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Growth, Expansion of Markets, and Income Elasticities in World Trade

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Growth, Expansion of Markets, and Income Elasticities in World Trade

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Abstract

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The Houthakker-Magee effect implies that a country facing unfavorable income elasticities in trade must either grow at a slower rate than its trading partners or experience a trend worsening of its current account and/or depreciation of its real exchange rate. Krugman (1989) first documented the existence of a "45-degree rule" under which relative income elasticities are systematically related to relative growth rates. In this paper, we develop and test an intertemporal current account model in which Krugman's original 45-degree rule is a special case. The result suggests that secular trends in current accounts and/or real exchange rates are much smaller than one would have projected based on conventional income elasticities.

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I. INTRODUCTION

This paper reexamines the Houthakker-Magee effect using an intertemporal setup. Houthakker and Magee (1969) documented large differences in the income elasticities of trade flows across countries. Some countries (notably Japan) have faced a favorable combination of a high income elasticity for their exports and a low income elasticity of import demand, while others (such as the United Kingdom and the United Sates) have faced the reverse. If these elasticities are structural, the Houthakker-Magee effect implies that the latter countries must either grow at a slower rate than their trading partners or experience a trend worsening of the current account and/or depreciation of the real exchange rate.[1] For example, the apparent increase in the U.S. trend GDP growth in the mid-1990s, when combined with the Houthakker-Magee effect, would predict a drastic and substantial worsening of the U.S. current account deficit.[2]

But are the income elasticities truly "structural"? Or might they change as trend growth rates change? In this paper, we construct an intertemporal current account model to show that the income elasticities in conventional trade equations are in fact not structural. In particular, the model implies that conventional trade regressions will find a spurious 45-degree relationship between relative export and import income elasticities and relative domestic and foreign trend growth rates.

Such a "45-degree rule" linking relative income elasticities and relative growth rates was first documented by Krugman (1989),[2] who proposed an explanation in the context of an increasing returns and monopolistic competition model. Krugman also provided empirical evidence appearing to support the 45-degree rule using the original Houthakker-Magee sample and a sample of 8 industrial countries in a later time period.

The 45-degree rule has not been universally accepted, however, on both empirical and theoretical grounds. Schatz (1989) argues that empirically the rule is fragile. In the Houthakker-Magee sample, for example, the results appear to be driven by three countries: Japan, the United States, and the United Kingdom. Removing them cuts the R^2 from 0.75 to 0.05. On the theoretical side, Iwata (1989) emphasizes the desirability of including the intertemporal allocation of consumption. Trade is always balanced in Krugman's one-period model. As shown in Section III, this yields the 45-degree rule by construction. An intertemporal model, therefore, is not only desirable, but necessary to show the theoretical robustness of the relationship.

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[1] Indeed, Lawrence (1990) has attributed the deterioration of the U.S. current account over the 1980s to the Houthakker-Magee effect.

[2] Frankel (1997) has argued that, "The key question, for determining the sustainability of the U.S. current account deficit, is whether the U.S. elasticities are different from those for other countries (and higher on the import side than the export side)."

[2] Thirlwall (1979) has suggested that a country's growth rate is determined by the balance of payments constraint: $\hat{y} = \frac{\zeta_x}{\zeta_m}\hat{y}^*$ (dubbed as "Thirlwall's law"), where $\hat{y}$ and $\hat{y}^*$ denote domestic and foreign growth rates, respectively, and ζ_x and ζ_m denote the income elasticity of demand for exports and imports, respectively. This is equivalent, mathematically, to Krugman's 45-degree rule but the interpretation is different. See McCombie and Thirlwall (1997) for a survey on Thirlwall's law.

This paper's contribution is twofold. First, we construct a model that explicitly incorporates households' intertemporal decisions and allows for trade imbalance. The model leads to different 45-degree rules for different values of the elasticity of substitution between home and foreign goods. Krugman's original 45-degree rule turns out to be a special case of this more general setup. Second, we test the various 45-degree rules implied by the model using a substantially larger sample of 35 countries across time as well as across countries. The results are supportive of the model.

