]$

Here it is assumed that R_0, wealth and the term $(\ln i^* - a' - \ln\pi"^E)/ß"$ are exogenous

(9') $P"(t) = C'e'\exp\{- \zeta [\Omega"+ (\ln i^* - a' - \ln\pi"^E)/ß"]t\} +$

$+\{R_0 + \Omega"'(M/P + eF^*/P + P'K/P)\}/[\Omega"+(\ln i^* - a' - \ln\pi"^E)/ß"]$.

This solution of the differential equation converges towards a stable steady state solution {…}/[…] if $\zeta[\Omega"+(\ln i^* - a' - \ln\pi"^E)/ß"]>0$; in this case we have a Non-Hotelling rule with the special case of a long term price increase of zero. Moreover, the implication is that a critically high expected oil price inflation rate implies that that there is no steady state solution, namely if $\ln\pi"^E > ß"\Omega"+ \ln i^* - a'$: the price P"(t) will rise at a constant rate; thus we have established a modified Hotelling rule for this specific set of parameters. As i* is equal to the real interest rate r* plus the expected inflation rate which in turn (with π' denoting the inflation rate of non-oil-products) is $\alpha'\pi'^E + (1-\alpha')\pi"^E$ the critical condition can now be written – assuming for simplicity that $\alpha' + [(r + \alpha'\pi'^E)/\pi"^E]$ is close to zero – as $[(r + \alpha'\pi'^E)/\pi"^E] < -ß"\Omega"+a'+\alpha'$: The critical condition thus reads $\pi"^E>(r+\alpha'\pi'^E)/(a'+\alpha'-ß"\Omega")$ and hence a fall of the real interest rate or a’ exceeding a critical value or ß” or Ω” falling to a critical value could trigger a shift to an unstable regime in the sense that the economy moves from a setting with a stationary price P”# towards a regime with a sustained oil price inflation. The model presented suggests that P” will be stable over time for a specific set of parameters, however, if there is a critical change of parameters – including the expected oil inflation rate (which could be manipulated by various players in the global oil markets and certainly could be affected by major international political shocks) – there could be a phase of sustained oil price inflation. Oil price inflation expectations thus play a very critical role for current oil price dynamics.

The steady state solution – if there is one – depends on autonomous demand for oil, real money balances, the real price of stocks P’/P and the real stock of capital K as well as on the net real claims on the rest of the world (eF’/P). The higher e/P – we assume P* as given – the higher the equilibrium oil price level will be. Thus we have a positive long term relationship between P” and e.

Portfolio-theoretical Approach to Oil Markets

An alternative model with which to understand the oil price developments involves a portfolio-theoretical approach, and it is interesting to consider to which extent the implications are in line with the modified Hotelling rule established here. Let us consider such a portfolio approach in a US perspective so that all assets are denominated in $. We thus consider foreign bonds, money and oil as the three relevant assets. We assume that the share f’ of foreign bonds is a negative function of i and the expected oil price inflation rate π”; and a positive function of i*’:= i* + a“ (a” is the expected depreciation rate). The desired share of oil (u’) in the portfolio is a positive function of π“, a negative function of i and a negative function of i’* (here the budget constraint is n’+f’+u’=1). The budget constraint reads A’= M/P + eF*/P + P“V“/P so that in the modified portfolio model which contains the money market equilibrium line (MM curve), the equilibrium line for foreign bonds (FF* curve) and the equilibrium line for the oil market (VV curve), only two of the three equations are independent. Thus one can determine in the short-run market – ignoring the production function – the exchange rate e and the resource price P”.

