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Joseph W. Gruber

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Abstract: Empirical work regarding Intertemporal Current Account (ICA) models has centered around two distinct testing methodologies, present value tests and a productivity shock approach as formulated by Glick and Rogoff (1995). In previous work, Gruber (2001), I have tested and ICA model that allows for habits in aggregate consumption via the present value method. This paper applies the alternative Glick and Rogoff style approach to testing the model. The benefits of doing such are an ability to separate country-specific from worldwide output changes, a distinction of considerable importance, as well as to impose restrictions on the relationship between investment and output, neither of which are possible in the present value framework. The results of the test are supportive of the existence of habits and coincide with the results of Gruber (2001). The degree of habit persistence implied by the model is estimated for the G-7 countries. The paper also proposes habit formation as a possible solution to an empirical puzzle identified in the original Glick and Rogoff paper.

Keywords: current account, habit formation

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1 Introduction

Intertemporal current account (ICA) models assign a central role to aggregate consumption behavior in the determination of the current account.[1] In their simplest form these models function as little more than open-economy extensions of the permanent income hypothesis with consumption smoothing occurring in the aggregate and through the mechanism of the current account. Abstracting from investment, the current account is completely determined by the difference between current income and permanent income, where permanent income is defined as the annuity value of discounted expected future income. The importance of expected income in the theoretical results of intertemporal current account models, as with parallel closed-economy consumption models, complicates the empirical testing of the theory, and provides the central issue around which empirical work on ICA models is differentiated and defined.

Empirical tests of ICA models have previously been conducted via two distinct methodologies, the present value approach as formulated for a closed economy by Campbell (1987) and applied to the open-economy by Sheffrin and Woo (1990), Otto (1992), Ghosh (1995), and Nason and Rogers (2001) among others, and the productivity based approach of Glick and Rogoff (1995).[2] Neither approach has produced results completely supportive of an ICA approach to modelling the current account, but rather each methodology has identified an empirical anomaly at odds with the theoretical conclusions of standard ICA models.

In previous work, Gruber (2001), I have conjectured that the addition of habit formation in aggregate consumption can reconcile ICA theory with the empirical results derived from present-value-type tests of the model.[3] In that paper I showed that the stickiness in consumption adjustment introduced by habits allows a model that performs substantially better than non-habit models in matching the empirical record of G-7 current accounts. In this paper I intend to show that the improved performance of the habit model extends to the alternative productivity-based testing methodology of Glick and Rogoff (1995).[4]

Both the present value and the Glick and Rogoff empirical frameworks have their own advantages and disadvantages, providing an incentive for testing the habit formation ICA model in the context of both methodologies. The approaches are distinct in their construction of a measure of expected income, a necessary but elusive component of any empirical test of PIH-based theory. Whereas the Glick and Rogoff approach relies on a stochastic productivity element to calculate income and investment projections, the

[1] The application of intertemporal consumption behavior to the study of the current account was introduced in Sachs (1981). Obstfeld and Rogoff (1995) provides a survey of the intertemporal current account literature.

[2] Iscan (2000) presents a ICA model with disaggregated traded and non-traded good production in the mode of Glick and Rogoff (1995). Doing so allows the consideration of the impact of global and country-specific productivity shocks on each sector separately. Marquez (2001) checks the validity of Glick and Rogoff's results in the context of revised and extended samples.

[3] A number of recent papers, including but not limited to Campbell and Cochrane (1999), Carroll, Overland, and Weil (2000), and Fuhrer (2000), have suggested habit formation as a solution to some of PIH-consumption theory's most persistent empirical puzzles.

[4] The impact of habit formation in a continous time open-economy framework has been considered previously by Obstfeld (1992), Ikeda and Gombi (1998), and Mansoorian (1998)

present value method looks directly at the time series properties of net output, that is output less investment.

In practice, the approach of Glick and Rogoff (1995), and this paper, is to take a step back from the present value method of considering output and investment as a joint exogenous process. Now rather it is productivity that is exogenous and jointly determines output and investment. The advantage of this approach is twofold. First, restrictions can be imposed on the relationship between investment and output. Second, the productivity series is amendable to decomposition into country-specific and worldwide effects in a way that the more general net output series is not. Such a decomposition is potentially important in that the two types of shocks predict vastly different current account effects.

The productivity-based approach, though rectifying two potential failings of present value tests, is not without its own disadvantages, primarily with regard to the measurement and construction of a suitable productivity series. Given the difficulties in constructing a measure of productivity it seems questionable whether the step back from exogenous net output to exogenous productivity is one that is worthwhile making. Thus, testing the habit formation ICA model via the Glick and Rogoff approach is best viewed as a complement to the present value test of Gruber (2001) rather than as a substitute.

Another component of the paper examines whether habit formation provides an explanation for a particular empirical failing of the standard model identified in Glick and Rogoff (1995). A theoretical implication of the non-habit model is that the current account response to a positive country-specific productivity shock should exceed the investment response in absolute value. A positive productivity shock increases investment by raising the marginal product of capital. This increase in investment in turn implies a proportionate decline in the current account. By allowing costs to adjust the capital stock, the current account is adversely affected over and beyond the impact of the increase in investment alone. Contrary to the theoretical conclusions of their model, Glick and Rogoff find a larger coefficient in absolute value on country-specific productivity shocks in regard to the change in investment than to the change in the current account.[5]

This paper shows that Glick and Rogoff's empirical results are consistent with a model that allows for habit formation in aggregate consumption. The addition of a habit motive introduces a stickiness into the adjustment process of consumption following a productivity shock. With a positive shock, current income temporarily exceeds slow-

[5] In practice, present value tests have also generally failed to validate the assumptions of the basic ICA model. The method allows the construction of a predicted current account series, which can then be compared to the actual current account as a test of the theoretical assumptions of the model. Generally the result of such comparisons has been predicted current accounts that are far too smooth, in contrast to the volatility exhibited by actual current accounts, an empirical fact established in Sheffrin and Woo (1990), Otto (1992), and Ghosh (1995). I show in Gruber (2001) that habit formation presents a possible solution to the excess volatility puzzle of the standard ICA model. Habits add volatility to the current account by contributing a sluggishness to the consumption adjustment that follows unexpected income changes. In the standard model the current account is representative of any difference between permanent and current income, with habits the current account also incorporates an additional difference between the level of consumption and the permanent level of income.

to-adjust consumption, such that saving increases. The habit-induced jump in saving offsets some portion of the increase in investment, lessening the negative response of the current account to positive productivity shocks. The habit model allows for Glick and Rogoff's empirical findings, the impact of a positive productivity shock on investment can now exceed that on the current account in absolute value. Saving can now increase with the effect of lessening investment's negative impact on the current account.