The rest of the paper is organized as follows. Section II provides a brief literature review on the subject. Section III lays out the model and derives its implications. The empirical findings are presented in Section IV and finally, Section V gives some concluding remarks.

II. LITERATURE REVIEW

A lot of research has been devoted to explaining the presence of unequal income elasticities in world trade. Some researchers (for example, Marquez and McNeilly (1987)) have pointed out that inter-commodity differences in income elasticities, when combined with the differences in the commodity structure of trade across countries, imply differences in income elasticities for total exports and imports. Balassa (1979) estimated export income elasticities using hypothetical exports constructed by assuming each county has maintained its market share (the so-called constant-market-share approach) and got similar export elasticities for 13 industrial counties. These elasticities, however, are not comparable in a strict sense with income elasticities from traditional export demand equations. Sato (1977) argued that the conventional specification of the export demand function was incomplete and suggested adding a measure of the domestic production capacity. This is close to our argument. However, he did not provide a formal theoretical justification.

A number of studies have focused on the estimated high income elasticity of demand for U.S. imports. Helkie and Hooper (1988) and Feenstra (1994) emphasized the measurement error in U.S. import price indexes. Over the past several decades the United States has experienced an expansion in the range of new imports from rapidly growing, newly industrialized countries. The existing import price indexes, however, did not adequately capture the new product varieties and the decrease in import prices. This could lead to a spuriously high measured income elasticity. Feenstra (1994) demonstrates how to incorporate new product varieties into a constant-elasticity-of-substitution (CES) aggregate of import prices and finds that the corrected indexes are only able to account for part of the high U.S. income elasticity.

Another related literature considers the stability of the income elasticities for a single country over time (much of the work focussing on U.S. trade equations). A partial list includes Deyak, Sawyer, and Sprinkle (1989), Zietz and Pemberton (1993), Ceglowski (1997), and Hooper, Johnson, and Marquez (1998). Most studies find some evidence of instability in income elasticities over time. Some researchers, therefore, emphasize the importance of allowing time-varying income elasticities (Clarida, 1994; Marquez, 1994 and 1999).

Although the studies cited above suggest that there could be difference in income elasticities of trade across countries, none of them suggests a *systematic* relationship between relative income elasticities and relative growth rates. If such a relationship is established as a stylized fact, as shown later in the paper, then the explanations provided in these studies are not sufficient.

Finally, there have only been a very limited number of empirical tests on such a relationship. Ghatak and Price (1996) find no supporting evidence from 9 East Asian economies for the period 1960-1993. Caporale and Chui (1999), using cointegration techniques, estimate the income elasticities of trade for a group of 21 countries over 1960-1992 and find that the 45-degree relationship holds.

III. THE MODEL

It is useful to start with a brief summary of the model in Krugman (1989). There are two countries which are identical except in the size of the labor force. Labor is the only factor input and the labor required to produce a good involves a fixed cost. Each country can produce and consume any of an infinite number of product varieties, all of which entering symmetrically into the instantaneous utility function. Following the work of Dixit and Stiglitz (1977), each good will be produced by only one firm and such an economy will have a monopolistically competitive equilibrium. Each firm faces a constant elasticity of demand and will charge a price that is a markup over the wage rate. The zero-profit condition then determines the output of each firm. Under the full employment condition, the number of product varieties produced in a country is simply proportional to its labor force. Despite the difference in the size of the economy, the prices of representative goods will be equalized across the two countries. Therefore import demand will be proportional to the share of the varieties of the foreign produced goods to the total varieties of goods in the world market. Similarly, export demand depends not only on foreign GDP, but also on the range of goods produced in the home country relative to the range of goods produced in the rest of the world. Since there are no price effects, the income elasticity of exports from a conventional trade model is just the ratio of export growth to foreign output growth:

