Overshooting Adjustment to Tariff Protection

by

Christian Keuschnigg*

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Institute for Advanced Studies
Department of Economics
Stumpergasse 56
A–1060 VIENNA, AUSTRIA

Phone: (1) 59991–147
Fax: (1) 59991–163
E-mail: chkeu@ihssv.wsr.ac.at

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Abstract

The paper analyzes the effects of tariffs on savings, investment and the net foreign asset position of a small open overlapping generations economy. The gradual adjustment of production to tariffs on imported investment goods generates a gradually declining flow of disposable wage incomes. The main insight of the paper is that such a temporarily declining wage profile creates, in addition to the permanently operating savings incentives, a transitory life-cycle type savings motive for generations living early in the transition period. As the production sector converges to its long-run stationary position, wage profiles become flat again and the transitory savings motive vanishes. The transitory savings component may give rise to overshooting in total savings and net foreign assets in the early phase of adjustment. The paper identifies large foreign indebtedness due to weak permanent savings incentives as the main precondition for overshooting.

Das Papier untersucht die Auswirkungen von Zöllen auf Sparen, Investitionen und die Auslandsverschuldung einer kleinen offenen Volkswirtschaft mit überlappenden Generationen. Eine träge Anpassung der Produktion an höhere Zölle auf importierte Investitionsgüter erzeugt einen zunächst fallenden Strom von verfügbaren Arbeitseinkommen, der sich erst allmählich auf ein konstantes langfristiges Niveau einpendelt. Die Haupteinsicht des Papiers ist, daß zusätzlich zu den dauerhaften Sparanreizen ein vorübergehendes Lebenszyklusmotiv des Sparens geschaffen wird, solange die Lohneinkommen fallen. Dieses vorübergehende Sparmotiv verschwindet wieder, wenn die Anpassung im Produktionssektor zum Stillstand kommt und die Lohnprofile wieder flach werden. Diese zusätzliche, vorübergehende Sparkomponente kann zu überschießendem Verhalten der inländischen Ersparnisse und der Nettovermögensposition gegenüber dem Ausland führen. Als Bedingung für überschießende Anpassung identifiziert das Papier schwache permanente Sparanreize und damit einhergehend eine starke Auslandsverschuldung in der Ausgangssituation.

1 Introduction

In times of large trade balance and current account deficits when the economy is heading towards a long-run position of heavy foreign indebtedness, policy makers are often tempted to resort to tariff protection. Because of the supposedly favorable impacts on the trade balance, tariffs are considered an effective tool to generate a reverse trend and to improve the net foreign asset position. Particularly relevant for the formation of commercial policy are the short-run consequences of tariff protection. To explore the full potential for transitional adjustment patterns requires to embed intertemporally determined savings and investment flows in a growth model. The paper emphasizes that all the interesting dynamic effects indeed stem from the interaction of the savings and investment dynamics in an open economy.

Recent theoretical results on the dynamic effects of tariff protection have been coined by relying either on the overlapping generations (OLG) model with two period life-cycles or on models with infinitely lived representative agents (RA). In an open economy environment with a given world interest rate, both types of models, however, feature reduced dynamics of the savings and consumption flows. For reasons of existence of a long-run equilibrium in a small open economy, RA models must assume that the rate of subjective time preference is equal to the world interest rate. If labor supply is fixed, consumers find it optimal to have constant consumption expenditures determined by permanent income. Given that the production sector takes time to adjust, the implied gradual changes in income combined with a once and for all change in expenditures translate into monotonic adjustment of the current account. The long-run position depends on the initial conditions. Relying on variants of the open economy RA model, Brock and Turnovsky (1992), Gavin (1991,92), Murphy (1990), Nielsen (1991), Sen and Turnovsky (1989a,b), among others, investigated the effects of tariffs and terms of trade changes. Given that such shocks are unanticipated and permanent, none of these studies could detect non-monotonic adjustment patterns such as overshooting in the current account.

Persson and Svensson (1985), Eaton (1987) and Matsuyama (1988) perform similar experiments with the life-cycle OLG model. Again, the adjustment to unanticipated and permanent terms of trade changes is monotonic. Since life-cycles extend only over two periods, agents take only one period to adjust their savings. If, however, life-cycles were to extend over more periods with wage income accruing also in later periods of life, consumers would naturally take longer to adjust savings. Such prolonged adjustment of savings of each agent would naturally give rise to more interesting dynamics of the household sector as a whole. As in the RA model, but for different reasons, the monotonic adjustment to permanent shocks is due to the limited treatment of savings.

Undoubtedly, these two classes of models have earned great merits in highlighting important channels through which policy affects the economy. Given the limitations in the treatment of savings, however, these models tend to hide some of the possibilities for more complicated adjustment patterns. Yaari (1965) and Blanchard (1985) pioneered an alternative OLG model with life-time uncertainty which was recently extended by Weil (1989) and synthesized by Buiter (1988). It contains more potential for dynamics by relaxing some of the limitations of the rival models and combining some of their advantages. At each moment, new generations disconnected to preexisting agents enter the economy while part of the existing population dies away. The life-cycle of agents extends possibly over many periods but expected life-time is finite. In overlapping generations models with wage income accruing over many life-cycle periods, temporarily falling (rising) wage incomes create a life-cycle type savings incentive (disincentive) for those generations living early in the transition period of the economy. Such a transitory savings component comes on top of a base component that is elicited by permanently operating savings incentives. A transitorily operating life-cycle motive may cause stock of domestic savings and net foreign assets to overshoot their sustainable long-run values.

In a small open economy that takes the world interest rate as given, investment and savings flows are determined independently. A precondition for non-monotonicity in the current account is that investment adjusts slowly and thereby creates a gradual change in wage income going to consumers. In their analysis of tariffs, Engel and Kletzer (1990) assumed frictionless immediate adjustment of capital. Hence, they could not detect overshooting in the current account. Although in a different context, Bovenberg (1991) and Matsuyama (1987) anticipated some of the potential of this framework for possibly non-monotonic adjustment in net foreign assets. In analyzing dynamic effects of capital income taxation, Bovenberg (1981) showed with some illustrative simulations that some particular parameterizations of the model yield an overshooting current account. Matsuyama (1987) separated the effect of an oil price change into a wealth and a portfolio substitution effect and noted that the latter may give rise to non-monotonicities in foreign assets. This interpretation is somewhat misleading, however. His notion of portfolio substitution stems from a situation where human wealth, spending and savings remain all constant in the long-run. Hence, any long-run change in the net asset position reflects portfolio substitution of domestic equities for foreign bonds with overall financial wealth constant. This interpretation, however, ignores the transitional effects on human wealth, spending and savings of households, and therefore does not isolate the portfolio substitution effect during the transition. The present paper argues that all the interesting dynamic effects stem from the transitory savings motive and not from portfolio substitution. With financial wealth constant, portfolio substitution would give monotonic effects only since equity values change monotonically only, given an unanticipated and permanent shock to the production sector. Contrary to Matsuyama's contention, the source of overshooting originates with savings behavior and not with portfolio substitution.

The present paper takes up these issues in the context of tariff policy. Of course, the findings are relevant not only for tariff policy, but apply equally well to all kinds of permanent shocks (terms of trade changes, capital taxation, technology shocks etc.) that lead to gradual adjustment of the production sector of a small open economy. Of course, non-monotonic adjustment of the current account would not be surprising if they were policy induced. In anticipation of announced future tariff increases, or in case of temporary tariff changes, agents would want to substitute consumption or investment intertemporally. The implied investment and savings pattern that shifts these activities across periods, can easily translate into non-monotonicities such as overshooting or alternating phases of current account surpluses and deficits. It is not at all evident, however, that such dynamics should obtain if the tariff change is once and for all. In this case, the tariff change does not entail in itself any intertemporal substitution effects. According to recent theoretical contributions on the dynamic effects of unanticipated and permanent tariff changes, however, one would be surprised to find anything else than monotonic adjustment. This is because this literature relies on RA models or two period OLG models. The present paper shows that inertia in capital accumulation creates rising or falling wage profiles during the transition which in turn provide for temporary life-cycle type savings incentives. Such a transitory savings component may easily produce overshooting in total savings and net foreign assets. It is even possible in some circumstances that short and long-run effects are qualitatively different, a possibility with enormous policy implication. The paper highlights the conditions under which such surprising effects can happen.

The paper now proceeds by presenting a model of a small open economy importing investment and consumption goods. For simplicity and tractability, production is assumed to be specialized in the export good. Hence, the model ignores any structural effects of tariffs but conveniently captures the macroeconomic implications for savings, investment and the current account. Adopting an adjustment cost framework in the spirit of Tobin's q theory of investment, section 2 explains how the production sector adjusts gradually to an increase in tariffs on imported investment goods. With investment goods more expensive, capital is gradually decumulated, eroding the stream of disposable wage income. Section 3 portrays aggregate savings as the result of intertemporal consumption choices of overlapping agents who adapt to higher tariffs on imported consumption goods and to the non-capital income flows created in the production sector. In allowing for wage increasing productivity growth and possibly declining life-cycle earnings profiles, the model is made more compatible with the observed magnitudes of savings flows. Wage increasing productivity growth reduces the need to save for old age consumption. By way of contrast, a declining earnings profile reinforces the life-cycle motive for savings. These amendments to the model allow to consider a range of alternative cases. Furthermore, the section emphasizes the distinction between permanent and transitory savings incentives. Section 4 investigates what savings and investment imply for the net foreign asset position and the current account. If permanent savings incentives are sufficiently small, the transitory savings component will dominate the response of total savings and will very likely be felt in overshooting adjustment of foreign assets as well. Hence, overshooting is associated with highly indebted economies with a savings deficiency. We consider special cases analytically and explore the range of possible results via simulation of realistically parameterized examples. Section 5 concludes with a summary.

2 Production and Investment

Optimization: The home economy specializes in the production of an export good but requires imports for investment purposes. Since it is assumed small relative to world markets, it takes commodity prices as well as the interest on internationally traded bonds as given. The home and import goods are imperfect substitutes in demand. When building the capital stock, agents combine the two commodities using a technology $I(I^h, I^f)$. Assuming linear homogeneity, the technology is completely described by the unit isoquant. Hence, demands for home and import goods as well as expenditures depend linearly on the desired quantity I of the capital good. An exact price index $P(\tau)$ is defined by

$$P(\tau) = \min_{\{i^h, i^f\}} \{i^h + (1+\tau)i^f \quad s.t. \quad I(i^h, i^f) \geq 1\}. \tag{1}$$

Producer prices are normalized to unity. The demand price for imports exceeds the world price due to a proportional tariff rate τ. Unit demand functions for home and foreign investment goods are denoted by lower case letters $i^{h,f}(\tau)$. Total demands depend multiplicatively on the amount of the desired investment composite I: $I^{h,f} = i^{h,f}(\tau)I$. The price index depends positively on the tariff cost, $P'(\tau) > 0$. In fact, its percent change is equal to the expenditure share of the imported variety: $P_\epsilon/P \equiv \hat{P} = s^f\hat{\tau}$ with $s^f = (1+\tau)i^f/P$. The hat notation indicates percent changes, $\hat{\tau} = \tau_\epsilon/(1+\tau)$, for example. Furthermore, the price index multiplied with the composite good gives the overall investment budget $P(\tau)I = I^h + (1+\tau)I^f$.

We allow for wage increasing productivity growth at an exogenously given rate g. Hence, the state of labor productivity follows a deterministic trend $G_t = G_0e^{gt}$. Since it is simpler to analyze the detrended economy with a stationary long-run equilibrium, trending variables are expressed per efficiency unit of labor productivity. In capital market equilibrium under certainty, the rate of return on equity wealth V must be as good as the internationally fixed interest rate r on traded bonds. With trending variables given in labor efficiency units, the no-arbitrage condition requires the equality of[1] $(r-g)V = \chi + \dot{V}$. Assuming that investment is financed via retained earnings, the dividend payments to the owners amount to $\chi = f(k) - w - P(\tau)I$. The labor force is in fixed supply and equal to unity whence capital stock k and output $f(k)$ are per capita. Given the usual neoclassical constant returns to scale technology, the production function $f(k)$ in its intensive form satisfies $f'(k) > 0$, $f''(k) < 0$ as well as the Inada conditions. The flexibility in factor substitution is measured by the elasticity $\sigma^k \equiv -\frac{wf'}{kff''}$. A fraction $\alpha^k \equiv kf'/f$ of income accrues to capital and the rest $1-\alpha^k$ is labor's share. Excluding speculative bubbles on firm values, optimal capital accumulation derives from value maximization according to

$$V_t = \max_{I_s}\left\{\int_t^\infty \chi_s e^{-(r-g)(s-t)}ds \quad s.t. \quad \dot{k}_s = k_s[\phi(x_s) - \delta - g], \quad k_t = k_0\right\}. \tag{2}$$

A second technology constraint describes how the investment composite I and existing capital k combine to accumulate capital stocks. The technology is embodied in a linear homogeneous installation function. The intensive form satisfies $\phi'(x) > 0$ and $\phi''(x) \leq 0$ where $x \equiv I/k$. More investment contributes to a higher capital stock but at a declining rate so. Additional investment becomes less productive in augmenting the capital stock

[1] A dot denotes a time derivative. The original trending variables $\tilde{X}$ are obtained by multiplying the stationary variables X with the growth factor G: $\tilde{X} = XG$. Hence, the arbitrage equation would read $r\tilde{V} = \tilde{\chi} + \dot{\tilde{V}}$.

the higher the rate of accumulation already is. A convenient normalization is $\phi(\delta+g)=\delta+g$ and $\phi'(\delta+g)=1$ which means that a marginal unit of investment transforms into one unit of capital in a balanced growth equilibrium where investment covers depreciation at rate δ and keeps the capital stock growing at the rate g. The curvature $\phi''(x)$, or alternatively the elasticity $\sigma^x \equiv -x\frac{\phi''(x)}{\phi'(x)}$, measures inertia in capital installation. If it approaches zero, capital is adjusted without frictions while a large magnitude indicates inertness.