The goal of this paper is threefold. First, to examine whether the habit formation ICA model's success in regard to present value tests is matched under the Glick and Rogoff methodology. Second, to obtain estimates of the degree of habit persistence evidenced by the current account in the productivity shock framework and compare these estimates to those of Gruber (2001). And third, to examine whether the habit model does in fact pose a possible solution to the empirical failings of the standard model as identified in Glick and Rogoff (1995). As such the remainder of this paper takes the following form. The second section presents an intertemporal model of the current account that allows for habits. The third section devises an estimation strategy constructed around a stochastic productivity process. The fourth section contains the estimation results and the fifth and final section concludes.

2 The Model

This section constructs a basic intertemporal model of the current account that allows for habit formation in aggregate consumption. The model is essentially that of Gruber (2001). The core of the model is composed of an infinitely lived representative agent maximizing aggregate utility derived from a function of current and past consumption. The model is solved in terms of net output. The next section then moves the model back from net output to a more primitive productivity measure.

2.1 Consumption

Consumption is determined by an infinitely lived representative agent solving the following maximization problem:

$$\operatorname{Max} U_t = E_t\left[\sum_{s=t}^{\infty}\beta^{s-t}u(C_s-\gamma C_{s-1})\right] \quad (1)$$

$$\text{s.t. } B_{t+1} = (1+r)\,B_t + NO_t - C_t \quad (2)$$

$$\lim_{s\to\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t B_{s+1} = 0 \quad (3)$$

$$\text{where } NO_t = Y_t - I_t \quad (4)$$

The representative agent maximizes the expected infinite sum of utility discounted by β. Assets are accumulated via a single riskless bond, B, denominated in terms of consumption. Asset accumulation is subject to a "no-Ponzi" game condition, such that the agent is constrained from running up explosive debts or conversely accumulating limitless assets. Net output, NO, is defined as output less investment. The economy is assumed to be small and open, therefore precluding domestic actions from impacting the interest rate. The further assumption is made that the interest rate is constant in addition to being exogenous.

Following Muellbauer (1986), utility is defined over $C_s - \gamma C_{s-1}$. Previous levels of consumption enter the utility function to a degree determined by γ. With this formulation utility is only gained from that quantity of current consumption that exceeds some fraction of last period's consumption. The parameter γ, can be thought of as a representation of the strength of consumption habits.[6] If $\gamma = 0$ the agent cares only about the level of consumption in each period of the maximization problem and the model collapses to its standard non-habit form. If $\gamma = 1$, the agent is only concerned with the change in consumption. Intermediate values of γ allow a weighted average of the current level of consumption and the change as the argument in the utility function.

$$C_s - \gamma C_{s-1} = (1-\gamma) C_s + \gamma (\Delta C_s),$$

As γ approaches one, the speed with which any single level of consumption loses its appeal increases, until only the change in consumption yields utility to the agent.

Plausible values of γ for the habit formation model are constrained such that $0 \leq \gamma < 1$. If $\gamma < 0$, utility would depend positively on past consumption, a specification more appropriate for the consideration of durable goods than habits. If $\gamma \geq 1$, the model implies explosive consumption growth.

2.1.1 The Intertemporal Budget Constraint

Forward iteration of Eq. (2) with the imposition of Eq. (3) results in the following intertemporal budget constraint:

$$\sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t C_s = (1+r) B_t + \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t NO_s \tag{5}$$

The present discounted value of consumption expenditure must be equal to initial assets and the presented discounted value of future net output.

2.1.2 Solving the Maximization Problem

Redefining the argument of the utility function as $C_t^* = C_t - \gamma C_{t-1}$, as suggested by Alessie and Lusardi (1997), allows the Euler equation resulting from the maximization problem to be expressed as follows:

$$E_t U'(C_s^*) = \delta (1+r) E_t U'\left(C_{s+1}^*\right)$$

[6] This simple formulation of habits allows only the previous period's level of consumption to impact current utility. Richer formulations allowing further lags of consumption in the utility function can be achieved via the definition of a stock of habits, such as $Z_t = \rho Z_{t-1} + (1-\rho) C_{t-1}$ in Fuhrer (2000), and substituting this construction for C_{t-1} in the utility function. The current model, as solved, sets $\rho = 0$ so that there is no persistence in the actual stock of habits.

The assumption of a quadratic utility function in C^*, and that the rate of time preference is equal to the interest rate transforms the Euler equation into the following [7] :

$$E_t C_s^* = E_t C_{s+1}^*$$

Rewriting the budget constraint in terms of $C^*$and imposing the Euler equation expectation of a constant level of consumption results in the following consumption function:

$$C_t = \frac{\gamma}{1+r} C_{t-1} + \left(1 - \frac{\gamma}{1+r}\right) \frac{r}{1+r} \left[(1+r) B_t + \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t NO_s \right] \tag{6}$$

Without habit formation, $\gamma = 0$, the model collapses to the standard PIH characterization. Consumption is equal to permanent income, that is the annuity value of all future net output. As γ approaches one, however, the agent cares more about the change in consumption and less about the level. With $\gamma = 1$ the agent smooths the change in consumption across time rather than the level of consumption as in the standard model. With $\gamma = 0$ the agent consumes that amount that maintains permanent income at a constant level. With $\gamma = 1$ the agent consumes that amount that allows permanent income to grow at a constant rate so that the agent can increase consumption at a constant rate.

Rewriting the Eq. (6) in terms of the change in consumption:

$$\Delta C_t = \gamma \Delta C_{t-1} + \left(1 - \frac{\gamma}{1+r}\right) \frac{r}{1+r} \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (E_t - E_{t-1}) NO_s \tag{7}$$

As is apparent from Eq. (7), stronger habits lead to persistence in the change in consumption. Without habits, consumption only changes in response to a revision in the expected path of net output.

2.2 Conversion to Savings / Current Account

Defining the current account as $CA_t = rB_t + NO_t - C_t$ and substituting Eq. (6) for the level of consumption implies

$$CA_t = \gamma CA_{t-1} + \frac{\gamma}{1+r} \Delta NO_t - \left(1 - \frac{\gamma}{1+r}\right) \sum_{s=t+1}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} E_t \Delta NO_s \tag{8}$$

[7] The actual Euler equation is a second-order difference equation in marginal utility, $E_t \left[u'(C_t^*) - \beta\gamma u'(C_{t+1}^*)\right] = E_t (1+r) \left[\beta u'(C_{t+1}^*) - \beta^2 \gamma u'(C_{t+2}^*)\right]$ As time goes to infinity, and assuming $\beta\gamma < 1$, one of the roots of the difference equation is unstable and the solution associated with that root can be ruled out. The solution to the other root is the Euler equation given below. Hayashi (1985), Deaton (1992), and Dynan (2000) simplify non-separable utility Euler equations in a similar manner.