(10) A’= M/P + eF*/P + P“V/P

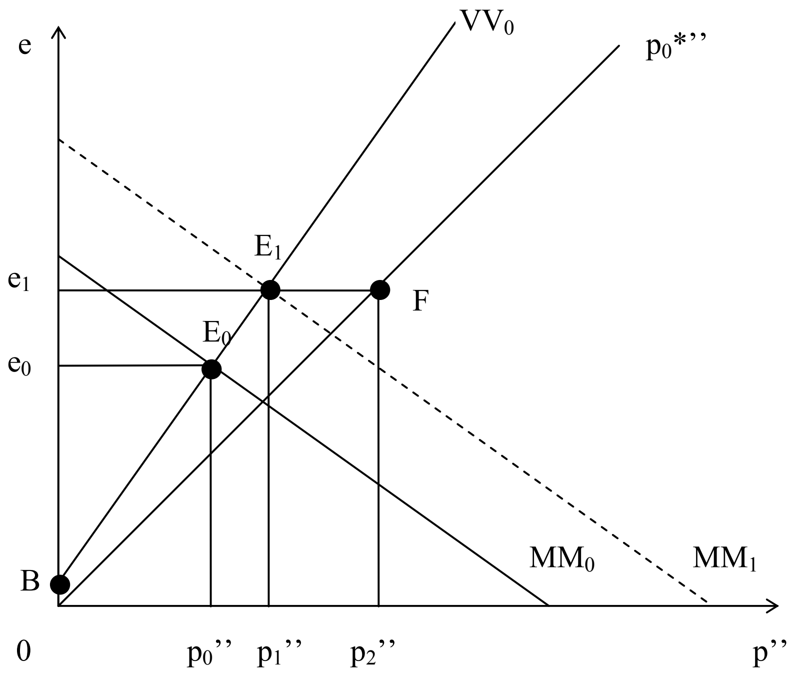
(10’) M/P = n’(i, i’*, π“)A’

(11) eF*/P = f’(i, i’*, π“)A’

(12) P“V“/P = u’(i, i’*, π“)A’

In an e-P“ diagram, the MM curve has a negative slope while the VV curve – showing the equilibrium in the oil market – has a positive slope. An expansionary monetary policy (through an expansionary open market policy: dM is raised as the central bank buys foreign assets) will bring about depreciation and a rise in the oil price P”. If we assume that the oil producer in country II has a target price (in domestic currency) of P_0*”, there is a problem to the extent that dlnP”/dM< dlne/dM: The price in foreign currency is P*”= P”/e; as P”= eP”* a target price line P_0*” implies that E_1 cannot be a stable new equilibrium point. Rather, as the oil producer from country II is assumed to have market power, it would rather fix the oil price in \$ at the price P_2" instead of P_1". Disregarding this strategic aspect of market power, one may argue that our portfolio-theoretical approach to oil price determination is in line with the logic of the modified quasi-Hotelling rule established above.

Figure 1: Exchange Rate and Oil Price Determination in the Hybrid-Portfolio-Model



4. Stock Market Analysis and Hybrid Portfolio Growth Model

Here we will consider a portfolio model with money, foreign bonds and domestic stocks whose number is assumed to be equal to K, the stock market price index is denoted by P'. In e-P'space, the equilibrium line for the money market – under standard assumptions – has a negative slope while the stock market equilibrium line has a positive slope (thus we have an analogy to the portfolio model with money, foreign bonds and oil). In the subsequent model both process innovations and product innovations (V') will be considered. It is assumed that the demand for money is raised (parameter λ">0) if V is on the rise, because a higher range of diversified products implies a higher utility of holding money balances. A rise in V will also lead to an increase (parameter λ'>0) in the demand for stocks, since profits are expected to be raised by said rise in V. The demand for foreign bonds is a negative function of V (parameter λ"'<0). The following model presents a new approach bridging portfolio analysis and growth analysis. The modified portfolio model puts the focus on the money market, the foreign bonds market and the stock market, and the basic assumption is that v, f and h – the quasi-shares in assets – depend on i, i'* and z' (the expected growth rate of the stock market price). For the case of a zero inflation rate, we will replace i by r.

Methodologically, the steady state analysis developed should not be confused with a non-evolutionary perspective of economic dynamics, rather the real world can be understood as being shaped by various shocks, including technology shocks. Calculating the steady state solutions thus indicates a sequence of consistent, long term equilibrium solutions. Moreover, as already emphasized it is possible to endogenize the progress rate and in particular to focus on the role of international capital flows (or trade).