$$(1) \qquad \zeta_x = \frac{\widehat{EX_t}}{\widehat{y_t^*}},$$

and the income elasticity of imports is the ratio of import growth to domestic GDP growth:

$$(2) \qquad \zeta_m = \frac{\widehat{IM_t}}{\widehat{y_t}}.$$

After solving the export and import income elasticities by plugging in the formula for exports and imports, Krugman derived the 45-degree rule:

$$(3) \qquad \frac{\zeta_x}{\zeta_m} = \frac{\hat{y}}{\hat{y}^*}.$$

Note that, dividing eq. (1) by eq. (2) one can directly get $\frac{\zeta_x}{\zeta_m} = \frac{\hat{Y}_t}{\hat{Y}_t^*}\frac{\widehat{EX}_t}{\widehat{IM}_t}$, which reduces to the 45-degree rule eq. (3) without the need of actually solving the elasticities since trade is balanced by construction in Krugman's one-period model and therefore $\frac{\widehat{EX}_t}{\widehat{IM}_t} = 1$. This gives a rationale for going beyond Krugman's static model to incorporate trade imbalances in an intertemporal setup.

An Intertemporal Model

There are also two countries, Home and Foreign. The residents of the Home country are represented by the interval $[0, L]$. The residents of the Foreign country are represented by the interval $(L, L + L^*]$. There is no labor mobility across national borders. The firms in the Home country are represented by the interval $[0, n_t]$, and the firms in the Foreign country are represented by the interval $(n_t, n_t + n_t^*]$. Every firm is presumed to produce a differentiated product in a monopolistically competitive market. All goods are tradable. All households throughout the world have identical preferences over a composite consumption index. All firms within the same country have the same technology. Due to symmetry, we need only analyze the optimization problems of the representative national consumer/producer.

A. Households

The intertemporal utility function of a representative Home agent is given by

$$(4) \qquad U_t = \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_s^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} \, ,$$

where β is the intertemporal discount factor, with $0 < \beta < 1$, and $\sigma > 0$, is the elasticity of intertemporal substitution. C denotes a CES real consumption index of Home and Foreign commodity bundles:

$$(5) \qquad C_t = \left[\gamma^{\frac{1}{\rho}} C_{H,t}^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} C_{F,t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} ,$$

where $C_{H,t}$ is an index of Home produced goods and $C_{F,t}$ is an index of Foreign produced goods. $\rho > 0$ is the elasticity of substitution between Home and Foreign goods. $C_{H,t}$ and $C_{F,t}$ are each in turn a CES aggregate across goods produced in Home and Foreign respectively:

$$(6) \qquad C_{H,t} = \left[\gamma^{-\frac{1}{\theta}} \int_0^{n_t} c(z)_t^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} , \qquad C_{F,t} = \left[(1-\gamma)^{-\frac{1}{\theta}} \int_{n_t}^{n_t+n_t^*} c(z)_t^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} ,$$

where $c(z)$ is the representative household's consumption of good z, and θ is the elasticity of substitution across goods produced within a country. The assumption that θ is larger than 1 ensures an interior equilibrium with a positive level of output.

Two specific versions of this more general setup are popular in the New Open Macroeconomics literature. Obstfeld and Rogoff (1995) consider the case where $\rho = \theta$, in which the real consumption index in eq. (5) becomes CES across all goods. Corsetti and Pesenti (2001), on the other hand, focus on the case where $\rho = 1$. In this case, the composite consumption index becomes Cobb-Douglas between Home and Foreign commodity bundles but CES for goods produced in the same country. We will consider both cases later and show that they yield different 45-degree relationships.