Once again without habit formation the model collapses to its standard form, the current account is equal to the negative of expected changes in net output. An expectation that net output will decrease implies that current net output is above its permanent level, a difference that is saved via a current account surplus according to the standard model. With habits, the lagged current account and current change in net output also impact the current account.

3 Solving for Net Output

The presence of expected future net output in the current account equation complicates the estimation of the equation's parameters. It is necessary to find a proxy for the expected net output term before estimation can proceed. The method of doing so presented here is along the lines of Glick and Rogoff (1995). A production function and the optimization problem of a profit-maximizing firm are combined with an exogenous productivity element to determine the output and investment components of net output. As a result Eq. (8) can be rewritten in terms of productivity, A, rather than NO. Estimating the time series properties of productivity and iterating forward then allows the construction of estimates of future income and investment changes.

In contrast to the productivity-based approach, present value tests estimate the time series properties of ΔNO directly through a VAR containing lagged ΔNO and CA terms. The structure of the VAR is a product of Campbell's realization that lagged savings contains all possible information regarding the representative agent's expectations of income changes conditional on the validity of the permanent income hypothesis. In open-economy models the current account is substituted for savings. If the current account is positive, the ICA model demands that NO be expected to fall, as saving implies that current income is above permanent income. By including CA in the VAR this expectation is incorporated into the estimation of ΔNO. Once the time series behavior of ΔNO is estimated, current values can be iterated forward to find the agent's expectation of future output changes.

Rewriting the model in terms of productivity is really just taking a step back from an exogenous NO process to a more primitive productivity process. One of the advantages of doing so lies in the ability to impose theoretical restrictions on the relationship between the I and Y components of NO. In the present value VAR the CA term provides information regarding expectations of future investment as well as output. A current account surplus is theoretically consistent with either the expectation of a decrease in income or an increase in investment, both of which have the effect of decreasing NO. When the time series properties of NO are estimated what is really being investigated is the merged behavior of two separate series, investment and output. Additionally, present value models impose no theoretical constraints on how output and investment relate. It seems plausible that including the restriction that higher current investment leads to higher expected income might improve the estimation of future expected NO.

Separating investment behavior also has the effect of diluting the consumption-centric focus of present value tests. In the standard present value model, consumption behavior is the driving force behind the determination of the current account, investment is taken as an exogenous process. It is clear from the basic current account identity, $CA = S - I$, that the current account is the joint product of saving and investment behavior.

Another disadvantage of the present value testing framework is the test's inability to separate country-specific from global output changes, a separation of considerable impact when assessing the predictions of an ICA model. The current account and expected future output changes are related only in regard to country-specific income movements. Global income shocks result in general equilibrium interest rate changes, rather than the transfer of resources between countries via current account surpluses or deficits.[8] In that present value tests implicitly gauge the forecasting power of the current account in regard to income changes, regardless of their global or country-specific nature, the tests are necessarily imperfect. A preponderance of global shocks may render the current account a poor forecaster in a manner consistent with the standard ICA model.

3.1 Income

Following Glick and Rogoff, output is determined via a production function that incorporates the costs of changing the level of the capital stock.[9]

$$Y_t = A_t K_t^{\alpha} - \frac{g}{2}\left(\frac{I_t^2}{K_t}\right)$$

Where investment is equal to the change in the capital stock less depreciation, $I_t = K_{t+1} - (1-\delta) K_t$, A_t is a multiplicative productivity factor, and the parameter g determines the cost of changing the level of the capital stock. Labor is assumed to be supplied inelastically. Linearizing Y, output, around the steady-state, indicated by a bar, results in the following:

$$Y_t = -g\delta I_t + \left[\alpha \overline{AK}^{\alpha-1} + \frac{g}{2}\delta^2\right] K_t + \overline{K}^{\alpha} A_t \tag{9}$$

or

$$Y_t = \phi_1 I_t + \phi_2 K_t + \phi_3 A_t$$

where $\phi_1 < 0$, $\phi_2 > 0$, and $\phi_3 > 0$. The change in investment contributes negatively to income growth as a result of the costs associated with changing the capital stock.

[8] This result is of course dependent on an identical preference structure across all countries. If consumption preferences vary, in the rate of time preference for example, this result no longer holds. This includes the rate of habit persistence in a habit model. Thus a general equilibrium model with varying degrees of habit formation across countries promises interesting current account and world interest rate effects that are not addressed in the current paper.

[9] The production function specified varies slightly from that of Glick and Rogoff (1995) in that the costs to changing the capital stock are not multiplied by output. Thus, costs of investment do not increase with output in the current model.

Additionally, the model differs by including capital depreciation, providing a theoretical basis for a non-zero steady-state level of investment.

3.2 Investment

Investment in the model results from the behavior of a profit-maximizing firm. The firm maximizes output less investment and the costs of investment subject to a capital accumulation constraint.[10]

$$\text{Max } V = \sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} \left[A_t K_t^{\alpha} - I_t - \frac{g}{2} \left(\frac{I_t^2}{K_t} \right) \right]$$
$$\text{s.t. } K_{t+1} = (1-\delta) K_t + I_t$$

Linearizing the first order conditions of the problem around the steady-state, and first differencing the resulting solution for the optimal capital stock allows investment to be expressed as a function of lagged investment, changes in the expectation of the future path of productivity, and a constant, c. Mathamatical derivations are contained in the appendix.

$$I_t = \lambda_1 I_{t-1} + \frac{\alpha \overline{K}^{\alpha}}{g \lambda_2} \left(\sum_{s=t}^{\infty} \left(\frac{1}{\lambda_2} \right)^{s-t} [E_t A_{s+1} - (1-\delta) E_{t-1} A_s] \right) + c$$

The parameters λ_1 and λ_2 are signed such that $0 < \lambda_1 < 1$ and $\lambda_2 > 1$. Investment depends on its past value due to costs to adjusting the capital stock. Revised expectations of productivity also induce changes in the level of investment, as the capital stock is adjusted to match the marginal product of captial to the world interest rate.

3.3 Productivity

Productivity is exogenous to the model and follows an AR(1) such that,

$$A_t = \rho A_{t-1} + \eta_t \tag{10}$$

where η_t is an i.i.d. error term, and $0 \leq \rho \leq 1$. The parameter ρ determines the persistence of shocks to productivity. If $\rho = 1$, productivity follows a random walk, and all shocks permanently affect the level of A.