If capital accumulation is chosen optimally to maximize firm value, the following conditions must hold in addition to the law of motion given in (2) and an appropriately specified transversality condition:

$$\begin{array}{lrcl} (a) & q\phi'(x) & = & P(\tau), \\ (b) & \dot{q}-(r+\delta)q & = & -f'(k)+P(\tau)x-q\phi(x). \end{array} \tag{3}$$

Condition (a) can be inverted to give an investment function in the spirit of Tobin's Q-theory of investment: The investment rate exceeds the stationary replacement rate $x=\delta+g$ whenever the market value of installed capital [equal to the shadow value q of capital] exceeds the acquisition cost P of new capital. Due to the linearity properties of the two technology constraints, the value of the firm is $V=qk$ according to a theorem of Hayashi (1982). Finally, for the production sector to settle in a stationary equilibrium, the investment rate x must approach $\delta+g$. In the long run, $q=P$ and $(r+\delta)P=f'(k)$ holds.

Dynamics: Using these long-run relationships, log-linearization of (3) and of the law of motion for capital yields a dynamical system describing small deviations from the initial steady state position upon a change in tariff rates:

$$\begin{bmatrix} \dot{\hat{q}}_t \\ \dot{\hat{k}}_t \end{bmatrix} = \begin{bmatrix} r-g & \frac{(r+\delta)(1-\alpha^k)}{\sigma^k} \\ \frac{\delta+g}{\sigma^x} & 0 \end{bmatrix} \begin{bmatrix} \hat{q}_t \\ \hat{k}_t \end{bmatrix} + \begin{bmatrix} 1 \\ -\frac{1}{\sigma^x} \end{bmatrix} (\delta+g)\hat{P}. \tag{4}$$

Since the determinant of the coefficients matrix Z is negative, the roots are of opposite sign and satisfy the condition for saddle-point stability[2], $\mu<0<r-g<\bar{\mu}$. Exploiting steady state relations as well as the definition of elasticities, the roots are

$$\{\mu,\bar{\mu}\}=\frac{1}{2}\left\{r-g\pm\sqrt{(r-g)^2+4\frac{(\delta+g)(r+\delta)(1-\alpha^k)}{\sigma^x\sigma^k}}\right\}. \tag{5}$$

[2]In a more compact notation, (4) is $\dot{X}_t=ZX_t+B$ with a characteristic polynomial $\psi(s)\equiv|sI-Z|$ satisfying $\psi(0)=|Z|=\frac{-(\delta+g)(r+\delta)(1-\alpha^k)}{\sigma^k\sigma^x}=\psi(r-g)<0$. Furthermore, $\mathrm{tr}(Z)=r-g=\mu+\bar{\mu}$ and $|Z|=\mu\bar{\mu}$.

Higher tariffs raise the price of the composite investment commodity and, therefore, induces producers to run down capital stocks (by letting it depreciate). As capital becomes a relatively more scarce production factor, it earns higher marginal dividend returns. This, in turn, raises the shadow price of capital to match increased acquisition costs. In the long-run, when the desired capital stocks are achieved, the market value of installed capital is exactly equal to the acquisition cost which makes the shadow price increase by the same amount as the price of the investment composite. With adjustment costs, it is optimal to stretch out investment. In the short-run, as capital accumulates only slowly, the dividend return on capital falls short of the opportunity cost and must be augmented by capital gains. Formally, the complete solutions of the trajectories of capital and shadow value are

$$\begin{array}{llll} (a) & \hat{k}_\infty = -\frac{\sigma^k}{1-\alpha^k}\hat{P}, & \hat{q}_\infty = \hat{P}, & \\ (b) & \hat{k}_t = \hat{k}_\infty(1-e^{\mu t}), & \hat{q}_t = \hat{q}_\infty - \frac{(r+\delta)(1-\alpha^k)}{\sigma^k \bar{\mu}}[\hat{k}_t - \hat{k}_\infty]. & \end{array} \tag{6}$$

The solution for $\hat{q}_t$ relies on the saddle path of the approximate linear system. Evaluating the saddle path at $t = 0$ yields a derived initial value $\hat{q}_0$. Knowing this, an alternative representation of the solution for the shadow price is $\hat{q}_t = \hat{q}_0 e^{\mu t} + \hat{q}_\infty(1-e^{\mu t})$. It increases in the long-run in line with the acquisition cost of capital. It will be important to know whether the shadow price rises or falls in the short-run. The stable arm gives

$$\hat{q}_0 = (1 - \tfrac{r+\delta}{\bar{\mu}})\hat{P} \quad \gtrless \quad 0. \tag{7}$$

Evaluating $\psi(r+\delta)$, one can compute the critical value for the elasticity of the installation function σ^x that makes the initial change in the shadow price of capital exactly zero,[3]

$$\hat{q}_0 \lesseqgtr 0 \quad \Leftrightarrow \quad r+\delta \gtrless \bar{\mu} \quad \Leftrightarrow \quad \psi(r+\delta) \gtrless 0 \quad \Leftrightarrow \quad \sigma^x \gtrless \tfrac{1-\alpha^k}{\sigma^k}. \tag{8}$$

These conditions are intuitive. If capital is sticky because of high installation costs (σ^x large), the dynamics is reflected in large variability of the shadow price (steep slope of the saddle path). In case of a low speed of capital decumulation, the dividend rate can increase only slowly and much of the opportunity costs of holding equities must be covered by capital gains. This, however, requires that the initial shadow price is quite low

[3]Assume parameters $\alpha^k = .3$, $\sigma^k = .9$, $r = .05$, $g = .02$ and $\delta = .1$. From (5), compute for alternative values of σ^x the root and the half-life of adjustment, $t_{0.5} = \ln(.5)/\mu$. For example, $\sigma^x = .6$ gives $\mu = -.138$ and $t_{0.5} \approx 5$ and implies a rise in the initial shadow value. For $\sigma^x = 1.4$, the root is $\mu = -.086$ and $t_{0.5} \approx 8$ implying a decline in the initial shadow value.

as compared to the long-run value giving rise to the necessary capital gains during the transition. A low elasticity σ^x indicates great flexibility in adjusting capital stocks to their desired long-run levels. In the limiting case of $\sigma^x \to 0$, the capital stock is immediately adjusted to its long-run value equating the dividend rate to the opportunity cost of owning equities. No capital gains are needed during the transition to compensate for any shortfall of the dividend return. The increased dividend return is fully capitalized in the shadow price which exactly matches the increased acquisition cost of capital. Formally, $\phi(x) = x$ $\phi'(x) = 1$ for all investment rates. Hence, condition (3a) implies $q_\epsilon = P_\epsilon$. In case of an unanticipated and permanent change, $\dot{q}_\epsilon = 0$ implying $(r+\delta)P_\epsilon = f''k_\epsilon$ via (3b). Hence, the long-run results derived in (6a) obtain without any transitional dynamics.

Firm Values and Disposable Wage Income: Once optimal capital accumulation is determined, all other results follow immediately. Since the marginal valuation of capital q equals the average stock market valuation of firms, the change in firm value simply obtains from differentiating $V = qk$. More protective tariff rates are reflected in firm values according to $\hat{V}_t = \hat{V}_0 e^{\mu t} + \hat{V}_\infty(1 - e^{\mu t})$ with

$$\hat{V}_0 = \hat{q}(0), \quad \hat{V}_\infty = (1 - \tfrac{\sigma^k}{1-\alpha^k})\hat{P}, \quad [\hat{V}_0 - \hat{V}_\infty] = [\tfrac{\sigma^k}{1-\alpha^k} - \tfrac{r+\delta}{\bar{\mu}}]\hat{P}. \tag{9}$$

As indicated in (6) and (7), high installation costs imply an initial fall in firm values due to a fall in the shadow price. To derive the long-run effect on firm values, $(r+\delta)P = f'$ is used. The stock market value of firms falls in the long-run if the elasticity of substitution in production is not overly low, $\sigma^k > (1-\alpha^k)$. In this case, the volume effect of lower capital stocks dominates the valuation effect of higher prices, see also Persson and Svensson (1985).

Intertemporally optimizing investment is inferred most easily from the law of motion given in (2). Upon linearization, $\dot{\hat{k}} = (\delta + g)(\hat{I} - \hat{k})$. Substituting the solution for capital as well as its time derivative yields $\hat{I}_t = [I_0 e^{\mu t} + I_\infty(1 - e^{\mu t})]\hat{P}$ with weights

$$I_0 = \tfrac{\sigma^k}{1-\alpha^k}\tfrac{\mu}{\delta+g} < 0, \quad I_\infty = -\tfrac{\sigma^k}{1-\alpha^k} < 0, \quad I_0 - I_\infty = \tfrac{\sigma^k(r+\delta-\bar{\mu})}{(1-\alpha^k)(\delta+g)} \gtrless 0 \Leftrightarrow \sigma^x \gtrless \tfrac{1-\alpha^k}{\sigma^k} \tag{10}$$

Upon an increase in tariffs on imported investment goods, firms find it optimal to decumulate capital stocks monotonically. Whether the short-run decline in investment overshoots the long-run reduction, depends on the speed with which capital stocks are decumulated. For example, if capital is sticky (large elasticity σ^x), then $\bar{\mu} < (r+\delta)$ and $0 > I_0 > I_\infty$. Producers find it optimal to spread their investment program over many years. With low adjustment costs, the initial decline in investment exceeds the long-run investment levels. The border line case is again given in (8).

To compute disposable non-capital income of households originating in the production sector ($Y = w + R^I$), we need to know how wages and revenues $R^I = \tau i^f(\tau)I$ respond to an increase in tariffs on imported investment goods. Given full employment, wages are $w = f(k) - kf'(k)$ and decline in line with capital decumulation according to $\hat{w}_t = \frac{\alpha^k}{\sigma^k}\hat{k}_t$, or $\hat{w}_t = -\frac{\alpha^k}{1-\alpha^k}(1 - e^{\mu t})\hat{P}$. In computing the change in revenues, use the compensated elasticity $\epsilon^f_\tau = -\frac{1+\tau}{i^f}\frac{\partial i^f}{\partial \tau} > 0$. It is useful to express the change in tax revenues relative to domestic absorption, $E \equiv PC + PI$, giving shares $1 = s^I + s^C$. Hence,

$$R^I_{\epsilon,t} = [i^f + \tau i^{f'}(\tau)]I\tau_\epsilon + \tau i^f I_{\epsilon,t}, \quad \hat{R}^I_t = s^I\hat{P} - \tfrac{\tau}{1+\tau}(\epsilon^f_\tau \hat{P} - s^f\hat{I}_t)s^I. \tag{11}$$

Revenues increase upon applying a higher tariff rate on the tax base, but the tax base tends to be eroded by static and dynamic tariff evasion. Static evasion reduces the tax base by substituting home goods for imports. Dynamic tariff evasion stems from capital decumulation brought about by a reduction in investment demand. Tariff evasion can be neglected to a first approximation if tariffs are zero initially. Adding the response of wages gives the change in disposable non-capital income relative to domestic absorption, $\hat{Y}_t = s^L\hat{w}_t + \hat{R}^I_t = y_t\hat{P}$:

$$\begin{aligned} y_t &= y_0 e^{\mu t} + y_\infty(1 - e^{\mu t}), \\ y_0 &= s^I - \tfrac{\tau}{1+\tau}(\epsilon^f_\tau - s^f I_0)s^I > 0, \\ y_\infty &= -(s^k - s^I) - \tfrac{\tau}{1+\tau}(\epsilon^f_\tau - s^f I_\infty)s^I < 0, \\ y_0 - y_\infty &= s^k + \tfrac{\tau}{1+\tau}s^f(I_0 - I_\infty)s^I > 0. \end{aligned} \tag{12}$$