The consumption-based price index is defined as the minimum expenditure that is necessary to buy one unit of the composite good. The overall Home-currency consumption-based price index is given by

(7) $$P_t = \left[\gamma P_{H,t}^{1-\rho} + (1-\gamma) P_{F,t}^{1-\rho}\right]^{\frac{1}{1-\rho}}.$$

The subindexes for Home and Foreign products measured in Home currency are, respectively,

(8) $$P_{H,t} = \gamma^{\frac{1}{\theta-1}} \left[\int_0^{n_t} [p(z)_t]^{1-\theta}\, dz\right]^{\frac{1}{1-\theta}}, \qquad P_{F,t} = (1-\gamma)^{\frac{1}{\theta-1}} \left[\int_{n_t}^{n_t+n_t^*} [p(z)_t]^{1-\theta} dz\right]^{\frac{1}{1-\theta}},$$

where $p(z)_t$ is the price of good z in the Home market. Note that, under symmetry, the subindexes will reduce to

(8′) $$P_{H,t} = \gamma^{\frac{1}{\theta-1}} n_t^{\frac{1}{1-\theta}} p(h)_t, \qquad P_{F,t} = (1-\gamma)^{\frac{1}{\theta-1}} n_t^{*\frac{1}{1-\theta}} p(f)_t,$$

where $p(h)_t$ and $p(f)_t$, respectively, denote the Home-currency price of the representative Home and Foreign produced goods sold in the Home market (h denotes the representative Home good and f the representative Foreign good).

The Foreign-currency price indexes faced by a representative Foreign household are similarly given by:

$$P_t^* = \left[\gamma P_{H,t}^{*1-\rho} + (1-\gamma) P_{F,t}^{*1-\rho}\right]^{\frac{1}{1-\rho}},$$

$$P_{H,t}^* = \gamma^{\frac{1}{\theta-1}} \left[\int_0^{n_t} [p(z)_t^*]^{1-\theta} dz\right]^{\frac{1}{1-\theta}}, \qquad P_{F,t}^* = (1-\gamma)^{\frac{1}{\theta-1}} \left[\int_{n_t}^{n_t+n_t^*} [p(z)_t^*]^{1-\theta} dz\right]^{\frac{1}{1-\theta}},$$

where $p(z)_t^*$ is the price of good z in the Foreign market.

Given the consumption indexes, eqs. (5) and (6), it is easy to show that a representative

Home household's demand across each of the goods produced in Home and Foreign are, respectively,

$$(9) \qquad c(h)_t = \frac{1}{\gamma}\left[\frac{p(h)_t}{P_{H,t}}\right]^{-\theta} C_{H,t} = \left[\frac{p(h)_t}{P_{H,t}}\right]^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_t, \text{ and}$$

$$c(f)_t = \frac{1}{1-\gamma}\left[\frac{p(f)_t}{P_{F,t}}\right]^{-\theta} C_{F,t} = \left[\frac{p(f)_t}{P_{F,t}}\right]^{-\theta}\left(\frac{P_{F,t}}{P_t}\right)^{-\rho} C_t,$$

Similarly, a representative Foreign household's demand across each of the goods produced in Home and Foreign is, respectively,

$$(9') \qquad c(h)^*_t = \left[\frac{p(h)^*_t}{P^*_{H,t}}\right]^{-\theta}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\rho} C^*_t, \qquad c(f)^*_t = \left[\frac{p(f)^*_t}{P^*_{F,t}}\right]^{-\theta}\left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\rho} C^*_t,$$

where $p(h)^*_t$ and $p(f)^*_t$ denote the Foreign-currency price of Home and Foreign produced goods in the Foreign market.

It is assumed that the only internationally traded asset is a real bond denominated in the composite consumption good C. Each household supplies one unit of labor which is fixed. The budget constraint for a representative Home household is therefore[3]

$$(10) \qquad P_t B_{t+1} = P_t(1+r_t)B_t + w_t - P_t C_t,$$

where r_t denotes the real interest rate on bonds between *t-1* and *t*, and w_t denotes the wage rate.