Substituting Eq. (10) into the investment equation results in the following:

$$I_t = \lambda_1 I_{t-1} + \frac{\alpha \rho}{g(\lambda_2 - \rho)} \overline{K}^{\alpha} \Delta A_t + \delta \frac{\alpha \rho}{g(\lambda_2 - \rho)} \overline{K}^{\alpha} A_{t-1} + c \tag{11}$$

[10] The firm can be thought of as being identical to the representative agent. The small open economy assumption in conjunction with the inelastic supply of labor ensures that the first order conditions of the firm and the consumer can be considered separately and then combined, as saving and investment decision-making are completely independent.

The small open economy assumption allows for an exogenous interest rate, thus severing one potentially complicating tie between the consumer and the firm. The inelastic supply of labor prevents consumer-generated labor supply decisions from impacting firm investment behavior. Thus, consumption and investment behavior attributed to the same individual can be studied in isolation and combined without worry of conflict.

Investment is determined by lagged investment, the change in productivity, and lagged productivity. As the persistence of productivity shocks increases so does the effect of a shock on the level of investment. If shocks dissipate immediately, $\rho = 0$, shocks have no effect on investment as the lag in the contribution of capital precludes any gain from increasing the capital stock. The equation can be rewritten as follows,

$$I_t = \lambda_1 I_{t-1} + \theta \Delta A_t + \delta \theta A_{t-1}$$

where the coefficients have the following signs, $\lambda_1 > 0$ and $\theta > 0$.

3.4 Consumption in Terms of Productivity Shocks

Now that both investment and output have been rewritten in terms of productivity and lagged investment, consumption changes can likewise be expressed in such a manner. Please refer to the appendix for details regarding the derivation.

$$\Delta C_t = \gamma \Delta C_{t-1} + \left(1 - \frac{\gamma}{1+r}\right)\left(\frac{r}{1+r-\rho}\right)\left[\theta \frac{(\phi_1 - 1)(r+\delta) + \phi_2}{1+r-\lambda_1} + \phi_3\right](A_t - \rho A_{t-1}) \tag{12}$$

The impact of a shock to productivity on consumption is unambiguously positive. Additionally, an increase in the persistence of shocks or a decrease in the level of habit formation raises the immediate consumption response to a shock at time t.

3.5 The Current Account

Using the current account identity, the change in the current account can be expressed as:

$$\Delta CA_t = rCA_{t-1} + \Delta Y_t - \Delta I_t - \Delta C_t$$

Replacing the change in output with the first difference of Eq.(9), the change in investment with Eq. (11) less lagged investment, and the change in consumption with Eq. (12), the change in the current account can be written in terms of productivity shocks, lagged investment, the lagged level of productivity, the lagged current account, and the lagged change in consumption.

$$\Delta CA_t = rCA_{t-1} + \pi_1 I_{t-1} + \pi_2 \Delta A_t + \pi_3 A_{t-1} - \gamma \Delta C_{t-1}$$

Imposing the steady-state condition that $\alpha \overline{AK}^{\alpha-1} + \frac{g}{2}\delta^2 = (1+g\delta)(r+\delta)$, the coefficients can be defined as follows:

$$\pi_1 = (1+g\delta)(1+r+\delta-\lambda_1)$$

$$\pi_2 = \phi_3 - \theta(1+\delta g) - \left(1 - \frac{\gamma}{1+r}\right)\left(\frac{r}{1+r-\rho}\right)\left[\theta \frac{(\phi_1 - 1)(r+\delta) + \phi_2}{1+r-\lambda_1} + \phi_3\right]$$

$$\pi_3 = -\delta\theta\left(1+\delta g\right) - \rho\left(1-\frac{\gamma}{1+r}\right)\left(\frac{r}{1+r-\rho}\right)\left[\theta\frac{\left(\phi_1-1\right)\left(r+\delta\right)+\phi_2}{1+r-\lambda_1}+\phi_3\right]$$

Setting $\gamma = 0$ and $\delta = 0$, the effect of a productivity shock on the current account is identical to that of Glick and Rogoff (1995).

Within the coefficient on the productivity shock, it can be shown that $(\phi_1 - 1)(r+\delta) + \phi_2 = 0$, as a condition of the optimality of investment. In the steady-state, $(1-\phi_1)$, the marginal cost of investment must be equal to the discounted marginal return on capital, $\frac{\phi_2}{(r+\delta)}$. Imposing this condition,

$$\pi_2 = \phi_3 - \theta\left(1+\delta g\right) - \left(1-\frac{\gamma}{1+r}\right)\left(\frac{r}{1+r-\rho}\right)\phi_3 \tag{13}$$

If investment is determined optimally, only the direct impact of productivity on output provokes an increase in consumption, with a corresponding negative effect on the current account. The additional output produced via the shock-induced increase in the capital stock does not increase consumption nor does it impact the current account. This result is a consequence of examining the model at the steady-state, where the cost of borrowing the temporary increase in investment is exactly equal to its return. Thus, while the shock-induced increase in investment leads to an expansion of output, permanent income is unaffected as the product of the additional investment is dedicated to paying the interest on the initial loan.[11]

Setting $\gamma = 0$ and assuming random walk productivity, $\rho = 1$, the effect of a productivity shock on the current account is completely determined by the cost of investment.[12] As Glick and Rogoff pointed out, under the assumption of a random walk in productivity a positive shock should adversely affect the current account to a greater degree than investment is positively impacted.

$$\left|\frac{\partial \Delta CA}{\partial \Delta A}\right| > \frac{\partial \Delta I}{\partial \Delta A}$$

or that

$$|\pi_2| > \theta \tag{14}$$

The inequality with $\gamma = 0$ and $\rho = 1$ is equivalent to:

[11] Glick and Rogoff assume that $(1-\phi_1) < \frac{\phi_2}{(r+\delta)}$, such that the marginal product of capital is greater than the marginal cost of investment. Under this assumption, the additional capital stock put in place following a positive productivity shock increases output by an amount greater than that needed to fund the increase in investment. Thus, there is an increase in permanent income following a positive shock and therefore in consumption as well.

[12] Glick and Rogoff, by assuming that the marginal product of investment exceeds its cost, allow an additional consumption effect on the current account. Glick and Rogoff's assumption creates a wedge between permanent and current income, leading to a decrease in saving that further decreases the current account.

$$|-\theta(1+\delta g)| > \theta$$

It is the empirical failure of the inequality in Eq. (14) that is central to the Glick and Rogoff puzzle. Evident from Eq. (13), however, is that mean-reverting shocks or a positive degree of habit formation undermine the inequality, and therefore present possible solutions to the puzzle.