Define the output share in absorption as $s^O = \frac{f(k)}{E}$. Similarly, the share of wages is $s^L = \frac{w}{E} = (1 - \alpha^k)s^O$ and capital's share amounts to $s^k = \frac{f-w}{E} = \alpha^k s^O$. Finally, the share of dividends in absorption, $\frac{X}{E} = (s^k - s^I) = \frac{s^I}{\delta+g}(r - g) > 0$, is positive as long as dynamic efficiency holds,[4] $r - g > 0$. The effects of tariffs on disposable wage income stem from two sources that tend to be offsetting. Upon lump-sum rebatement of tariff revenues, households see their disposable incomes growing. On the other hand, firms find it optimal to decumulate capital which depresses wages. In the above formula, the long-run wage reduction is indicated by capital's absorption share s^k. Unambiguous results are

[4]In checking such a dividend criterion, Abel, Mankiw, Summers and Zeckhauser (1989) indeed present convincing empirical evidence for dynamic efficiency.

obtained if the economy starts from an unprotected position ($\tau = 0$ initially). As capital is predetermined, wages are fixed in the short-run leaving only the effect of lump-sum revenue rebatement, $\hat{Y}_0 = s^I \hat{P} > 0$. Barring any Laffer type effects of rate increases on revenues, disposable income will rise in the short-run even in case of a protected situation. The short-run increase in disposable income is reversed in the long-run as the wage effect becomes dominant, $\hat{Y}_\infty = -(s^k - s^I)\hat{P} < 0$. If the economy starts from a protected position, tariff evasion makes the short-run rise in disposable wage income less pronounced and adds to the decline in the long-run. The results on the adjustment of the production sector are conveniently summarized in

Proposition 1 (Capital, Wages and Equity Value)
Suppose that tariffs on imported investment goods are unexpectedly and permanently increased. With inertia in capital installation, adjustment is gradual.
(a) Capital stocks decline monotonically.
(b) Disposable wage income increases in the short-run (at least for small initial tariffs) but declines in the long-run when the wage effect becomes dominant.
(c) Firm values decline in the long-run if the elasticity of factor substitution is relatively high as compared to labor's income share: $\hat{V}_\infty \lesseqgtr 0 \Leftrightarrow \sigma^k \gtreqless (1-\alpha^k)$. *In the short-run, firm values decline if capital is relatively sticky:* $\hat{V}_0 \lesseqgtr 0 \Leftrightarrow \sigma^x \gtreqless \frac{(1-\alpha^k)}{\sigma^k}$.

3 Aggregate Savings with Overlapping Generations

Optimization and Aggregation: In the overlapping generations model with life-time uncertainty, new agents continuously enter the economy. They are disconnected to preexisting dynasties and start their life with zero financial wealth. While the life span of each individual is uncertain, mortality risk cancels out in the aggregate and the fraction of the population dying at each date is deterministic. Since agents differ in their age and in the amount of previously accumulated wealth, they need to be carefully distinguished by their date of birth. Consider an agent born at date $s \leq t$ maximizing expected life-time utility

$$U_{s,t} = \int_t^\infty u(\tilde{C}_{s,u}) e^{-(\rho+\theta)(s-t)} ds \tag{13}$$

which is a stream of future felicities discounted at a risk adjusted rate $\rho + \theta$. The subjective discount rate is ρ while θ denotes the conditional probability of death. For ease of aggregation, it is assumed constant and age independent. Agents want home goods and imports, and their consumption choice is greatly simplified by assuming homothetic felicity. With such preferences, demand for different commodities may be thought of as demand for a composite commodity[5] $\tilde{C} = GC(C^h, C^f)$ which is available at an exact consumer price index P. The allocation across commodities is then a static subproblem of obtaining $C(C^h, C^f)$ at minimal expenditures. The unit expenditure function gives a price index with exactly the same properties as in (1), and total spending (per efficiency unit) amounts to $P_t C_{s,t} = C^h_{s,t} + (1 + \tau_t) C^f_{s,t}$. Agents shift consumption of commodities intertemporally by accumulating real assets $\tilde{A}_{s,t}$ which are denominated in the import commodity available at a world price of unity,

$$\dot{\tilde{A}}_{s,t} = (r + \theta)\tilde{A}_{s,t} + \tilde{\omega}_{s,t} - P_t \tilde{C}_{s,t}. \tag{14}$$

Financial wealth includes equities and internationally traded bonds. We assume that insurance contracts are available at an actuarially fair premium rate θ which is equal to the risk of death or, equivalently, to the aggregate mortality rate of the population. All assets and liabilities are insured against the risk of the owner's life. Hence, the effective interest on assets is $r + \theta$. Since prices and interest are the same for all generations, they need not be indexed by date of birth. Wage income may accrue according to an earnings profile declining with age in order to mimic the life-cycle motive of savings for retirement. Hence, generation specific disposable wage income $\tilde{\omega} = \tilde{w} + \tilde{R}^I + \tilde{R}^c = \tilde{Y} + \tilde{R}^c$ is tied to economy wide averages according to $\tilde{\omega}_{s,t} = \tilde{\omega}_t a e^{-\gamma(t-s)}$. The coefficient $a = (\theta + \gamma)/\theta$ makes cohort specific wages sum up to aggregate wages. Specifically, we must assume that lump-sum government transfers are distributed over the life-cycle in exactly the same way as wage income[6]. This has no less justification than age independent lump-sum revenue rebatement. It does have the consequence of shifting the intergenerational income distribution in favor of young agents which tends to increase aggregate savings.

From the first order conditions of intertemporal optimization, one obtains the Euler equation governing generational consumption profiles, $\dot{\tilde{C}}_{s,t}/\tilde{C}_{s,t} = \sigma^c[r - \rho]$, where σ^c

[5]The composite good $\tilde{C}$ as well as other variables contain a deterministic trend due to productivity growth. Detrending is most easily done after solving the intertemporal problem.

[6]If lump-sum income were distributed according to some other rule, for example in an age independent fashion, then one would have to distinguish two types of human wealth following separate laws of motion. This would complicate the analysis considerably by increasing the dimensionality of the dynamic system describing aggregate savings.

denotes the intertemporal elasticity of substitution. Whenever interest exceeds the subjective rate of time preference, agents want consumption to increase with age. Hence, this condition determines – together with the life-cycle pattern of income – whether household's save or dissave. While consumption profiles are determined by intertemporal price ratios, levels are fixed by the amount of the agents' life-time resources. With this argument, current spending on consumption $\tilde{M} \equiv P\tilde{C}$ is proportional to life-time wealth,

$$\tilde{M}_{s,t} = m(\tilde{A}_{s,t} + \tilde{H}_{s,t}), \qquad m \equiv [r + \theta - \sigma^c(r - \rho)]. \tag{15}$$

The marginal propensity to consume out of full wealth m is constant in the present environment of constant intertemporal price ratios. If prices were to fluctuate, the marginal propensity would change to bring about the desired intertemporal substitution. In the long-run, however, when all prices become stationary, it would approach again the constant value given above.

In the OLG model, macroeconomic variables are thought of as a weighted average of cohort specific magnitudes. The weights are the sizes in date t of cohorts born in dates s. The gross birth rate θ is the rate at which new generations disconnected to the existing population enter the economy, and it is equal to the mortality rate since population is assumed constant. Upon aggregation, individual risks cancel out and one obtains a deterministic dynamic system for the household sector as a whole. In the aggregate, the laws of human and financial wealth emerge as $\dot{\tilde{H}} = (r+\theta+\gamma)\tilde{H} - \tilde{\omega}$ and $\dot{\tilde{A}} = r\tilde{A} + \tilde{\omega} - \tilde{M}$. Variables marked with a tilde contain a trend component, i.e. $\tilde{X}_t = G_t X_t$. It is more convenient analytically to consider the detrended economy with all variables stationary in a long-run equilibrium. Per effective labor unit, the aggregate savings system is then

$$\begin{array}{llcl} (a) & M & = & m(A+H), \\ (b) & \dot{A} & = & (r-g)A + \omega - M, \\ (c) & \dot{H} & = & (r+\theta+\gamma-g)H - \omega. \end{array} \tag{16}$$

By integration, human wealth is shown to be the present value – discounted with the risk adjusted interest rate $r + \theta$ – of future disposable wage incomes $\tilde{\omega}$. General trend growth increases wage income over the life-cycle while the earnings profile is declining with age at the rate γ and reduces income growth over the life-cycle. Contrary to the case of human wealth, the aggregate law of motion for financial wealth does not depend on the mortality rate. Given that the insurance sector is competitive and makes no profits, insurance payments between households and the insurance companies exactly offset each other in the aggregate.

Long-run Effects: To understand how the household sector adjusts to changes in income and prices, it is best to eliminate human wealth in (16). Differentiating (16a) and using the definition of m in (15), one obtains together with (16b) a dynamical system in (A, M) describing the evolution of savings and aggregate consumption spending. Disposable wage income is $\omega = Y + R^c$ where Y contains wages plus lump-sum transfers that stem from rebatement of revenues from tariffs on imported investment goods. Use the short-hand $\xi \equiv \sigma^c(r-\rho) + \gamma - g$ and get

$$\begin{aligned} (a).\ \dot{M} &= \xi M - m(\theta+\gamma)A, \\ (b)\ \ \dot{A} &= (r-g)A - M + Y + R^c. \end{aligned} \tag{17}$$

A unit of the consumption bundle C costs $P = c^h + (1+\tau)c^f$ while the unit cost net of tariffs at world prices amounts to[7] $\bar{c} = c^h + c^f < P$. Since tariff revenues are rebated to consumers, the effective spending net of tariffs is $M - R^c = \bar{c}(\tau)C = \frac{\bar{c}(\tau)}{P(\tau)}M$ only. Therefore, in a stationary equilibrium, the levels of assets and consumption ultimately depend on the amount of disposable wage income Y originating in the production sector:

$$M = \frac{-m(\theta+\gamma)}{(r-g)\xi - m(\theta+\gamma)\frac{\bar{c}}{P}}Y, \qquad \frac{A}{A+H} = \frac{\xi}{\theta+\gamma}. \tag{18}$$

The model makes sense only with the following restrictions which also give determinate comparative dynamic effects. The interest rate exceeds the growth rate yielding a dynamically efficient allocation, $r > g$, the marginal propensity m for current spending on consumption out of life-time income is positive, and steady state consumption is positively related to income Y as in (18). This last restriction is equivalent to $(r-g)\xi - m(\theta+\gamma)\frac{\bar{c}}{P} < 0$. The coefficient ξ captures the savings incentives as it determines the equilibrium level of financial wealth in the economy. Indeed, (17a) may be shown to emerge from aggregation of the individual Euler equations which allocate budgets optimally across time.[8] The

[7]For simplicity only, we assume that subutility is the same as with investment. Hence, the static part of consumption choice boils down to the problem described in (1) giving an identical price index and identical unit demand functions. Unit costs at world prices $\bar{c} = P - \tau c^f$ are increasing in the tariff rate, $\bar{c}' = P' - c^f - \tau c^{f\prime} = -\tau c^{f\prime} > 0$.

[8]If the OLG structure were absent ($\theta = \gamma = 0$), it would reduce to the Euler equation governing consumption growth in a representative agent economy which requires $\xi = \sigma^c(r-\rho) - g = 0$ for a stationary equilibrium to exist.

dependance of consumption growth on the level of assets implies that the composition of total wealth matters. The savings incentive $\xi = \sigma^c(r-\rho)-(g-\gamma)$ fixes the long-run share of financial wealth as indicated by the last equation in (18). Agents want consumption to grow at a rate $\sigma^c(r-\rho)$ over their life-time as indicated by the individual Euler equation. The other factor determining savings is the net growth rate $g-\gamma$ of income over the life-cycle. In the borderline case of $\xi = 0$, a new born agent prefers consumption to grow at the same rate as disposable wage income and saves nothing. As old generations face the same incentives, aggregate steady state savings is nil in this case. A positive value of ξ, however, tilts the desired consumption pattern towards the future – relative to an income stream growing at rate $g-\gamma$. Hence, it provides an incentive to save for higher future consumption. As this holds true for all generations, aggregate savings is positive. While individual savings incentives do not diminish with the level of financial wealth, aggregate accumulation (in efficiency units) grinds to a halt since the size of cohorts melts away with age.[9]

Consider the revenues that come with higher tariffs on imports for consumption purposes. Revenues respond in a way perfectly analogous to (11) except that agents now shift consumption intertemporally instead of investment. It is convenient to define the change in spending relative to absorption, hence $\hat{M} \equiv \frac{M_\epsilon}{E} = s^C(\hat{P}+\hat{C})$. Substituting this into the consumption version of (11) reveals how tax revenues increase relative to absorption,

$$\hat{R}_t^C = [s^C - \tfrac{\tau}{1+\tau}(\epsilon_\tau^f + s^f)s^C]\hat{P} + \tfrac{\tau}{1+\tau}s^f\hat{M}_t. \tag{19}$$

Revenue effects are interpreted essentially in the same way as in (11). The term $-\frac{\tau}{1+\tau}s^f s^C \hat{P}$ captures the fact that for a given budget M an increase in the price index implies a reduction in the consumption bundle which lowers revenues. The last term indicates that any more lavish budget is spent partly on imports which raises revenues. Use (19) when linearizing (17) and observe how savings and spending evolve in the vicinity of the initial steady state:

$$\begin{aligned}
\begin{bmatrix} \dot{\hat{M}}_t \\ \dot{\hat{A}}_t \end{bmatrix} &= \begin{bmatrix} \xi & -m(\theta+\gamma) \\ -\bar{c}/P & r-g \end{bmatrix} \begin{bmatrix} \hat{M}_t \\ \hat{A}_t \end{bmatrix} + \begin{bmatrix} 0 \\ \hat{b}_t \end{bmatrix}, \\
\hat{b}_t &= [y(t) + s^C - \tfrac{\tau}{1+\tau}(\epsilon_\tau^f + s^f)s^C]\hat{P}.
\end{aligned} \tag{20}$$

[9]For a vivid discussion of the consumption tilting and other savings motives, see Frenkel and Razin (1987). At any moment in time, agents differ only in their wealth. Irrespective of their age, they have identical expected remaining life-times and identical marginal propensities to consume which is quite distinct from life-cycle models with a fixed maximum life-span.