It is important to emphasize that the subsequent setup is for an open economy with capital flows. Thus in the growth model, the steady state solution for the capital intensity k':=K/(AL) and for output per unit of labor in efficiency units (y':=Y/AL)) must be considered. If one wants to consider an explicit portfolio bloc –with a focus on money, foreign bonds and stocks – with the interest rate i, the yield abroad i' and the expected growth rate (z') of the stock market price index, one will have to consider the subsequent system (13)-(16). The equations (13)-(18) are the basic system and deserve no further comment. The goal is to have an explicit solution. Equation (19) is derived by considering (14) and (16) in combination with (13) and (18); equation (15) can, of course, be ignored due to the budget constraint. Next we reformulate the equations (14) and (16) in such a way that we have only $\{\ldots\}^{\alpha}$ on the right hand side: Equating and reformulating gives (19) which indicates the equilibrium stock market price.

(13) $A' = M/P + P'K/P + eF^*/P$

(14) $M/P = v(i,i'^*, z')\, A'^{\alpha} Y^{1-\alpha}\, V'^{\lambda''}$

(15) $eF^*/P = f(i,i'^*, z')\, A'^{\alpha} Y^{1-\alpha}\, V'^{\lambda'''}$

(16) $P'K/P = h(i,i'^*, z') A'^{\alpha} Y^{1-\alpha}\, V'^{\lambda'}$

(17) $k'\# = (s/(a+n)(1+\varphi''))^{1/(1-ß)}$

(18) $y'\# = (s/(a+n)\,(1+\varphi''))^{ß/(1-ß)}$

$$(19)\qquad \left(P'/P\right) = h\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{1+\frac{\alpha\beta}{1-\beta}} V'^{\lambda'}$$

$$(20)\qquad \left(\frac{M/P}{AL}\right) = v\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{(1-\alpha)\beta}{1-\beta}} V'^{\lambda''}$$

Rearranging and equating (19) and (20) yields:

$$(21)\qquad P' = \frac{h}{v}\frac{M}{AL}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{1}{1-\beta}} V'^{\lambda'-\lambda''}$$

$$(22)\qquad \frac{dP'}{d\frac{M}{AL}} = \frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{1}{1-\beta}} V'^{\lambda'-\lambda''} > 0$$

$$(23)\qquad \frac{dP'}{ds} = -\frac{h}{v}\frac{M}{AL}\frac{1}{1-\beta}\frac{(a+n)(1+\varphi'')}{s^2}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{\beta}{1-\beta}} V'^{\lambda'-\lambda''} > 0$$

$$(24)\qquad \frac{dP'}{da}=\frac{h}{v}\frac{M}{AL}\frac{1}{1-\beta}\frac{1+\varphi''}{s}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{\beta}{1-\beta}}V'^{\lambda'-\lambda''}<0$$

$$(25)\qquad \frac{dP'}{dn}=\frac{h}{v}\frac{M}{AL}\frac{1}{1-\beta}\frac{1+\varphi''}{s}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{\beta}{1-\beta}}V'^{\lambda'-\lambda''}<0$$

$$(26)\qquad \frac{dP'}{dV'}=(\lambda'-\lambda'')\frac{h}{v}\frac{M}{AL}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{1}{1-\beta}}V'^{\lambda'-\lambda''-1}$$; the sign depends on λ' und λ"

Inserting (21) in (19) yields:

$$(27)\qquad e=\frac{AL}{F^*}\left[P\left\{\frac{1}{vP}\frac{M}{AL}\right\}^{\frac{1}{\alpha}}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}}V'^{-\frac{\lambda''}{\alpha}}-\frac{M}{AL}\left\{1+\frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{2}{1-\beta}}V'^{\lambda'-\lambda''}\right\}\right]$$

$$(28)\qquad \frac{de}{d\frac{M}{AL}}=\frac{AL}{F^*}\left[\frac{1}{\alpha v}\left\{\frac{1}{vP}\frac{M}{AL}\right\}^{\frac{1-\alpha}{\alpha}}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}}V'^{-\frac{\lambda''}{\alpha}}-\left\{1+\frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{2}{1-\beta}}V'^{\lambda'-\lambda''}\right\}\right]$$