Glick and Rogoff propose mean-reverting productivity shocks as a possible solution to their puzzle. An implication of the theoretical model is that productivity shocks exhibit distinct effects dependent on the degree of their persistence. In the context of an infinite time horizon model even the most persistent though temporary shock will have a limited impact on the level of permanent income, and therefore consumption. Temporary shocks increase current income above consumption, boosting saving. Temporary shocks also elicit a smaller investment response, so that the positive current account effect of increasing saving can offset the negative impact of increasing investment and the inequality in Eq. (14) need no longer hold.

Ignoring habits, whether the inequality holds or not depends on the value of ρ, with more persistent shocks reinforcing the inequality. In an exercise similar to that carried out by Glick and Rogoff, Figure 1 maps the absolute value of the productivity coefficient on the current account less that on investment across different values of ρ. For the purposes of the figure $r = 0.04$, $\delta = 0.1$, $\alpha = 0.33$, and $g = 1$. Allowing g to range between 0.1 and 2 has only a small impact on the outcome of the excercise. Values of ρ between 0 and 1 are considered. The figure reveals that the inequality quickly breaks down as shocks become less persistent.

Habit formation also acts to increase saving in response to a positive productivity shock, as consumption adjusts slowly to its new permanent level. As saving increases with the shock, the inequality in Eq. (14) need no longer be true. In a manner similar to that carried out for different values of ρ, Figure 2 examines the role of habits in determining the relationship between the productivity coefficients on the current account and investment. Assuming a random walk in productivity, fairly small degrees of habit formation reverse the inequality.

Figure 3 maps the difference between the productivity coefficients across values of both ρ and γ. Clearly, only a small fraction of the joint parameter space coincides with the prediction that productivity shocks have a greater negative effect on the current account than positive effect on investment.

The next section provides empirical results for the model. First, the time series behavior of productivity is examined, with the idea of testing whether productivity shocks have a unit root. It is clear from the discussion above that mean-reverting shocks and habit formation both have a significant impact on the current account behavior that the model predicts following a shock to productivity. Estimating whether productivity shocks follow a random walk is then useful in assessing the importance of habits in determining observed current account behavior. Next, the model is estimated in the absence of habit formation in order to re-establish the empirical puzzle to be solved. Then the model is estimated with habits, allowing the estimation of an explicit habit-formation parameter that can be assessed for significance and compared to previous results in the literature.

4 Estimation

4.1 Data

In order to maintain comparability, I use the Glick and Rogoff data set to estimate the habit-formation modified model. Investment and current account data were taken from the IFS data set for the G7 countries at an annual frequency over a span from 1960 - 1990. All series were deflated and the current accounts transformed from dollars to local currency units at the average market exchange rate for the year.

Productivity was determined as the Solow residual of a Cobb-Douglas production function. Since the primary object of concern is the change in the Solow residual rather than the level, capital was ignored in the construction of the residual on account of the relative small magnitude of capital stock adjustments even at an annual frequency. Thus the residual was formed via the division of a BLS constructed index of manufacturing output by a BLS index of labor hours in manufacturing multiplied by labor's share of output.[13] Glick and Rogoff use labor shares as reported by Stockman and Tesar (1994). Global productivity was taken as a weighted average of the country indices, where the weights were determined by real 1975 GDP. The global shock was then defined as the log difference of the global index. Country-specific shocks resulted from the log difference of the country Solow residual indices less the defined global shock. In order to scale the regression coefficients on the productivity shocks each country's productivity series were multiplied by that country's mean GDP over the sample.

4.2 Results

4.2.1 Unit Root Tests

In that both habits and non-random walk productivity are manifested by an increase in saving following an increase in income, it becomes important to accurately identify the persistence of productivity shocks so as to separate the habit motive from behavior that might otherwise be generated by an expectation of productivity reverting to a previous level.

In order to determine whether the assumption of a random walk in productivity can be justified by the data I performed unit root tests on the country-specific and global productivity series. In conducting my tests I applied an augmented Dickey-Fuller procedure. The tests were preformed with the inclusion of a constant, a time trend, and one lag. The results are reported in Table 1. In no case can the hypothesis of a unit root be rejected at conventional levels of significance.

The low power of unit tests is well known. The tests have a difficult time distinguishing between unit root and near unit root processes, a difference of considerable importance when considering the current account predictions of the model. Glick and

[13] By focusing completely on manufacturing productivity important developments in the productivity of service industries are ignored. However, in order to maintain comparability to the previous literature I only consider the manufacturing-based measure in the current analysis.

Rogoff propose the low power of unit root tests, and the improper identification of temporary shocks as permanent, to be the source of the apparent discrepancies between their model and the data. An alternative approach, and the one I follow in this paper, is to allow the random walk evidence but instead modify the model.

Table 1 also reports the test results for unit roots in the current account and investment series. Italy provides the only current account sample that allows the hypothesis of a unit root to be rejected at standard levels of significance, suggesting that changes in the current account exhibit a large degree of persistence. The investment series also do not allow for the rejection of the hypothesis of unit root, with the relatively strong exception of the United States.

4.2.2 Non-Habit Regression Results

Estimating the model without habits re-establishes the Glick and Rogoff empirical puzzle. The following two equations were estimated,

$$\begin{aligned}\Delta I_t &= a_1 + a_2 I_{t-1} + a_3 \Delta A_t^w + a_4 \Delta A_t^c + a_5 A_{t-1}^c + \varepsilon_1 \\ \Delta CA_t &= b_1 + b_2 I_{t-1} + b_3 \Delta A_t^w + b_4 \Delta A_t^c + b_5 A_{t-1}^c + \varepsilon_2\end{aligned}$$

where A^c is the country-specific component of the productivity shock and A^w is the worldwide shock, constructed as outlined above. The results are presented in Table 2. The regressions are generally supportive of the standard ICA model, though not without exception. The worldwide shocks are insignificant, as predicted, in all the CA equations with the exception of the UK and Japan. The country-specific shocks are significant in four out of seven cases and negative as the theory predicts. However the model's prediction that $|b_4| > a_4$ is not supported in six of the seven samples. Country-specific productivity shocks appear to have a larger positive effect on investment than a negative effect on the current account, with the implication that saving is increasing with the shock rather than decreasing.