The term $\frac{\bar{c}}{P} = 1 - \frac{\tau}{1+\tau}s^f$ captures two effects of an increase in consumption spending on savings. First, an increase in the budget M reduces savings directly by the same amount. Second, part of this additional spending is channelled into imports and generates tariff revenues which are rebated in lump-sum form to consumers. Hence, more spending simultaneously increases transfer income, and $-\frac{\bar{c}}{P}\hat{M}$ gives the net reduction of savings.

The conditions that come with (18) guarantee a negative determinant of the coefficients matrix and, thus, saddle point stability[10]. In fact, the roots satisfy $\eta < 0 < r - g < \bar{\eta}$. Using $s^C + s^I = 1$, the long-run solutions emerge as

$$\hat{M}_\infty = \frac{-m(\theta+\gamma)}{|Z|}\hat{b}_\infty, \qquad \hat{A}_\infty = \frac{-\xi}{|Z|}\hat{b}_\infty. \tag{21}$$

A separate appendix which is available upon request, derives the complete solution describing the trajectories for spending and assets. As a first step, one needs to pin down the initial adjustment of aggregate spending that is consistent with bounded long-run solutions.

$$\begin{array}{llcl} (a) & \hat{M}_0 & = & \frac{m(\theta+\gamma)}{\bar{\eta}-(r-g)}\left\{L_{\bar{\eta}}[\hat{b}_t] + \hat{A}_0\right\}, \\ (b) & L_{\bar{\eta}}[\hat{b}_t] & = & \int_0^\infty \hat{b}_t e^{-\bar{\eta}t}dt = [\hat{b}_0 - \hat{b}_\infty]\frac{1}{\bar{\eta}-\mu} + \hat{b}_\infty\frac{1}{\bar{\eta}}. \end{array} \tag{22}$$

The initial adjustment of spending is ambiguous as it depends on two offsetting influences: the capital gains $\hat{A}_0$ and the present value of the newly created flow of disposable wage income, discounted at rate $\bar{\eta}$. The initial change in financial wealth is predetermined by the windfall gains or losses on equities which depend on the speed of adjustment of the investment system [see proposition 1 (c)]. If the production sector adjusts fast, initially living generations reap windfall gains, $\hat{A}_0 = s^v\hat{V}_0 > 0$. Disposable wage income, however, will rise only for a very short period of time and be negative for the rest of life giving very likely a negative present value $L_{\bar{\eta}}[\hat{b}_t] < 0$. If the production sector adjusts slowly, initial generations suffer from capital losses but have higher disposable wage income for a longer time, giving possibly a positive present value. Since these two effects tend to offset each other in the general case, the initial change in expenditures is ambiguous. Given the boundary conditions, the complete solution is

$$\begin{array}{lcl} \hat{M}_t & = & \hat{M}_0 e^{\eta t} + \hat{M}_\infty(1 - e^{\eta t}) \;+\; \left(\frac{e^{\eta t}-e^{\mu t}}{\eta-\mu}\right)\frac{m(\theta+\gamma)(\hat{b}_0-\hat{b}_\infty)}{\bar{\eta}-\mu}, \\ \hat{A}_t & = & \hat{A}_0 e^{\eta t} + \hat{A}_\infty(1 - e^{\eta t}) \;+\; \left(\frac{e^{\eta t}-e^{\mu t}}{\eta-\mu}\right)\frac{(\xi-\mu)(\hat{b}_0-\hat{b}_\infty)}{\bar{\eta}-\mu}. \end{array} \tag{23}$$

[10]The characteristic polynomial $\psi(s) = |sI - Z|$ gives $\psi(0) = |Z| = (r-g)\xi - m(\theta+\gamma)\frac{\bar{c}}{P} < 0$. Additionally, $\psi(r-g) = -m(\theta+\gamma)\bar{c}/P < 0$ makes the unstable root exceed $r - g$.

To understand the comparative dynamic effects, consider first a tariff exclusively on consumption imports. The simplicity of this case rests on the fact that labor supply is assumed fixed and that the price of the domestically produced commodity is internationally determined (think of infinitely elastic export demand). Hence, household sector decisions do not impact on production via labor and commodity markets which leaves the income component Y unaffected. The agents' disposable wage income, however, rises permanently by the amount of tariff revenues rebated in the form of lump-sum transfers. The term $\hat{b}_t = [s^C - \frac{\tau}{1+\tau}(\epsilon^f_\tau + s^f)s^C]\hat{P}$ captures the direct revenue effect diminished by static tariff evasion and adds a constant stream to existing income. As human wealth increases, consumers can afford more lavish spending on consumption over all of their life-time. With $\xi > 0$, consumers like to tilt consumption towards the future and consequently save part of the additional income stream in the early phase of their remaining lives. Hence, aggregate savings also rise as indicated in (21). Since the additional lump-sum income $\hat{b}$ is a constant stream, the last term in (23) is zero. Spending and savings approach monotonically their long-run equilibrium values. Note that assets are predetermined at the time of the tariff increase, no windfall gains or losses are involved with consumption tariffs. From (20), the maximum initial increase in the budget that keeps financial wealth constant, is $\hat{M}_0 = \hat{b}\frac{P}{\bar{c}}$. If no savings incentives were provided ($\xi = 0$), agents permanently increase spending by this maximum amount and there is no transitional dynamics. Since an increase in spending generates additional rebates, it exceeds the rise in the income component $\hat{b}$. A positive value of ξ induces agents to tilt consumption towards the future. The initial rise in spending must then fall short of the maximum amount to allow for the desired savings.

Welfare of agents ultimately hinges on the implied changes of real consumption, but not on any change in spending which may just reflect cost. One may easily infer the implications for real consumption in the aggregate. On impact, the effect on consumption may be inferred from the maximum amount $\frac{\bar{c}}{P}\hat{M}_0 \leq \hat{b}$. Using $\frac{\bar{c}}{P} = 1 - \frac{\tau}{1+\tau}s^f$ as well as $\hat{M} = s^C(\hat{P} + \hat{C}$ with $\hat{C} = C_\epsilon/C$, the effect on initial consumption is given by $\frac{\bar{c}}{P}\hat{C}_0 \leq -\frac{\tau}{1+\tau}\epsilon^f_\tau\hat{P}$. In the absence of savings incentives, this relation is an equality and the effect is permanent. Real consumption is unchanged if the economy starts from an unprotected position, but declines due to substitution towards home goods in case of positive initial tariffs. In case of consumption tilting towards the future, the relation is a strict inequality making consumption decline initially in order to increase it later on. The long-run effect on consumption in this case is seen by manipulating the solution for $\hat{M}_\infty$ in (21) (use the determinant given in fn.9) to obtain $\hat{C}_\infty = \frac{1}{|Z|}[m(\theta+\gamma)\frac{\tau}{1+\tau}\epsilon_\tau^f - (r-g)\xi]\hat{P}$. With positive permanent savings incentives and small initial tariffs, long-run aggregate consumption rises while it remains unaffected in the absence of savings and initial tariffs.

Proposition 2 (Tariffs on Consumption)
(a) Disposable wage income rises due to lump-sum revenue rebatement, if initial tariff rates are small. Adjustment of spending and savings is monotonic.
(b) Aggregate consumption expenditures are permanently higher, $\hat{M}_0 > 0$, $\hat{M}_\infty > 0$. *If consumption is tilted towards the future (present), the short-run increase in spending is less (higher) than in the long-run:* $\hat{M}_0 \lesseqgtr \hat{M}_\infty \Leftrightarrow \xi \gtreqless 0$. *In the border line case of* $\xi = 0$, *all of the additional wage income is fully spent on consumption and nothing is saved. Adjustment is instantaneous in this case.*
(c) Financial wealth remains unaffected in the short-run since no revaluation of equities occurs. The long-run adjustment of financial wealth depends on savings incentives. If household sector financial wealth is positive initially ($\xi > 0$)*, then it increases in the long-run. If it is negative initially, then it decreases:* $\hat{A}_\infty \gtrless 0 \Leftrightarrow \xi \gtrless 0$.

If tariffs were levied on imported investment goods only, disposable wage income would depend on the production sector only, $\hat{b}_t = \hat{Y}_t$. As indicated in (12), the decline in wages dominates in the long-run over the increase in income from revenue rebatement giving $\hat{Y}_0 > 0 > \hat{Y}_\infty$. According to (21), this would erode aggregate spending and financial wealth in the long-run. We summarize the effects in

Proposition 3 (Tariffs on Investment)
(a) In the long-run, consumption budgets are depressed in line with lower disposable wage income: $\hat{b}_\infty = \hat{Y}_\infty < 0$ *and* $\hat{M}_\infty < 0$. *If consumption is tilted towards the future, financial wealth is reduced, and vice versa:* $\hat{A}_\infty \lesseqgtr 0 \Leftrightarrow \xi \gtreqless 0$.
(b) In the short-run, the change in financial wealth is given by the capital gains or losses on firm values which depend on the degree of inertia in capital installation: $\hat{A}_0 = s^v \hat{V}_0 \lesseqgtr 0 \Leftrightarrow \sigma^x \gtreqless \frac{(1-\alpha^k)}{\sigma^k}$, *[see proposition (1c)]. The initial adjustment of spending is ambiguous.*
(c) The complete transition paths are a combination of two components, one monotonic and the other non-monotonic and transitory, see (22). Disposable wage income declines gradually (at rate μ*), creating a transitional life-cycle savings motive for generations living early in the transition period. The transitional savings effect creates the possibility of overshooting adjustment in financial wealth, and its size depends on the difference between*

the initial and terminal change in disposable wage income, $\hat{b}_0 - \hat{b}_\infty$. The monotonic component depends on the difference $\hat{A}_0 - \hat{A}_\infty$ between the initial capital gains effect and the permanent savings effect, the latter depending on the incentive ξ.

Overshooting adjustment of financial wealth is likely if permanent savings incentives are weak and the difference between the initial capital gains and the long-run financial wealth position happens to be small. The transitional savings motive is easily isolated by eliminating the permanent savings incentive and the initial capital gains, ($\xi = 0$ and σ^x such that $\hat{A}_0 = 0$). Figure 1 depicts the phase diagram of the savings system. The MM- line which represents the $\dot{\hat{M}} = 0$ schedule in (20), is rather flat reflecting weak permanent savings incentives.[11] The AA-lines correspond to the $\dot{\hat{A}} = 0$-schedule in (20). The AA_0-lines (one for each value of σ^x which controls the initial change in investment) first shift to the right by a magnitude determined by the intial increase in disposable wage income $\hat{b}_0 > 0$. As disposable wage income is eroded, the AA_0-lines shift to the right and eventually come to a rest at a position determined by the long-run decline in disposable wage income, see the AA_∞-line. The saddle path SS would indicate the convergent path if the change in disposable wage income were once and for all equal to $\hat{b}_\infty$. The curved solid lines give the convergent paths for alternative values of σ^x that savings and spending actually follow in case of declining wage incomes. The phase diagram in fig.1 can be understood as follows: As long as disposable wage income is high, the dynamics of spending and savings is governed by the MM and AA_0-schedules. With sufficiently large capital gains and continuity of the adjustment paths under perfect foresight, the starting position must lie in the north western region of the intersection of the MM and AA_0-schedules where the dynamics indicate decreasing expenditures and increasing assets. If σ^x is small, wage incomes decline quite fast and the MM and AA_∞-schedules soon begin to dominate the dynamics making assets as well as spending decline. If σ^x is large, agents are initially hit by windfall losses on their assets placing the initial conditions to the south western region of the MM and AA_0-schedules making both savings and spending increase in the initial phase. With slow adjustment of production, wage income declines only slowly and this region dominates the dynamics for some time. Certainly assets must increase above the levels indicated by the MM-line in order to approach the

[11]The base case savings parameters are $r = .05$, $g = .02$, $\rho = .03$, $\sigma^c = .5$, $\gamma = .015$ and $\theta = .045$. They imply a rather low speed of convergence $\eta = -.054$ giving a half-life of approximately $t_{.5} = 13$. With these parameters, the domestic stock of savings is small and initial foreign indebtedness amounts to a GDP-share equal to $D/f = -1.26$.

saddle path SS indicating the direction of changes in spending and assets in the long-run when disposable wage incomes are low. These arguments clearly demonstrate the source of overshooting in savings lies in gradually declining disposable wage incomes which continuously shift the AA-schedules in fig.1. In figure 2, the savings incentive is varied by considering alternative degrees of impatience as captured by the subjective discount rate ρ. The transitional savings motive apparently creates overshooting for small values of ξ, but speeds up convergence for large values of ξ producing a large adjustment of long-run financial wealth. The intuitive explanation is that low permanent savings incentives make the transitory life-cycle savings a large component of total savings and therefore increase the likelihood and magnitude of overshooting.