Maximizing the household intertemporal utility function (4) subject to the budget constraint eq. (10) yields the familiar first-order condition describing optimal intertemporal consumption allocation between two periods:

$$(11) \qquad C^{\sigma}_{t+1} = \beta(1+r_{t+1})C^{\sigma}_t.$$

The same Euler equation can be derived for Foreign households:

$$(11') \qquad C^{*\sigma}_{t+1} = \beta(1+r_{t+1})C^{*\sigma}_t.$$

B. Firms and Production

The production function of a representative Home firm is modeled as

$$(12) \qquad x(h)_t = A_t l(h)_t - F.$$

[3] Since Ricardian equivalence holds in this setup, we can, without loss of generality, assume that there is no government transfer.

Here $x(h)_t$ denotes the output of a representative Home firm, A_t is a measure of the Home productivity level, $l(h)_t$ is the labor employed by the firm, and F represents the fixed costs. The production function of a representative Foreign firm is similar with technology parameter A_t^* and fixed costs F^*. These fixed costs are introduced *à la* Blanchard and Kiyotaki (1987) and can be interpreted as being in terms of the firm's own output.

A representative Home firm maximizes the present value of profits

$$(13) \qquad V(h)_t = \sum_{s=t}^{\infty} R_{t,s}\pi(h)_s,$$

where $R_{t,s} \equiv \frac{1}{\Pi_{v=t+1}^{s}(1+r_v)}$. Profits in period t, $\pi(h)_t$, consist of the domestic and foreign market revenue minus production costs

$$(14) \qquad \pi(h)_t = p(h)_t\left[Lc(h)_t\right] + e_t p(h)_t^*\left[L^*c(h)_t^*\right] - w_t\frac{x(h)_t+F_t}{A_t},$$

where the exchange rate, e_t, is defined in units of Home currency needed to buy one unit of Foreign currency.

Maximizing firm value (eq. (13)) is equivalent to maximizing firm profits in each period. We assume there are a large number of firms and, therefore, changes in $p(h)_t$ have a negligible impact on C_t and P_t. Similarly changes in $p(h)_t^*$ have a negligible impact on P_t^* and C_t^*. We can then substitute in the Home and Foreign demand for Home products, eqs. (9) and (9′), and maximize firm profits (eq. (14)) to solve for the prices that a representative Home firm will charge in the Home and Foreign markets:

$$(15) \qquad p(h)_t = \frac{\theta}{\theta-1}\frac{w_t}{A_t}, \qquad p(h)_t^* = \frac{\theta}{\theta-1}\frac{w_t}{e_tA_t}.$$

A representative Home firm will thus charge the same price for its product in the Home and Foreign markets (when measured in the same currency):

$$(16) \qquad p(h)_t = e_t p(h)_t^*.$$

Thus the law of one price holds. Consumption based purchasing power parity (PPP) also holds:

$$(17) \qquad P_t = e_t P_t^*.$$

PPP holds here because preferences are identical across countries and there are no departures from the law of one price. Relative prices of the representative Home and Foreign goods need not remain constant.

We can then rewrite the profit of a representative Home firm (eq. (14)) as

$$\pi(h)_t = p(h)_t x(h)_t - w_t\frac{x(h)_t+F_t}{A_t}.$$

If profits are positive, new firms will enter until profits are driven to zero in equilibrium. This implies the equilibrium output level of a representative Home firm (and similarly the output of a representative Foreign firm) is constant as in the static model.

$$x(h)_t = F(\theta - 1), \qquad x(f)_t = F^*(\theta - 1). \tag{18}$$

Labor is assumed to be fully employed in each country, so:

$$n_t \frac{x(h)_t + F_t}{A_t} = L, \qquad n_t^* \frac{x(f)_t + F_t^*}{A_t^*} = L^*. \tag{19}$$

From eqs. (18) and (19), we obtain the number of firms in the Home and Foreign countries, which equals the number of product varieties:

$$n_t = \frac{A_t L}{F\theta}, \qquad n_t^* = \frac{A_t^* L^*}{F^*\theta}. \tag{20}$$