The sign is ambiguous.

$$(29)\qquad \frac{de}{ds}=\frac{AL}{F^*}\left[\frac{P}{(a+n)(1+\varphi'')}\frac{\beta(1-\alpha)}{\alpha(1-\beta)}\left\{\frac{1}{vP}\frac{M}{AL}\right\}^{\frac{1}{\alpha}}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}-1}V'^{-\frac{\lambda''}{\alpha}}+\frac{(a+n)(1+\varphi'')}{s^2}\frac{2}{1-\beta}\frac{M}{AL}\frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{1+\beta}{1-\beta}}V'^{\lambda'-\lambda''}\right]>0$$

$$(30)\qquad \frac{de}{da}=-\frac{AL}{F^*}\left[\frac{sP}{(a+n)^2(1+\varphi'')}\frac{\beta(1-\alpha)}{\alpha(1-\beta)}\left\{\frac{1}{vP}\frac{M}{AL}\right\}^{\frac{1}{\alpha}}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}-1}V'^{-\frac{\lambda''}{\alpha}}+\frac{M}{AL}\frac{2}{1-\beta}\frac{1+\varphi''}{s}\frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{1+\beta}{1-\beta}}V'^{\lambda'-\lambda''}\right]<0$$

$$\frac{de}{dV'} = -\frac{AL}{F^*}\left[\frac{P\lambda''}{\alpha}\left\{\frac{1}{vP}\frac{M}{AL}\right\}^{\frac{1}{\alpha}}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}} V'^{-\frac{\lambda''}{\alpha}-1} \right. \tag{31}$$

$$\left. + \frac{M}{AL}(\lambda' - \lambda'')\frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{1}{1-\beta}} V'^{\lambda'-\lambda''-1}\right]$$

The sign of the above equation is ambiguous: if λ'>λ"; the sign for de/dV' is positive.

Explicit solutions are derived, and it is interesting that we get unambiguous multiplier results for many policy cases. The term h/v is interesting and a rather simple specification will give more insight: Assume that h= 1/(σr) and v= 1/(ε'r) (with parameters σ>0, ε'>0) so that h/v= ε'/σ; in this simplified set-up, we ignore i'* an z'. One of the partial derivatives of the quasi-shares must be positive if at least one derivative is negative, since the adding-up constraint is otherwise not met. Here, we are not concerned with this aspect, since in a further step we will indeed include the bond market; thus, a negative partial derivative of h, v and f with respect to r is not a problem, as the partial derivative of b with respect to r is positive. If one assumes – in the context of a non-inflationary economy (with a positive parameter ε") – that f=1/(ε" r) and h=1/(σr), one can replace φ" with σ/ ε".

As regards the above multiplier analysis, we find that a rise in M/(AL) will bring about a devaluation if the savings rate is sufficiently high, while a rise in the savings rate will always bring about a devaluation. However, as regards the latter, one may well have to consider the case that a higher savings rate is the basis for financing more innovation projects and hence to raise innovativeness. A rise in the process innovation rate will bring about a (real) devaluation. If λ'> λ", a higher degree of product innovativeness will bring about a devaluation; if λ'< λ" a rise in V could bring about – conditional on a certain parameter set – an appreciation. One should note that the case of inflation could be considered in the context of i = r + expected inflation rate, which is the determined by the growth rate μ' (μ':=dln[M/(AL)]/dt) minus the growth rate of output which is equal to a+n.