If tariffs do not discriminate between the use of goods for consumption and investment purposes, agents earn higher long-run disposable wage incomes, spend more on consumption and have higher financial wealth in the aggregate:

$$\hat{b}_\infty = \{1 - s^k - \frac{\tau}{1+\tau}[\epsilon^f_\tau + s^f(s^C - I_\infty s^I)]\}\hat{P} > 0. \qquad (24)$$

That higher tariffs raise long-run disposable wage income is easily seen from the ISS relationship (17b). Using the portfolio identity $A = D + V$ as well as the dividend equation and the stationary no-arbitrage condition $(r-g)V = \chi$, the current account is $\dot{D} = (r-g)D + f - (PI - R^I) - (M - R^c)$. By homotheticity, the net of tax budget is $M - R^c = \frac{\bar{c}}{P}M$ and similarly for investment. With identical unit demands, and expressing relative to domestic absorption, the initial current account satisfies $\frac{\bar{c}}{P} = (r-g)s^D + s^O$. In the absence of tariff protection, the critical value of capital's share in absorption that may turn around the comparative static result in (24) is $s^k = s^O\alpha^k = 1$ which gives an absorption share of output equal to $s^O = 1/\alpha^k$. From the current account, the implied critical value for the absorption share of foreign debt is $s^D = -\frac{1-\alpha^k\bar{c}/P}{\alpha^k(r-g)}$. At least in an initially unprotected equilibrium ($\frac{\bar{c}}{P} = 1$), the long-run effects noted above could be overturned only for quite degenerate cases.[12] Hence, the case is clear cut if tariffs are zero initially. If tariffs are positive, tariff evasion as captured by the terms in the square bracket tends to offset the other term. At least for small initial rates, tariff evasion is guaranteed not to dominate. The case of non-discriminating tariffs is directly implied by the previous two propositions and (24).

[12] Assume zero tariffs, $\alpha^k = .3$, $r = .05$ and $g = .02$ to see that foreign debt would have to be 78 times the value of absorption.

Proposition 4 (Non-Discriminating Tariffs)
(a) In the long-run, the increase in disposable wage income due to consumption tariffs dominates the income depressing effects of investment tariffs. Disposable wage income increases even more in the short-run: $\hat{b}_0 > \hat{b}_\infty > 0$. *The long-run effects on spending and financial wealth are as in proposition 2 but smaller in magnitude:* $\hat{M}_\infty > 0$ *and* $\hat{A}_\infty \gtrless 0 \Leftrightarrow \xi \gtrless 0$.
(b) The short-run effect on financial wealth is given by proposition 3 (b):$\hat{A}_0 = s^v \hat{V}_0 \lesseqgtr 0 \Leftrightarrow \sigma^x \gtrless \frac{(1-\alpha^k)}{\sigma^k}$. *The initial adjustment in spending is positive if capital losses on equity value are not too large.*
(c) The possibility for overshooting transition paths hinges on the magnitude of the transitional savings effect (depending on $\hat{b}_0 - \hat{b}_\infty > 0$*) relative to the magnitude of the initial capital gains and permanent savings effects (given by* $\hat{A}_0 - \hat{A}_\infty > 0$*).*

The transition formulas in (23) yield straightforward interpretations. The first two terms correspond to the standard case of a constant change in disposable wage income. The last term stems from the fact that disposable wage income increases excessively in the short-run but declines afterwards at the rate μ to give a more moderate increase in the long-run, $\hat{b}_0 - \hat{b}_\infty > 0$. This works like an additional life-cycle motive for savings and makes generations living early in the transition periods save a lot in order to smooth consumption. For a generation born in period t, the importance of this consumption smoothing motive depends on the magnitude of the excess of short-run over long-run income, $\hat{b}_t - \hat{b}_\infty$, as well as the speed of adjustment. As time passes, the population is continuously replaced by new agents for whom consumption smoothing becomes less important since the pattern of wages becomes flat again. The adjustment of the production sector to higher tariffs introduces additional savings incentives in the short-run which vanish again over time. Hence, aggregate savings and spending adjusts excessively in the short-run which is captured by the last term in (23). It is easily verified that this transitory component starts out with zero and asymptotically approaches zero again. Since disposable wage income declines, it is unambiguously positive during the transition irrespective of which sector adjusts faster, at least so if financial wealth was positive initially ($\xi > 0 > \mu$). Adding this transitory component to the monotonic adjustment pattern emerging from a constant permanent income change may produce non-monotonicities in the overall dynamics of spending and assets. The possibilities for overshooting or non-monotonic adjustment hinges on gradual accumulation of capital in the production sector and on the relative size of the transitory and permanent savings components as determined by the incentive

ξ.

4 Overshooting in the Foreign Accounts

The dynamic effects of tariffs on foreign debt accumulation and the current account are most easily inferred from the portfolio identity using the solutions for asset accumulation and equity values: $\hat{D}_t = \hat{A}_t - s^v \hat{V}_t$. Net foreign wealth is predetermined, hence $\hat{D}_0 = \hat{A}_0 - s^v \hat{V}_0 = 0$, of course. If tariffs are targeted exclusively on consumption imports, the implications for the foreign accounts are almost trivial since production and equity values are not affected: $\hat{D}_t = \hat{A}_t = \hat{A}_\infty(1 - e^{\eta t})$. In case of positive savings incentives ($\xi > 0$), the household sector accumulates financial wealth which fully translates into a gradual improvement of the net foreign asset position. The current account improves permanently.[13] The trade balance improves in the short-run to initiate the accumulation of net foreign assets while the change in the trade balance turns negative in the long-run which is perfectly sustainable in face of higher net foreign interest income.[14]

If tariffs are targeted selectively towards investment commodities, long-run disposable wage income declines instead and the long-run net asset position is likely to deteriorate. Net foreign lending unambiguously shrinks if household sector savings finance at least part of the domestic equity wealth ($\xi > 0$) and if the elasticity of factor substitution is not too large ($\sigma^k < 1 - \alpha^k$), see propositions (1c) and (3a). This result may be perverted, however, in case of high factor substitutability and large initial indebtedness due to deficient savings. The savings deficiency may be caused, for example, by a high subjective discount rate ρ, a low intertemporal elasticity of substitution σ^c, and a negligible life-cycle motive γ, leading to asset decumulation, or rendering the increase in financial wealth to unimportant magnitudes. Combined with a rather large elasticity of factor substitution, the quantity effect of tariffs dominates the valuation effect making firm values decline. With a dominant portfolio substitution effect of tariffs, the erosion of equity values leaves more of domestic financial wealth to be invested in foreign bonds.[15] The net asset position

[13] The current account is $\widehat{CA}_t = \dot{\hat{D}}_t + g\hat{D}_t$. With tariffs on consumption only, it monotonically adjusts from $\widehat{CA}_0 = -\eta\hat{A}_\infty > 0$ to $\widehat{CA}_\infty = g\hat{A}_\infty > 0$.

[14] The trade balance follows $\hat{B}_t = \dot{\hat{D}}_t - (r-g)\hat{D}_t$. It adjusts monotonically from $\hat{B}_0 = -\eta\hat{A}_\infty > 0$ to $\hat{B}_\infty = -(r-g)\hat{A}_\infty < 0$.

[15] Portfolio substitution means that, for a given portfolio size A, any erosion of equity wealth is offset by a corresponding increase in foreign bond holdings.

must improve. The discussion of proposition 3 and figures 1 and 2 shows that the gradual adjustment of the production sector to higher tariffs on imported investment goods makes an overshooting adjustment of savings likely if the economy is initially indebted abroad due to deficient permanent savings incentives. Overshooting in savings may then produce an overshooting non-monotonic evolution of the net foreign asset position.

In the non-discriminating case where both tariffs are raised by the same amount, tariffs on consumption imports dominate the direction of long-run effects. Investment tariffs dominate the nature of transitional effects. Tariffs on imported investment goods make production and disposable wage income gradually decline, thereby creating a temporary savings motive and producing a possibly overshooting adjustment of savings and foreign assets. The possibility of overshooting in the net asset position is most easily seen by considering a special case: if $\sigma^x = 1 = \frac{1-\alpha^k}{\sigma^k}$, firm values change neither in the short-run nor in the long-run as the quantity effect of investment tariffs exactly offsets the valuation effect at all dates. Assume further that the economy lacks any permanent savings incentive ($\xi = 0$). Therefore, the total equity value of the domestic capital stock is borrowed abroad giving large initial foreign indebtedness. With these assumptions, there are neither capital gains ($\hat{A}_0 = 0$) nor any permanent savings response ($\hat{A}_\infty = 0$) nor any portfolio substition effect ($\hat{V}_t = 0$ all t). Any effects on the net asset position exclusively originate in the transitory savings motive which is created by the gradually declining flow of disposable wage incomes. For generations living early in the transition period, this creates a temporarily operating life-cycle motive for savings which vanishes over time as the production sector completes the adjustment to tariffs and wage profiles become flat again. Depending on their degree of short-sightedness, all agents see only declining wage profiles at the date of the tariff increase. They save part of the initial increase in income to provide for old age consumption. At some later date, these very same agents either die away or start to consume their previously acquired assets while new generations see only the flat portion of the wage trajectory and don't add any new savings. In the long-run, the population is completely rolled over, and new agents lack any transitory savings incentives. Hence, aggregate assets are brought back to the level consistent with the permanently operating savings incentive captured by the coefficient ξ. In the special case considered here, the change in net foreign assets exclusively reflects this temporary savings motive: foreign debt is reduced during a transitory period and increases again later on as the savings motive vanishes.

The special case just discussed demonstrates that the transitory life-cycle savings effect may be an important source of non-monotonicity. Whether it can translate into overshooting non-monotonic adjustment of the net asset position, however, is a matter of relative magnitudes of the transitory and permanent savings components and the portfolio substitution effects. No clear cut conditions can be given that would separate the range of parameters generating monotonic adjustment from the cases giving rise to overshooting. Figures 3 and 4 demonstrate what can happen when the transitory savings motive interacts with the other sources of adjustment to determine overall evolution of the net asset position.

Figure 3 tests the sensitivity with respect to variations in the adjustment speed of the production sector as compared to the base case which implied a half-life of adjustment of 8 periods [see also footnote 3]. High flexibility in capital installation (low value of σ^x) means that wages fall quite rapidly to approch their long-run values. Hence, the transitory savings motive is powerful in the early phase but vanishes quite fast. Therefore, the overshooting of the net asset position occurs much earlier than in the base case. Furthermore, the absolute amount of overshooting is higher in the extreme cases of low or high elasticities of the installation function. The mechanics are somewhat different, however, as is seen from the two inserted graphs in figure 3. In the high speed case, overshooting would occur not only because of the transitory savings effect (difference between the solid and dotted asset lines) but also because the monotonic part of savings declines much slower than firm values. The difference between these two determinants of foreign debt becomes large very fast, and so does the increase in the net asset position. After a few periods, the production sector effectively completes adjustment while monotonic savings still declines and reverses somewhat the overly large early increase in net claims that is due to the rapidly operating portfolio substitution effect. In the low speed case of figure 3, part of the overshooting seems to be due to the fact that portfolio substitution occurs much less quickly than the monotonic part of the savings effect. Insert the solutions for savings and equity values into $\hat{D}_\infty = \hat{A}_\infty - s^v \hat{V}_\infty$. In defining $\bar{A}_t$ to be the transitory saving effect, the following formula separates formally the two separate sources of potential non-monotonicity:

$$\begin{array}{llll} (a) & \hat{D}_t & = & [\hat{D}_\infty - \bar{D}_t] + \bar{A}_t, \\ (b) & \bar{D}_t & = & (\hat{A}_\infty - \hat{A}_0)e^{\eta t} - s^v(\hat{V}_\infty - \hat{V}_0)e^{\mu t}, \\ (c) & \dot{\bar{D}}_t & = & \eta(\hat{A}_\infty - \hat{A}_0)e^{\eta t} - \mu s^v(\hat{V}_\infty - \hat{V}_0)e^{\mu t}. \end{array} \tag{25}$$

The square bracketed part $[\hat{D}_\infty - \bar{D}_t]$ may be called *permanent-savings-portfolio-*

substitution (PSPS) effect and is potentially an additional source of non-monotonicity in foreign indebtedness that may offset or reinforce the transitory savings effect. The PSPS effect vanishes as a source of non-monotonicity either when the eigenvalues coincide ($\mu = \eta$) or when the initial capital gains are such that they fall into the interval $[s^v \hat{V}_\infty, \hat{A}_\infty]$ the length of which determines the long-run impact on the net asset position. In the first case, foreign indebtedness simply follows $\hat{D}_t|_{\mu=\eta} = \hat{D}_\infty(1 - e^{\eta t}) + \bar{A}_t$. In the second case, it is easily verified that

$$\hat{D}_\infty \gtrless 0 \quad \Leftrightarrow \quad \bar{D}_t \gtrless 0 \quad \text{and} \quad \dot{\bar{D}}_t \lesseqgtr 0 \quad \text{all t.}$$

With $\bar{D}_t$ adjusting monotonically, the PSPS effect also does. It therefore cannot be a separate source of non-monotonicity which then exclusively rests on the transitory savings component.