As has been discussed previously, the failure to match the standard model prediction that $|b_4| > a_4$ can result from either mean-reverting productivity, as stressed by Glick and Rogoff, or habit persistence in aggregate consumption. The hypothesis of mean-reverting productivity is not supported by the results of unit root tests. Estimating the habit model, and indentifying a significant degree of habit formation, would then provide support for habits as an alternative explanation.

4.2.3 Habit Regression Results

The habit model allows the following system, which can then be estimated to generate a measure of the degree of habit persistence. The results of the estimation are reported in Table 3.

$$\begin{aligned}\Delta I_t &= c_1 + c_2 I_{t-1} + c_3 \Delta A_t^w + c_4 \Delta A_t^c + c_5 A_{t-1}^c + \varepsilon_3 \\ \Delta CA_t &= d_1 + d_2 I_{t-1} + d_3 \Delta A_t^w + d_4 \Delta A_t^c + d_5 A_{t-1}^c + d_6 CA_{t-1} + \varepsilon_4\end{aligned}$$

In the investment equation both productivity shock coefficients should be positive. Productivity shocks, both country-specific and global, increase the marginal product of capital and drive increased investment. This result is prevalent in the data, although significance is not universal.

With the current account equation global productivity shocks should be insignificant. With the exception of the UK and Canada this prediction is consistent with the regression results, as opposed to the UK and Japan in the non-habit regressions. The coefficients on country-specific productivity are negative and significant in four of the seven samples, with significance exhibited in Canada, Italy, Japan, and the United Kingdom, exactly those countries with significant parameters in the non-habit regressions.

In every case the coefficient on the country-specific productivity shock in the investment equation is greater than the absolute value of the coefficient on the current account, confirming Glick and Rogoff's earlier results. The standard model predicts the reverse, that a productivity shock worsens the current account to a greater extent than investment increases. As has been shown, a model that includes habits no longer requires the model to have this prediction.

The coefficient on the lagged current account, d_6, is representative of the degree of habit formation in the model. The coefficient is negative, as predicted, and significant in four of the seven samples, for the United States, Canada, Italy, and the United Kingdom. The significant coefficients range in value from -0.292 to -0.377, a level roughly consistent with previous estimates of habit formation in the literature. Quarterly estimates of γ have typically fallen in a range between 0.7 and 0.8, implying annual values between 0.24 and 0.41.

5 Conclusion

The empirical results presented in this paper suggest that the consideration of habit formation in aggregate consumption expenditure may be an important component in understanding the behavior of the current account. Supporting the results of Gruber (2001), though with a different empirical framework, I find a significant parameter for habit formation in four of the seven samples considered, with the estimates falling in a range consistent with the results of the earlier paper.

Additionally, the habit formation model provides a possible solution to Glick and Rogoff's empirical puzzle. With habits it is no longer necessary that a positive productivity shock induce a greater negative response on the part of the current account than a positive response in regard to investment.

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Appendix

Investment

The derivation or investment follows Shapiro (1986) and Glick and Rogoff (1995). The first order conditions from the firm's maximization problem are:

$$\begin{aligned}\frac{\partial V}{\partial K_{t+1}} &= E_t \frac{1}{1+r}\left[\alpha A_{t+1} K_{t+1}^{\alpha-1} + \frac{g}{2}\left(\frac{I_t^2}{K_t}\right) + (1-\delta)\, q_{t+1}\right] - q_t = 0 \\ \frac{\partial V}{\partial I_t} &= -1 - g\frac{I_t}{K_t} + q_t = 0\end{aligned}$$

where q_t is the Lagrange multiplier and also the shadow price of capital. Defining $K_t^* = \left(K_t - \overline{K}\right)$, the F.O.C.s can be combined and linearized:

$$K_{t+2}^* + \left[\frac{(\alpha-1)\,\alpha\overline{AK}^{\alpha-1}}{g} - (2+r)\right] K_{t+1}^* + (1+r)\, K_t^* = \frac{\alpha\overline{AK}^{\alpha}}{g} - \frac{\alpha\overline{K}^{\alpha}}{g} E_t A_{t+1}$$

The left-hand side of the linearization can be expressed as a lag polynomial,

$$\left(1 + \left[\frac{(\alpha-1)\,\alpha\overline{AK}^{\alpha-1}}{g} - (2+r)\right] L + (1+r)\, L^2\right) K_{t+2}^* = \frac{\alpha\overline{AK}^{\alpha}}{g} - \frac{\alpha\overline{K}^{\alpha}}{g} E_t A_{t+1}$$

or

$$(1-\lambda_1 L)(1-\lambda_2 L)\, K_{t+2}^* = \frac{\alpha\overline{AK}^{\alpha}}{g} - \frac{\alpha\overline{K}^{\alpha}}{g} E_t A_{t+1}$$

where λ_1 and λ_2 are the roots of polynomial such that $0 < \lambda_1 < 1$ and $\lambda_2 > 1$.

Solving for K_t^*,

$$K_t^* = \lambda_1 K_{t-1}^* + \frac{\alpha\overline{AK}^{\alpha}}{g}(1-\lambda_2 L)^{-1} + \frac{\alpha\overline{K}^{\alpha}}{g}\sum_{s=t}^{\infty}\left(\frac{1}{\lambda_2}\right)^{s-t+1} E_{t-1} A_s$$

First differencing this equation then provides the solution for investment presented in the text.

Consumption

Equation (7) expresses the change in consumption in terms of the lagged change and revision of expectations regarding future net output. Decomposing NO into I and Y, and using the linearized solution for Y:

$$\Delta C_t = \gamma \Delta C_{t-1} + \left(1 - \frac{\gamma}{1+r}\right) \frac{r}{1+r} \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (E_t - E_{t-1}) \begin{bmatrix} (\phi_1 - 1) I_s \\ +\phi_2 K_s + \phi_3 A_s \end{bmatrix}$$

Considering each component of decomposed NO separately:

$$\sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (E_t - E_{t-1}) A_s = \left(\frac{1+r}{1+r-\rho}\right) (A_t - \rho A_{t-1})$$

$$\sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (E_t - E_{t-1}) I_s = \theta \frac{1+r}{1+r-\lambda_1} \left[1 + \frac{\rho + \delta - 1}{1+r-\rho}\right] (A_t - \rho A_{t-1})$$

$$\sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (E_t - E_{t-1}) K_s = \theta \frac{1+r}{1+r-\lambda_1} \left[\frac{1}{1+r-\rho}\right] (A_t - \rho A_{t-1})$$

Substituting the components back into Eq. (7) produces Eq. (12), the change in consumption as a function of the lagged change and productivity.