If one wants to consider a production with real balances (M/P)/(AL):=m' entering firms' production functions as a positive external effect of households holding money (WELFENS, 2007a), the production function (with ß" denoting the output elasticity of money) is given by $Y=m^{ß''}K^{ß}(AL)^{1-ß-ß''}$ or equivalently $Y/(AL) = m'^{ß''}k'^{ß''}$. Hence we have the following result for y' in the steady state:

(18') $y'\# = m'^{ß''}\{s/[(a+n)(1+\varphi'')]\}^{ß/(1-ß)}$

Inserting this equation in the portfolio growth model we get some modifications in the results:

$$(P'/P) = hm'^{\beta(1-\alpha)}\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{1+\frac{\alpha\beta}{1-\beta}} V'^{\lambda'} \tag{19'}$$

(20') $$\left(\frac{M/P}{AL}\right) = vm'^{\beta(1-\alpha)}\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{(1-\alpha)\beta}{1-\beta}} V'^{\lambda''}$$

(20'') $$m'^{1-\beta(1-\alpha)} = v\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{(1-\alpha)\beta}{1-\beta}} V'^{\lambda''}$$

Basically, the implication is that equation (21) is not changing and that the multipliers with respect to P' remain unchanged. The real money balance m' will raise the real stock market price in the steady state while the effect on e is ambiguous. Inserting (21) in (19') gives:

(27') $$e = \frac{AL}{F^*}\left[Pm'^{-\frac{\beta}{\alpha}(1-\alpha)}\left\{\frac{m'}{v}\right\}^{\frac{1}{\alpha}}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}} V'^{-\frac{\lambda''}{\alpha}} - Pm'\left\{1 + \frac{h}{v}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{\frac{2}{1-\beta}} V'^{\lambda'-\lambda''}\right\}\right]$$

One could change the multipliers accordingly, but there are no qualitative changes. Next we explicitly specify – in a setup in which domestic bonds also are considered – the desired quasi-shares of assets (parameters: σ'<0, σ'''<0, σ''>0; σ<0), the bonds market equilibrium condition is given in equation (V)

(I) $A' = M/P + B/P + P'K/P + eF^*/P$

(II) $M/P = r^{\sigma'} A'^{\alpha} Y^{1-\alpha} V'^{\lambda''}$

(III) $eF^*/P = r^{\sigma'''} A'^{\alpha} Y^{1-\alpha} V'^{\lambda'''}$

(IV) $P'K/P = r^{\sigma} A'^{\alpha} Y^{1-\alpha} V'^{\lambda'}$

(V) $B/P = r^{\sigma''} A'^{\alpha} Y^{1-\alpha} V'^{\lambda}$

(19'') $$(P'/P) = r^{\sigma} m'^{\beta(1-\alpha)}\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{(a+n)(1+\varphi'')}{s}\right\}^{1+\frac{\alpha\beta}{1-\beta}} V'^{\lambda'}$$

(20'') $$\left(\frac{M/P}{AL}\right) = r^{\sigma'} m'^{\beta(1-\alpha)}\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{(1-\alpha)\beta}{1-\beta}} V'^{\lambda''}$$

(32) $$\left(\frac{B/P}{AL}\right) = r^{\sigma''} m'^{\beta(1-\alpha)}\left\{\frac{M/P + P'K/P + eF^*/P}{AL}\right\}^{\alpha}\left\{\frac{s}{(a+n)(1+\varphi'')}\right\}^{\frac{(1-\alpha)\beta}{1-\beta}} V'^{\lambda}$$

Equating and rearranging (19") and (20") yields:

(21') $$P' = \frac{M}{AL}\left\{\frac{(a+n)(1+\varphi")}{s}\right\}^{\frac{1}{1-\beta}} r^{\sigma-\sigma'} V'^{\lambda'-\lambda"}$$

Inserting (21') in (19'') yields:

(27') $$e = \frac{AL}{F^*}\left[Pm'^{-\frac{\beta}{\alpha}(1-\alpha)} \left\{\frac{1}{r^{\sigma'}P}\frac{M}{AL}\right\}^{\frac{1}{\alpha}} \left\{\frac{s}{(a+n)(1+\varphi")}\right\}^{\frac{\beta(1-\alpha)}{\alpha(1-\beta)}} V'^{-\frac{\lambda"}{\alpha}} - \frac{M}{AL}\left\{1 + r^{\sigma-\sigma'}\left\{\frac{(a+n)(1+\varphi")}{s}\right\}^{\frac{2}{1-\beta}} V'^{\lambda'-\lambda"}\right\}\right]$$

Equating and rearranging (20") and (32) gives:

(33) $$r = \left(\frac{M}{B}\right)^{\frac{1}{\sigma'-\sigma"}} V'^{\frac{\lambda'-\lambda"}{\sigma'-\sigma"}}$$

Thus the real interest rate r is a positive function of B/M. Morever, it is a negative function of V', provided λ'> λ". The structure of (21') and (27'), respectively, is similar to (21) and (27) and hence there is no change in the sign of the multipliers. From (33) we have as multipliers:

(34) $$\frac{dr}{d\frac{M}{AL}} = \frac{1}{\sigma'-\sigma"}\frac{B}{AL}\left(\frac{M}{B}\right)^{\frac{1-\sigma'+\sigma"}{\sigma'-\sigma"}} V'^{\frac{\lambda'-\lambda"}{\sigma'-\sigma"}} < 0$$

(35) $$\frac{dr}{ds} = \frac{dr}{da} = \frac{dr}{dn} = 0$$

(36) $$\frac{dr}{dV'} = \frac{\lambda'-\lambda"}{\sigma'-\sigma"}\left(\frac{M}{B}\right)^{\frac{1}{\sigma'-\sigma"}} V'^{\frac{\lambda'-\lambda"}{\sigma'-\sigma"}-1}$$ the sign depends on λ' and λ"

An important result is dr/da = 0 and dr/dn =0, as this shows neutrality of growth with respect to the real interest rate. Under the assumption $\lambda' > \lambda"$, a higher intensity of product innovations brings about a fall in the real interest rate. If we have profit maximization in the steady state such that $r=ßk'^{ß-1}$, the implication is that B/(AL) – according to equation (33) – is endogenous. Moreover it must hold that the value of stocks is equal to the discounted value of profits, so that we have P'K=ßPY/r. Therefore, it holds that the price of existing capital (P') is equal to the price (P) of newly produced investment goods.

From (21') we find that we can thus rewrite the equation as $(M/(AL))P = V(Y/(AL))^{1/(1-ß)}$, where V is quasi-velocity which is defined as $V:=r^{\sigma-\sigma'}V'^{\lambda'-\lambda"}$. Hence we have derived a modified Fisher equation – with an income elasticity of the demand for money exceeding unity. A rise in the product innovativeness variable will increase velocity, provided that λ'> λ". Note that in a set-up considering inflation, it would be necessary to replace in the portfolio equilibrium equations r by the nominal interest rate i; and i would also enter V. Hence, we have derived some important new results.

5. Conclusions

This approach provides new insights into long term economic dynamics of open economies and innovation. For the first time, the portfolio model of an open economy has been linked to the growth model of an open economy, and both process and product innovations have been analyzed. These findings give a theoretical basis for some of the empirical literature, with a focus on the links between stock market pricing and innovation dynamics.

Basic arguments for considering oil markets in a portfolio balance approach were also discussed; linking such an approach with the production function would, however, be fruitful in a broad sense if one should consider a production function with labor, capital, knowledge and oil (or another non-renewable resource). Thus, we have presented some new thoughts on key problems of macroeconomic analysis. Based on these first steps we need, of course, more comprehensive and refined models. It is noteworthy that one could include welfare theoretical analysis in such new approaches, to the extent that the utility function contains both consumption and wealth. Furthermore, this also opens up new approaches to the optimum growth theory. Finally, the theoretical approaches presented explain global asset market dynamics – including oil price dynamics – in the context of the US banking crisis 2007/08.

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