If the initial windfall gains or losses fall outside the interval, the PSPS effect may, in principle, produce two kinds of non-monotonicities where both depend on relative magnitudes of the adjustment speeds of savings and investment: crossing and overshooting. Fig. 4 treats cases of large capital losses such that $\hat{A}_0$ falls below the interval $[s^v \hat{V}_\infty, \hat{A}_\infty]$. The upper graphs show crossing where the PSPS effect first erodes foreign assets before it augments them. Note that $\bar{D}_0 = \hat{D}_\infty$ and $\bar{D}_\infty = 0$. Hence, with a positive long-run effect on net foreign assets, $\bar{D}_t$ must eventually decline if it is to vanish in the long-run. If the rate of change first points into the opposite direction ($\dot{\bar{D}}_0 > 0$), then the PSPS effect makes foreign assets decline before it augments them (the permanent savings and the equity valuation lines cross in fig. 4). Evaluating (25c), the crossing condition is

$$\dot{\bar{D}}_0 \gtrless 0 \quad \Leftrightarrow \quad \frac{\mu}{\eta} \gtrless \frac{(\hat{A}_\infty - \hat{A}_0)}{s^v(\hat{V}_\infty - \hat{V}_0)} \gtrless 1 \quad \text{for} \quad \hat{D}_\infty \gtrless 0. \tag{26}$$

In fig. 4, net foreign assets increase, hence, the total adjustment of savings is larger than the difference between equity values in the short and long-run. For the PSPS effect to produce crossing, investment must adjust faster than savings. Even though the PSPS effect runs counter to the transitory savings effect, the latter (equal to the vertical difference of total foreign assets and the PSPS part) clearly dominates. The left insert of fig.3 demonstrates that the PSPS effect itself can produce overshooting, thereby reinforcing the transitory savings effect. The tariff increase generates large initial capital gains ($\hat{A}_0$ exceeds the above noted interval). The overshooting occurs because the overall adjustment of firm values is large but done very fast while the overall adjustment of savings is small but occurs very slowly. After a short time period, firm values have effectively obtained their lower long-run levels while overall financial assets have been adjusted only partly. The associated portfolio substitution effect produces a large increase in foreign assets after a short time already which is then eroded again as savings continue to decline. These adjustments are reflected in the derivative of $\dot{\tilde{D}}_t$ in (25) which is first very negative due to the steep slope of firm values relative to savings but eventually turns positive as the weight of the savings part remains relatively high due to slow convergence of savings while the weight for the change in firm values rapidly disappears. The overshooting in the PSPS effect reinforces the transitory savings effect in this case but the latter is rather small anyway since wage profiles are falling only for a very short time.

Finally, figure 4 nicely documents the possibility of 'perverse' adjustment to tariff protection. If the valuation effect of tariffs dominates the quantity effect to give higher equity values, and if the permanent savings motive is small, foreign indebtedness may increase in the long-run instead of decline. The long-run increase in savings is insufficient to cover the increase in domestic equity values. Although new generations (born in the distant future) save more, they need to borrow abroad to acquire domestic equities (portfolio substitution). The initially existing generations, however, save much more than future generations since falling wage incomes create a transitory life-cycle savings motive. Hence, the economy wide net foreign asset position first increases and declines only at some later periods, giving opposing short and long-run effects. Figure 4 also demonstrates that these overshooting phenomena are mainly relevant for highly indebted nations with a savings deficiency. If permanent savings incentives are sufficiently large so that domestic savings exceed domestic equity values making the country a net lender, then the transitory savings component is less important and can produce only minor overshooting if at all. It does have the effect, however, that the stock of savings approaches its long-run amount faster than it would otherwise.

Proposition 5 (Tariffs and Net Lending)

(A) Long-run effects:

(a) Tariffs on consumption: Disposable wage income increases due to revenue rebatement. The net foreign asset position improves if $\xi > 0$.

(b) Tariffs on investment: A dominating wage effect erodes disposable wage income. Net lending deteriorates if $\xi > 0$ *and* $\sigma^k < 1 - \alpha^k$. *The reverse holds if permanent savings incentives are sufficiently small and factor substitutability is sufficiently large,* $\sigma^k > 1-\alpha^k$.

(c) Non-discriminating tariffs: Disposable wage incomes rise. Net lending increases for

$\xi > 0$ and $\sigma^k > 1 - \alpha^k$. For sufficiently weak savings incentives and inflexible factor substitution ($\sigma^k < 1 - \alpha^k$) net lending is depressed.

(B) Transitional effects:

(a) Disposable wage incomes gradually decline, irrespective of whether tariffs are targetted on consumption, investment or both. This always creates a positive transitory savings component during the transition.

(b) Small permanent savings incentives (ξ near zero is associated with large initial foreign indebtedness) and intermediate values of production parameters (in a neighborhood of $\sigma^x = 1 = \frac{1-\alpha^k}{\sigma^k}$) make the transitory savings effect large relative to permanent savings and portfolio substitution effects and give rise to overshooting adjustment of the net asset position. Opposite short and long-run effects are well possible.

5 Conclusions

The paper showed that even with seemingly static policies, a small open economy populated with overlapping generations may produce overshooting adjustment of savings and net foreign assets. With transitory and/or preannounced tariff changes, one would expect non-monotonic adjustment due to intertemporal substitution in consumption and investment. An unexpected and permanent increase in tariffs, however, does not change any intertemporal trade-offs and, thereby, excludes intertemporal substitution. It is rather surprising then that the adjustment should be non-monotonic. The analysis of representative agent models or overlapping generations models with two period life cycles support the expectation of gradual and monotonic adjustment. In a sense, both models display only redimentary dynamics on the household side: the RA model has complete consumption smoothing allowing for monotonic adjustment of net foreign assets only. When the two period OLG model misses future wage incomes, it features a degenerate life-cycle that cannot capture the kind of transitory life-cycle motives emphasized in the present paper. Hence, it too allows for monotonic adjustment only. Therefore, the possibilities for overshooting current account effects of permanent tariff changes have been neglected sofar either because the problem was analyzed in the framework of RA or two period lived OLG models, or because the change in wage income was assumed instantaneous in the absence of inertia in the investment process. The present paper emphasized that a gradual adjustment of the production sector creates a temporarily operating life-cycle motive for savings that may give rise to overshooting. The precondition is an insufficient permanent savings motive and, therefore, large foreign indebtedness. This makes the transitory savings component large relative to the permanent one, and therefore creates overshooting.

References

[1] Abel, Andrew B., Gregory N. Mankiw, Lawrence H. Summers and Richard J. Zeckhauser, 1989, Assessing Dynamic Efficiency: Theory and Evidence, Review of Economic Studies 56, 1–20.

[2] Blanchard, Olivier J., 1985, Debt, Deficits, and Finite Horizons, Journal of Political Economy 1985, 223–247.

[3] Bovenberg, Lans A., 1991, Investment–Promoting Policies in Open Economies: The Importance of Intergenerational and International Distributional Effects, Erasmus University of Rotterdam, mimeo.

[4] Brock, Philip L. and Stephen J. Turnovsky, 1992, The Growth and Welfare Consequences of Differential Tariffs with Endogenously Supplied Capital and Labor, NBER WP 4011.

[5] Buiter, Willem H., 1988, Death, Birth, Productivity Growth and Debt Neutrality, Economic Journal 98, 279–293.

[6] Eaton, Jonathan, 1987, A Dynamic Specific–Factors Model of International Trade, Review of Economic Studies 54, 325–338.

[7] Engel, Charles and Kenneth Kletzer, 1990, Tariffs and Saving in a Model with New Generations, Journal of International Economics 28, 71–91.

[8] Frenkel, Jacob A. and Assaf Razin, 1987, Fiscal Policies and the World Economy, Cambridge: MIT Press.

[9] Gavin, Michael, 1991, Tariffs and the Current Account: On the Macroeconomics of Commercial Policy, Journal of Economic Dynamics and Control 15, 27–52.

[10] Gavin, Michael, 1992, Income Effects of Adjustment to a Terms of Trade Disturbance and the Demand for Adjustment Finance, Journal of Development Economics 37, 127–153.

[11] Hayashi, Fumio, 1982, Tobin's Marginal q and Average q: A Neoclassical Interpretation, Econometrica 50, 213–224.

[12] Matsuyama, Kiminori, 1987, Current Account Dynamics in a Finite Horizon Model, Journal of International Economics 23, 299–313.

[13] Matsuyama, Kiminori, 1988, Terms-of-trade, Factor Intensities and the Current Account in a Life-Cycle Model, Review of Economic Studies 55, 247–262.

[14] Murphy, Robert G., 1990, The Terms of Trade, Investment, and the Current Account, Boston College, WP No. 202.

[15] Nielsen, Søren Bo, 1991, Terms of Trade, the Current Account and Imports of Intermediates and Investment Goods, Copenhagen Business School, mimeo.

[16] Persson, Torsten and Lars E.O. Svensson, 1985, Current Account Dynamics and the Terms of Trade: Harberger–Laursen–Metzler Two Generations Later, Journal of Political Economy 93, 43–65.

[17] Sen, Partha and Stephen J. Turnovsky, 1989a, Tariffs, Capital Accumulation, and the Current Account in a Small Open Economy, International Economic Review 30, 811–831.

[18] Sen, Partha and Stephen J. Turnovsky, 1989b, Deterioration of the Terms of Trade and Capital Accumulation: A Re–Examination of the Laursen–Metzler Effect, Journal of International Economics 26, 227–250.

[19] Weil, Philippe, 1989, Overlapping Families of Infinitely–Lived Agents, Journal of Public Economics 38, 183–198.

[20] Yaari, Menahem E., 1965, Uncertain Lifetime, Life Insurance, and the Theory of the Consumer, Review of Economic Studies 32, 137–150.