Table 1 – Unit Root Tests

	Test Statistic		
	A	CA	I
USA	-0.721	-2.539	-4.200
Canada	-2.058	-1.467	-2.580
France	-0.893	-2.818	-0.108
Germany	-1.608	-2.195	-3.531
Italy	-1.575	-3.659	-1.960
Japan	-1.311	-3.056	-1.871
United Kingdom	-1.481	-2.596	-2.753
Global	-2.016		

The table contains augmented Dickey-Fuller test for a unit root in productivity, the current account, and investment. The variable of interest was regressed against a time trend, intercept, and the lagged difference of the variable. The critical values are –3.573 at the 5 percent confidence level and –3.220 at the 10 percent confidence level. A test statistic above the critical value implies that the hypothesis of a unit root in the series can be rejected with that degree of confidence. All series cover the period from 1961 – 1990.

Table 2 – Non-Habit Regression Results

$$\Delta I_t = a_1 + a_2 I_{t-1} + a_3 \Delta A_t^w + a_4 \Delta A_t^c + a_5 A_{t-1}^c + \varepsilon_1$$

$$\Delta CA_t = b_1 + b_2 I_{t-1} + b_3 \Delta A_t^w + b_4 \Delta A_t^c + b_5 A_{t-1}^c + \varepsilon_2$$

		a_2, b_2	a_3, b_3	a_4, b_4	a_5, b_5	R^2	χ^2
USA	ΔI	-0.202	0.464*	0.168	-0.068*	0.57	0.91
		(0.179)	(0.092)	(0.110)	(0.031)		(0.33)
	ΔCA	0.142*	-0.007	-0.058	0.047*	0.30	
		(0.049)	(0.068)	(0.063)	(0.018)		
Canada	ΔI	-0.126	0.256	0.528*	0.285*	0.53	5.11*
		(0.171)	(0.194)	(0.223)	(0.086)		(0.02)
	ΔCA	-0.050	0.065	-0.252*	-0.014	0.31	
		(0.058)	(0.119)	(0.107)	(0.056)		
France	ΔI	-0.157	0.278	0.262**	-0.117	0.40	3.62**
		(0.131)	(0.189)	(0.126)	(0.083)		(0.06)
	ΔCA	0.004	0.045	-0.025	0.030	0.04	
		(0.073)	(0.147)	(0.150)	(0.066)		
Germany	ΔI	-0.156*	0.547*	0.494*	0.035	0.55	15.22*
		(0.072)	(0.123)	(0.131)	(0.074)		(0.00)
	ΔCA	0.006	-0.001	-0.202	-0.015	0.11	
		(0.074)	(0.066)	(0.136)	(0.044)		
Italy	ΔI	-0.173	0.267	0.609*	-0.004	0.66	84.62*
		(0.142)	(0.213)	(0.119)	(0.101)		(0.00)
	ΔCA	0.095	-0.053	-0.309*	-0.076	0.26	
		(0.158)	(0.185)	(0.140)	(0.082)		
Japan	ΔI	0.253*	0.587*	0.355*	-0.199*	0.78	16.47*
		(0.066)	(0.117)	(0.059)	(0.045)		(0.00)
	ΔCA	-0.206*	-0.110**	-0.100*	0.104*	0.36	
		(0.046)	(0.061)	(0.038)	(0.028)		
UK	ΔI	0.053	0.655*	0.500*	-0.004	0.76	0.01
		(0.104)	(0.107)	(0.113)	(0.052)		(0.94)
	ΔCA	-0.036	-0.200*	-0.510*	-0.020	0.50	
		(0.075)	(0.074)	(0.120)	(0.027)		

All regressions conducted over 1961-1990 interval with the exception of France for which the interval is 1968-1990. Newey – West HAC standard errors are reported in parenthesis below the coefficient estimates. Significance at the 5% level is denoted by * and at the 10% level by **. Constant terms are not reported. A time trend is included though not reported in the investment regression. The χ^2 statistic tests the hypothesis that a_4=- b_4.

Table 3 – Habit Regression Results

$$\Delta I_t = c_1 + c_2 I_{t-1} + c_3 \Delta A_t^w + c_4 \Delta A_t^c + c_5 A_{t-1}^c + \varepsilon_3$$

$$\Delta CA_t = d_1 + d_2 I_{t-1} + d_3 \Delta A^w{}_t + d_4 \Delta A_t^c + d_5 A_{t-1}^c + d_6 \Delta C_{t-1} + \varepsilon_4$$

		c_2, d_2	c_3 , d_3	c_4 , d_4	c_5 , d_5	d_6	R^2	χ^2
USA	ΔI	-0.202	0.464*	0.168	-0.068*		0.57	2.22
		(0.179)	(0.092)	(0.110)	(0.031)			(0.14)
	ΔCA	0.264*	0.053	-0.012	0.074*	-0.292*	0.43	
		(0.056)	(0.063)	(0.054)	(0.019)	(0.100)		
Canada	ΔI	-0.126	0.256	0.528*	0.285*		0.53	4.99*
		(0.171)	(0.194)	(0.223)	(0.086)			(0.02)
	ΔCA	0.025	0.165**	-0.250*	0.023	-0.350*	0.40	
		(0.057)	(0.093)	(0.111)	(0.049)	(0.170)		
France	ΔI	-0.157	0.278	0.262**	-0.117		0.40	3.00**
		(0.131)	(0.189)	(0.126)	(0.083)			(0.08)
	ΔCA	-0.010	0.042	-0.045	0.035	0.156	0.04	
		(0.082)	(0.151)	(0.166)	(0.069)	(0.239)		
Germany	ΔI	-0.156*	0.547*	0.494*	0.035		0.55	15.33*
		(0.072)	(0.123)	(0.131)	(0.074)			(0.00)
	ΔCA	0.006	-0.001	-0.202	-0.016	0.005	0.11	
		(0.075)	(0.064)	(0.131)	(0.046)	(0.152)		
Italy	ΔI	-0.173	0.267	0.609*	-0.004		0.66	45.94*
		(0.142)	(0.213)	(0.119)	(0.101)			(0.00)
	ΔCA	0.076	-0.162	-0.314*	-0.073	-0.346**	0.32	
		(0.156)	(0.173)	(0.131)	(0.084)	(0.207)		
Japan	ΔI	0.253*	0.587*	0.355*	-0.199*		0.78	15.79*
		(0.066)	(0.117)	(0.059)	(0.045)			(0.00)
	ΔCA	-0.191*	-0.090	-0.097*	0.099*	-0.105	0.36	
		(0.045)	(0.064)	(0.040)	(0.028)	(0.142)		
UK	ΔI	0.053	0.655*	0.500*	-0.004		0.76	3.87*
		(0.104)	(0.107)	(0.113)	(0.052)			(0.05)
	ΔCA	0.095	-0.138*	-0.346*	0.012	-0.377*	0.62	
		(0.066)	(0.069)	(0.083)	(0.022)	(0.086)		

All regressions conducted over 1961-1990 interval with the exception of France for which the interval is 1968-1990. Newey – West HAC standard errors are reported in parenthesis below the coefficient estimates. Significance at the 5% level is denoted by * and at the 10% level by **. Constant terms are not reported. A time trend is included though not reported in the investment regression. The χ^2 statistic tests the hypothesis that c_4=- d_4.