Defining y_t and y_t^* as the Home and Foreign countries' real GDP respectively, we get

$$y_t = n_t x_t = \frac{\theta-1}{\theta} A_t L, \qquad y_t^* = n_t^* x_t^* = \frac{\theta-1}{\theta} A_t^* L^*. \tag{21}$$

Under higher fixed costs, a firm needs to raise the production level to break even and thus will employ more workers. This, however, will reduce the number of workers available to the other firms and consequently reduce the number of firms in the economy. The two effects cancel out and fixed costs will have no impact on the economy's total output. If the labor force is assumed to be constant, technological progress is the engine of long-run economic growth. Productivity growth, by reducing the labor inputs needed by a representative firm to produce the same amount of output, will lead to an increase in the number of firms in the economy and thus the total output. The peculiar feature that growth is solely represented by the increase in number of firms with no effect on the production of individual firms is the result of our production (linear) and utility (CES) functions, which are chosen for their tractability.

C. Goods Market Clearing

The world demand for Home or Foreign produced goods must equal its supply:

$$\left[\frac{p(h)_t}{P_{H,t}}\right]^{-\theta} \left(\frac{P_{H,t}}{P_t}\right)^{-\rho} (LC_t + L^* C_t^*) = x_t = F(\theta - 1), \tag{22}$$

$$\left[\frac{p(f)_t}{P_{F,t}}\right]^{-\theta} \left(\frac{P_{F,t}}{P_t}\right)^{-\rho} (LC_t + L^* C_t^*) = x_t^* = F^*(\theta - 1), \tag{22'}$$

where we have applied the law of one price. Dividing eq. (22) by (22′) and applying eq. (8′), we obtain the relative prices of representative Home and Foreign goods:

$$(23) \qquad \frac{p(h)_t}{p(f)_t} = \left[\frac{F}{F^*}\left(\frac{\gamma}{1-\gamma}\frac{n_t^*}{n_t}\right)^{\frac{\theta-\rho}{1-\theta}}\right]^{-\frac{1}{\rho}} = \left(\frac{F}{F^*}\right)^{\frac{1-\rho}{\rho(\theta-1)}}\left(\frac{\gamma}{1-\gamma}\frac{y_t^*}{y_t}\right)^{\frac{\theta-\rho}{\rho(\theta-1)}}$$

Trade and the 45-degree Rule

Home country's demand for imports is simply the demand of foreign produced goods by all of Home's residents:

$$(24) \qquad IM_t = L\int_{n_t}^{n_t+n_t^*} c(z)_t dz = Ln_t^*\left[\frac{p(f)_t}{P_{F,t}}\right]^{-\theta}\left(\frac{P_{F,t}}{P_t}\right)^{-\rho} C_t = \frac{L}{F(\theta-1)} y_t^*\left[\frac{p(f)_t}{P_{F,t}}\right]^{-\theta}\left(\frac{P_{F,t}}{P_t}\right)^{-\rho} C_t.$$

Analogously, Home exports are:

$$(25) \qquad EX_t = L^*\int_0^{n_t} c^*(z)_t dz = L^* n_t\left[\frac{p(h)_t}{P_{H,t}}\right]^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_t^* = \frac{L^*}{F^*(\theta-1)} y_t\left[\frac{p(h)_t}{P_{H,t}}\right]^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_t^*,$$

where we again applied the law of one price. Taking logarithm of the above eqs. yields:

$$(26) \qquad \ln IM_t = \ln\left[\frac{L}{F(\theta-1)}\right] + \ln y_t^* - \theta\ln\left[\frac{p(f)_t}{P_{F,t}}\right] - \rho\ln\left(\frac{P_{F,t}}{P_t}\right) + \ln C_t,$$

$$(27) \qquad \ln EX_t = \ln\left[\frac{L^*}{F^*(\theta-1)}\right] + \ln y_t - \theta\ln\left[\frac{p(h)_t}{P_{H,t}}\right] - \rho\ln\left(\frac{P_{H,t}}{P_t}\right) + \ln C_t^*.$$