Fig. 1: Investment Tariffs

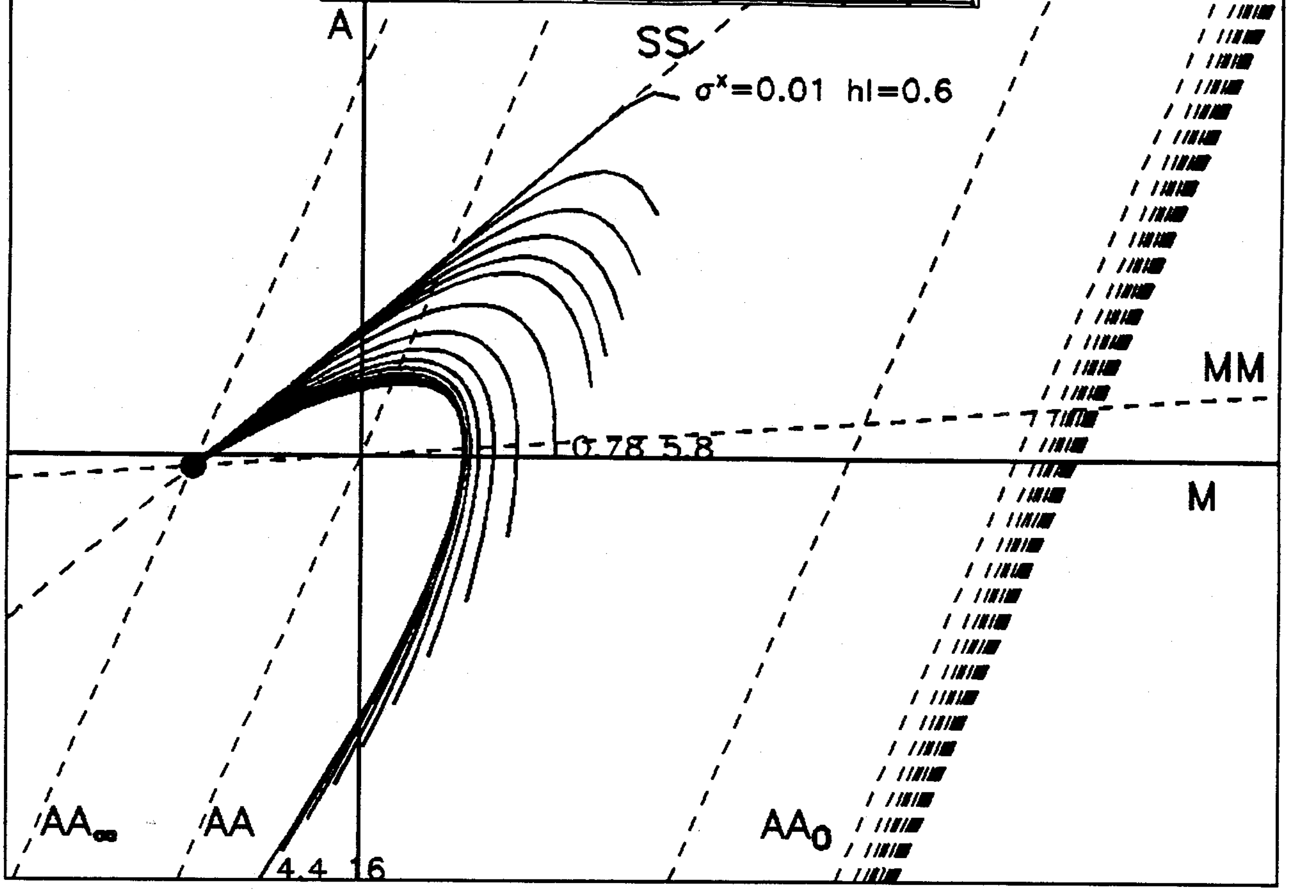


Fig. 2: Asset Accumulation

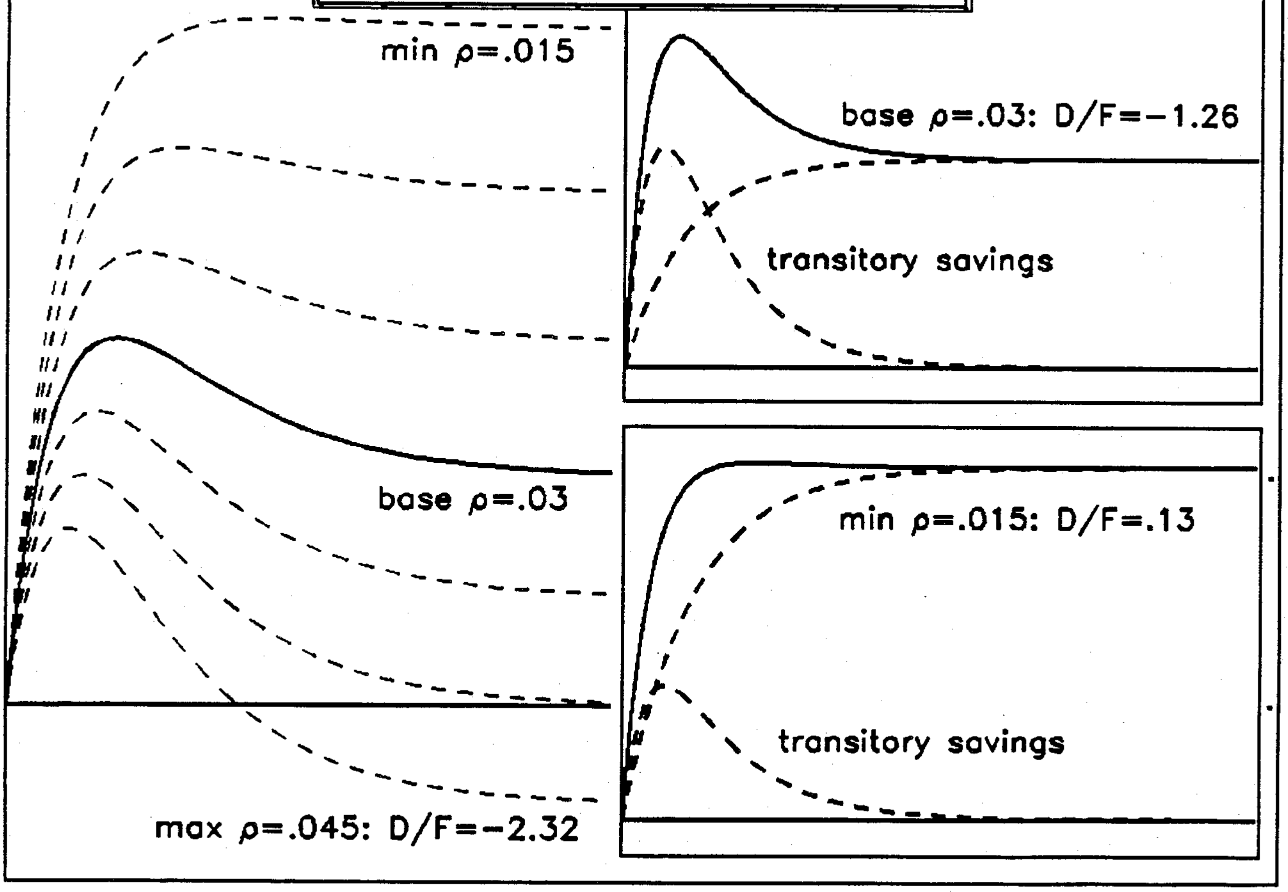


Fig.3: Net Foreign Assets

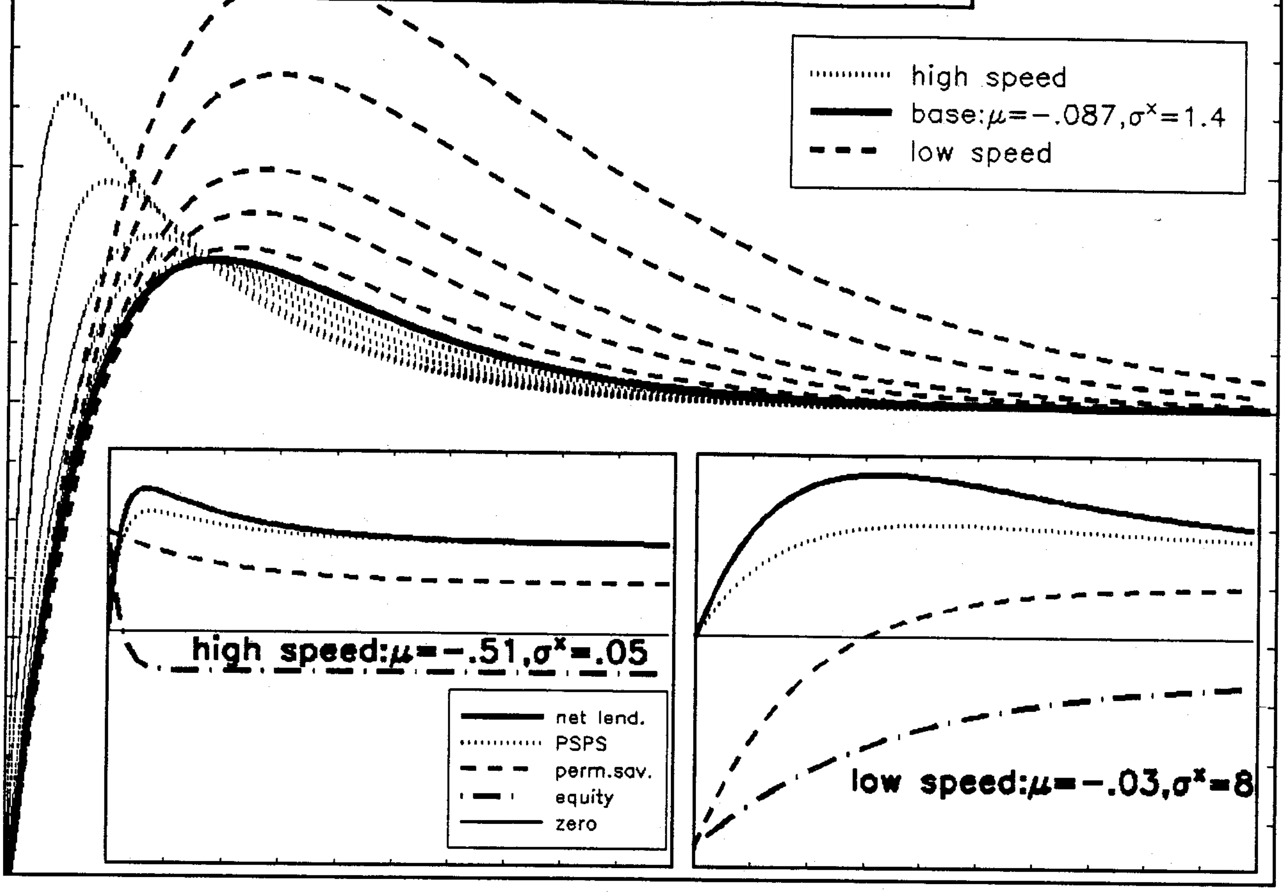
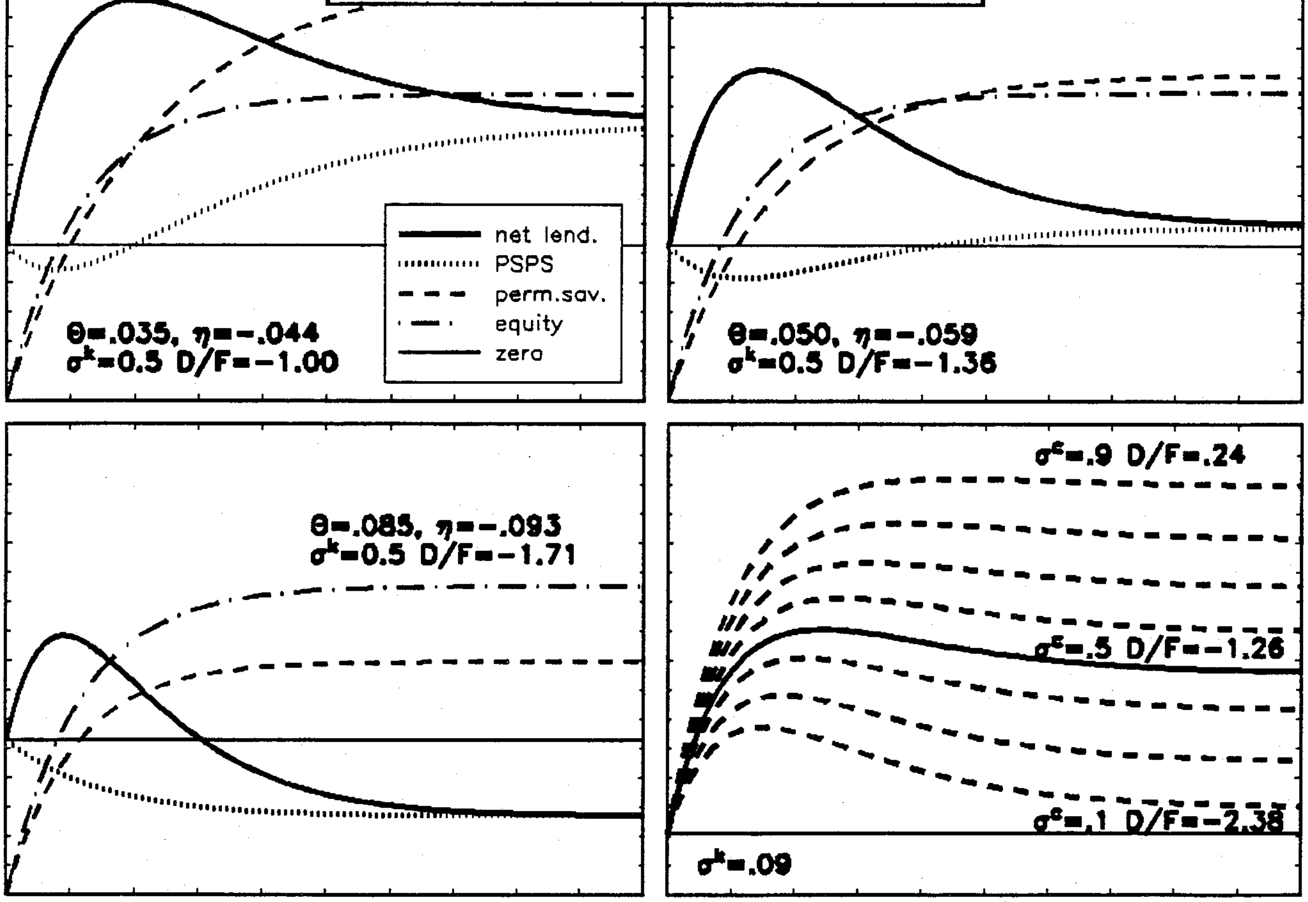