Figure 1: Coefficient Comparison across ρ

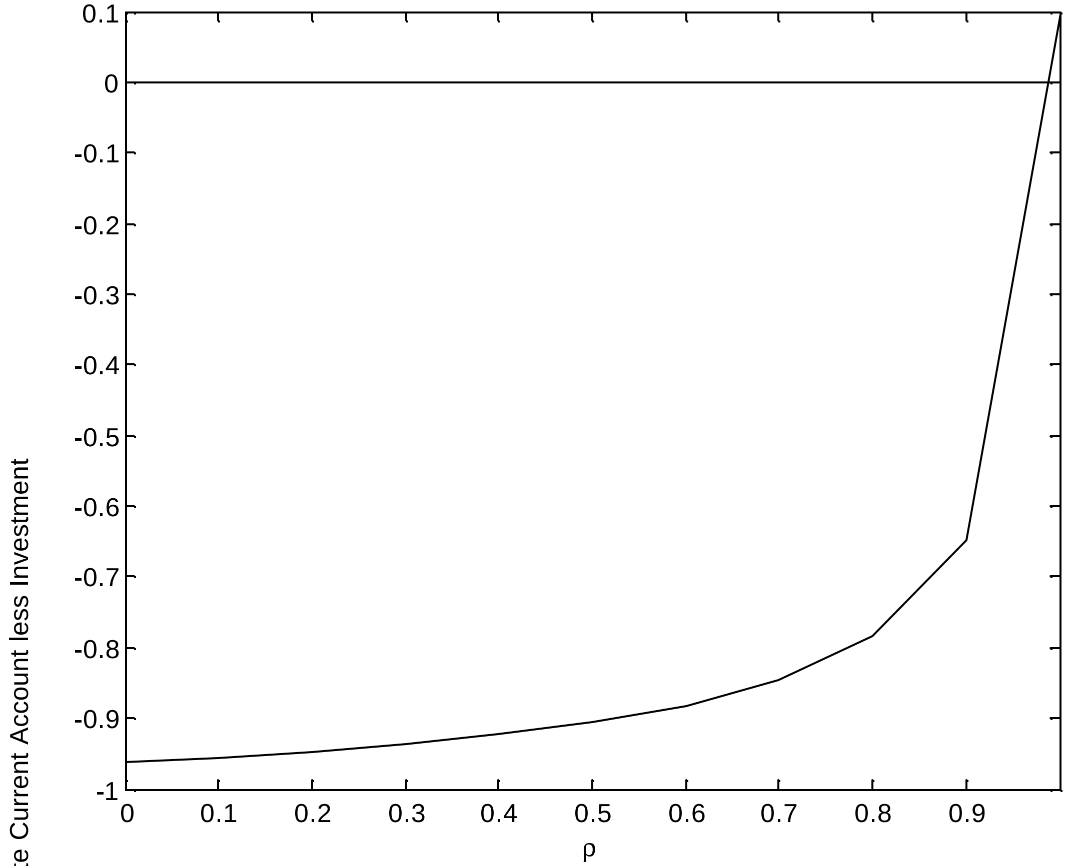

Figure 2: Coefficient Comparison across γ

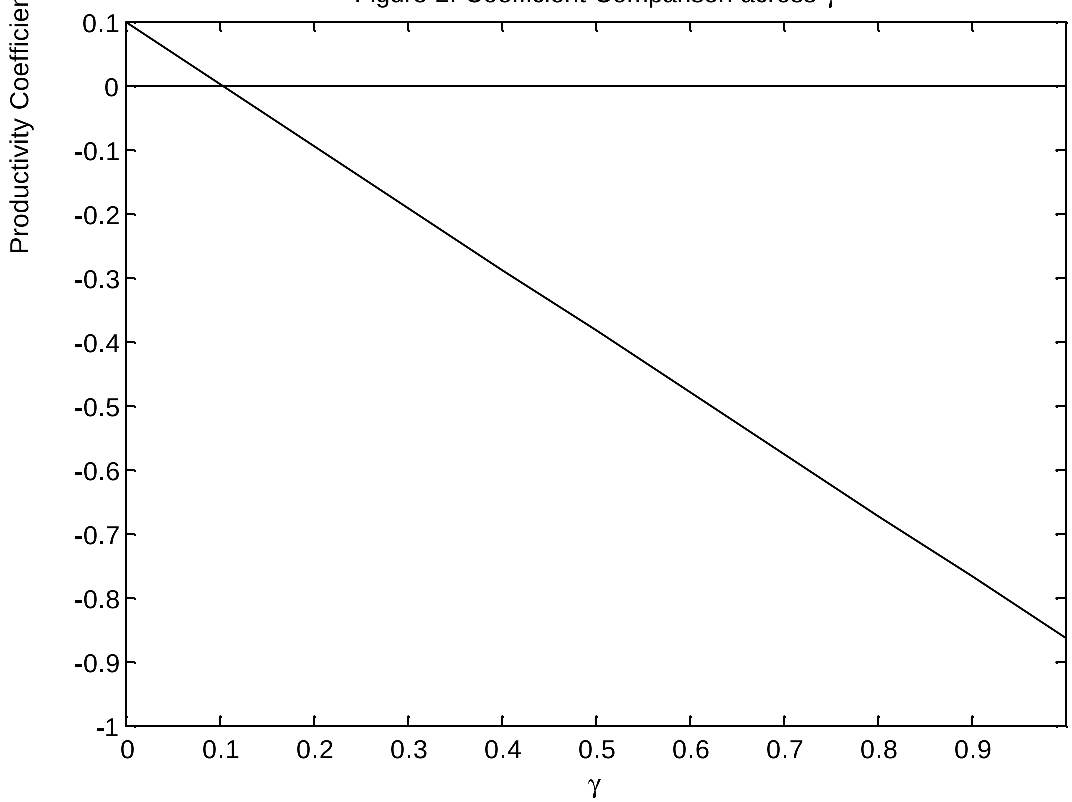

Figure 3: Coefficient Comparison across ρ and γ