Fig.4: Net Foreign Assets



Appendix: Transitional Dynamics

Consider a dynamical system $\dot{X}_t = ZX_t + B_t$ such as given in (19) with $X_t = [\hat{M}_t, \hat{A}_t]'$ and $B_t = [0, \hat{b}_t]'$. This appendix derives explicit solutions for the dynamic variables contained in X_t. Since the absolute term depends on time, the standard solution formulas are not applicable any more. But one can solve via the method of Laplace transforms. Denoting the coefficients of the Z-matrix in (19) by $z_{11} = \sigma^c(r-\rho) + \gamma - g$, $z_{12} = -m(\theta+\gamma)$, $z_{21} = -\bar{c}/P$, and $z_{22} = r - g$, the Laplace transform of the system is

$$\psi(s) \begin{bmatrix} L_s[\hat{M}_t \\ L_s[\hat{A}_t] \end{bmatrix} = \begin{bmatrix} (s - z_{22}) & z_{12} \\ z_{21} & (s - z_{11}) \end{bmatrix} \begin{bmatrix} \hat{M}_0 \\ L_s[\hat{b}_t] + \hat{A}_0 \end{bmatrix}. \tag{1}$$

Evaluating the transform at a rate $s = \bar{\eta} > 0$ equal to the positive eigenvalue makes the polynomial $\psi(\bar{\eta})$ zero. Upon the non-explosion condition, the l.h.s is zero which pins down the initial value of the jump variable. As the forcing variable $\hat{b}_t$ adjusts with the speed μ, its Laplace transform is easily computed as

$$\begin{array}{llcl} (a) & \hat{b}_t & = & \left[\hat{b}_0 - \hat{b}_\infty\right] e^{\mu t} + \hat{b}_\infty, \\ (b) & L_s[\hat{b}_t] & = & [\hat{b}_0 - \hat{b}_\infty]\frac{1}{s-\mu} + \hat{b}_\infty \frac{1}{s}. \end{array} \tag{2}$$

In the text, we have $\hat{b}_\infty > 0$ and $\hat{b}_0 - \hat{b}_\infty = (y_0 - y_\infty)\hat{P} > 0$. The long-run solutions stated in (27) in the text may be more compactly written as

$$\hat{M}_\infty = \frac{z_{12}}{\bar{\eta}\eta}\hat{b}_\infty, \qquad \hat{A}_\infty = \frac{-z_{11}}{\bar{\eta}\eta}\hat{b}_\infty. \tag{3}$$

Evaluating (1) at rate $\bar{\eta}$ yields the restrictions

$$\begin{array}{llcl} (a) & (\bar{\eta} - z_{22})\hat{M}_0 & = & -z_{12}\left\{L_{\bar{\eta}}[\hat{b}_t] + \hat{A}_0\right\}, \\ (b) & -z_{21}\hat{M}_0 & = & (\bar{\eta} - z_{11})\left\{L_{\bar{\eta}}[\hat{b}_t] + \hat{A}_0\right\}. \end{array} \tag{4}$$

The two equations can be shown to be identical. All terms in both conditions except the last one are positive indicating that expenditures increase on impact.[16] The exception is the last term which stems from the windfall gains or losses on equities. By Hayashi's (1982) theorem, $V = qK$. In case of overshooting in the asset price, $\hat{q}_0 < 0$, and $\hat{A}_0 =$

[16]This comes out also from a graphical argument.

$s^V\hat{V}_0 < 0$ as well. The reduction in firm values erodes financial wealth making the initial increase in expenditures less likely. This counterveiling effect can occur only if adjustment costs are high.

The inverse operation on (1) yields the complete solutions for the adjustment paths. Using (2b) and (3), we first write the transform more conveniently as

$$\begin{aligned} L_s[\hat{M}_t] &= \tfrac{1}{\psi(s)}\Big\{\hat{M}_0 s + \tfrac{z_{12}\hat{b}_\infty}{s} + z_{12}\tfrac{\hat{b}_0-\hat{b}_\infty}{s-\mu} - z_{22}\hat{M}_0 + z_{12}\hat{A}_0\Big\}, \\ L_s[\hat{A}_t] &= \tfrac{1}{\psi(s)}\Big\{\hat{A}_0 s - \tfrac{z_{11}\hat{b}_\infty}{s} + [\hat{b}_0 - \hat{b}_\infty]\Big[\tfrac{s}{s-\mu} - \tfrac{z_{11}}{s-\mu}\Big] + z_{21}\hat{M}_0 - z_{11}\hat{A}_0 + \hat{b}_\infty\Big\}. \end{aligned} \tag{5}$$

Note $\psi(s) = (s-\bar{\eta})(s-\eta)$. To find the reverse transform and the complete solutions for the transition, we need some further results to apply the formulas for Laplace operations. Specifically,

$$\begin{aligned} (a)\quad \tfrac{1}{\psi(s)} &= \tfrac{1}{(s-\bar{\eta})(s-\eta)} = \tfrac{1}{(\bar{\eta}-\eta)}\Big[\tfrac{1}{(s-\bar{\eta})} - \tfrac{1}{(s-\eta)}\Big], \\ (b)\quad \tfrac{s}{(s-\mu)\psi(s)} &= \tfrac{s}{(s-\mu)(s-\bar{\eta})(s-\eta)} = \tfrac{1}{(\bar{\eta}-\eta)}\Big[\tfrac{s}{(s-\mu)(s-\bar{\eta})} - \tfrac{s}{(s-\mu)(s-\eta)}\Big]. \end{aligned} \tag{6}$$

Show (6a) by the method of partial fractions. Since $\psi(s)$ has distinct roots, we have

$$\frac{1}{(s-\eta)(s-\bar{\eta})} = \frac{C_1}{(s-\eta)} + \frac{C_2}{(s-\bar{\eta})}.$$

Finding the common denominator on the r.h.s. and comparing the coefficients of the numerators on both sides yields $C_2 = -C_1$ and $C_1 = -1/(\bar{\eta}-\eta)$ which gives (6a). In (6b), we could have $\mu = \eta$ in principle. In this case of repeated roots, the following decomposition is useful:

$$\frac{s}{(s-\eta)^2} = \frac{C_1}{(s-\eta)^2} + \frac{C_2}{(s-\eta)}.$$

Comparing coefficients, we have $C_1 = \eta$ and $C_2 = 1$. We obtain the following inverse transforms:

$$\begin{aligned} L^{-1}\Big[\tfrac{1}{(s-\eta)(s-\mu)}\Big] &= \tfrac{e^{\eta t}-e^{\mu t}}{\eta-\mu} = te^{\eta t} \quad \text{for} \quad \mu=\eta, \\ L^{-1}\Big[\tfrac{s}{(s-\eta)(s-\mu)}\Big] &= \tfrac{\eta e^{\eta t}-\mu e^{\mu t}}{\eta-\mu} = (1+\eta t)e^{\eta t} \quad \text{for} \quad \mu=\eta, \\ L^{-1}\Big[\tfrac{1}{s\psi(s)}\Big] &= \tfrac{1}{\bar{\eta}\eta} + \tfrac{e^{\bar{\eta}t}}{\bar{\eta}(\bar{\eta}-\eta)} - \tfrac{e^{\eta t}}{\eta(\bar{\eta}-\eta)}, \\ L^{-1}\Big[\tfrac{1}{(s-\mu)\psi(s)}\Big] &= \tfrac{1}{(\bar{\eta}-\eta)}\Big\{\tfrac{e^{\bar{\eta}t}-e^{\mu t}}{\bar{\eta}-\mu} - \tfrac{e^{\eta t}-e^{\mu t}}{\eta-\mu}\Big\}, \\ L^{-1}\Big[\tfrac{s}{(s-\mu)\psi(s)}\Big] &= \tfrac{1}{(\bar{\eta}-\eta)}\Big\{\tfrac{\bar{\eta}e^{\bar{\eta}t}-\mu e^{\mu t}}{\bar{\eta}-\mu} - \tfrac{\eta e^{\eta t}-\mu e^{\mu t}}{\eta-\mu}\Big\}. \end{aligned}$$

Armed with these results, the inverse of (5) emerges as

$$
\begin{aligned}
\hat{M}_t &= \left\{z_{12}\hat{A}_0 - z_{22}\hat{M}_0\right\}\left[\tfrac{e^{\bar{\eta}t}-e^{\eta t}}{\bar{\eta}-\eta}\right] + z_{12}\hat{b}_\infty\left[\tfrac{1}{\eta\bar{\eta}} + \tfrac{e^{\bar{\eta}t}}{\bar{\eta}(\bar{\eta}-\eta)} - \tfrac{e^{\eta t}}{\eta(\bar{\eta}-\eta)}\right] \\
&\quad + \hat{M}_0\left[\tfrac{\bar{\eta}e^{\bar{\eta}t}-\eta e^{\eta t}}{\bar{\eta}-\eta}\right] + \tfrac{z_{12}(\hat{b}_0-\hat{b}_\infty)}{\bar{\eta}-\eta}\left[\tfrac{e^{\bar{\eta}t}-e^{\mu t}}{\bar{\eta}-\mu} - \tfrac{e^{\eta t}-e^{\mu t}}{\eta-\mu}\right], \\
\hat{A}_t &= \left\{z_{21}\hat{M}_0 - z_{11}\hat{A}_0 + \hat{b}_\infty\right\}\left[\tfrac{e^{\bar{\eta}t}-e^{\eta t}}{\bar{\eta}-\eta}\right] - z_{11}\hat{b}_\infty\left[\tfrac{1}{\eta\bar{\eta}} + \tfrac{e^{\bar{\eta}t}}{\bar{\eta}(\bar{\eta}-\eta)} - \tfrac{e^{\eta t}}{\eta(\bar{\eta}-\eta)}\right] \\
&\quad + \hat{A}_0\left[\tfrac{\bar{\eta}e^{\bar{\eta}t}-\eta e^{\eta t}}{\bar{\eta}-\eta}\right] + \tfrac{\hat{b}_0-\hat{b}_\infty}{\bar{\eta}-\eta}\left[\tfrac{(\bar{\eta}-z_{11})e^{\bar{\eta}t}-(\mu-z_{11})e^{\mu t}}{\bar{\eta}-\mu} - \tfrac{(\eta-z_{11})e^{\eta t}-(\mu-z_{11})e^{\mu t}}{\eta-\mu}\right].
\end{aligned} \tag{7}
$$

By (2b) evaluated at $\bar{\eta}$ and (4), all the terms involving $e^{\bar{\eta}t}$ add up to zero. This is intuitive since (4) is implied by the condition that the solution is bounded. Hence, it must suppress the influence of the explosive eigenvalue $\bar{\eta} > 0$ on the solution trajectory. Collect the terms involving $e^{\eta t}$, use the long-run solutions given in(3), and exploit once again the restriction (4) for simplification and obtain

$$
\begin{aligned}
\hat{M}_t &= \hat{M}_0 e^{\eta t} + \hat{M}_\infty(1-e^{\eta t}) &- \left(\tfrac{e^{\eta t}-e^{\mu t}}{\eta-\mu}\right)\tfrac{z_{12}(\hat{b}_0-\hat{b}_\infty)}{\bar{\eta}-\mu}, \\
\hat{A}_t &= \hat{A}_0 e^{\eta t} + \hat{A}_\infty(1-e^{\eta t}) &+ \left(\tfrac{e^{\eta t}-e^{\mu t}}{\eta-\mu}\right)\tfrac{(z_{11}-\mu)(\hat{b}_0-\hat{b}_\infty)}{\bar{\eta}-\mu}.
\end{aligned} \tag{8}
$$

This formula yields straightforward interpretations. The first two terms correspond to the standard solution formula for a constant policy change. The last term stems from the fact that the production and consumption sectors converge at different speeds to their long-run equilibria. It is easily verified that the last term starts out with zero and asymptotically approaches zero again. It is unambiguously positive in case that financial wealth was positive initially ($z_{11}-\mu > 0$) during the transition irrespective of which sector adjusts faster. Adding this third term to the monotonic paths emerging from the first two terms may produce non-monotonicities in the overall dynamics of spending and assets. The possibilities for overshooting or non-monotonic adjustment hinge on the difference in the rates of adjustment of savings and investment. In case that these adjustment rates happen to be identical, we substitute

$$\lim_{\mu\to\eta}\frac{e^{\eta t}-e^{\mu t}}{\eta-\mu} = \lim_{\mu\to\eta} te^{\mu t} = te^{\eta t}.$$

This term stems from the inverse transform of $\frac{1}{(s-\eta)(s-\mu)}$ in case of $\eta = \mu$ which gives $L^{-1}[\frac{1}{(s-\eta)^2}] = te^{\eta t}$.