We then differentiate eqs. (26) and (27) with respect to time and take the difference. After applying eqs. (8′) and (23) we get

$$\widehat{EX}_t - \widehat{IM}_t = (\hat{y}_t - \widehat{C}_t) - (\hat{y}_t^* - \widehat{C}_t^*),$$

From the Home and Foreign consumption Euler equations (11) and (11′), consumption must grow at the same rate in both countries under the equalized international real interest rate, therefore

$$(28) \qquad \widehat{EX}_t - \widehat{IM}_t = \hat{y}_t - \hat{y}_t^*.$$

Eq. (28) indicates that fast-growing countries will have faster volume growth of exports than imports.

The derivation provides some insights into the pitfalls of estimating elasticities with a conventional trade model:

$$\ln IM_t = \alpha_m + \zeta_m \ln y_t + \varepsilon_m \ln\left[\frac{p(f)_t}{p(h)_t}\right] + u_m,$$

$$\ln EX_t = \alpha_x + \zeta_x \ln y_t^* + \varepsilon_x \ln\left[\frac{p(h)_t}{p(f)_t}\right] + u_x,$$

where ζ_m and ζ_x are income elasticities as defined before, and ε_m and ε_x (both negative) are price elasticities for imports and exports, respectively. u_m and u_x are error terms. If the true model is given by eq. (26) and (27), one would find an apparent income elasticity of import demand equal to, on average:

$$(29) \qquad \zeta_m = \frac{\widehat{IM}_t + \varepsilon_m\left[\widehat{p(h)}_t - \widehat{p(f)}_t\right]}{\widehat{y}_t}.$$

Similarly, the apparent income elasticity of export demand would be equal to:

$$(30) \qquad \zeta_x = \frac{\widehat{EX}_t - \varepsilon_x\left[\widehat{p(h)}_t - \widehat{p(f)}_t\right]}{\widehat{y_t^*}}.$$

Combining eqs. (23), (28), (29) and (30) we derive a relationship between the estimated income elasticities and the relative GDP growth rates:

$$(31) \qquad \frac{\zeta_x + 1 + (\varepsilon_x + \varepsilon_m)\frac{\theta-\rho}{\rho(\theta-1)}}{\zeta_m + 1 + (\varepsilon_x + \varepsilon_m)\frac{\theta-\rho}{\rho(\theta-1)}} = \frac{\widehat{y}_t}{\widehat{y_t^*}}.$$

Two choices of the parameter ρ have been popular in the literature.

Case 1: $\rho = \theta$.

From eq. (23), the relative prices of representative Home and Foreign products are constant and eq. (31) reduces to a 45-degree relationship slightly different from that of Krugman's static model:

$$(32) \qquad \frac{\zeta_x + 1}{\zeta_m + 1} = \frac{\widehat{y}_t}{\widehat{y_t^*}}.$$

From eqs. (11), (11′), (22), (22′), (24) and (25), the import and export quantity demanded for a single product is constant. Thus, the fast-growing country is able to expand its market by increasing the number of goods it produces faster than the other country. The result is to produce apparently favorable income elasticities.

Case 2: $\rho = 1$.

Eq. (31) reduces to a different 45-degree rule:

$$(33) \qquad \frac{\zeta_x + (1 + \varepsilon_x + \varepsilon_m)}{\zeta_m + (1 + \varepsilon_x + \varepsilon_m)} = \frac{\widehat{y}_t}{\widehat{y_t^*}}.$$

The import and export eqs. reduce to

$$(34) \qquad \ln IM_t = \varphi_m + \tfrac{1}{1-\theta}\ln n_t^* - \gamma \ln\left(\tfrac{P_{F,t}}{P_{H,t}}\right) + \ln C_t$$
$$= \varphi_m' + \tfrac{\gamma}{1-\theta}\ln n_t + \tfrac{1-\gamma}{1-\theta}\ln n_t^* - \gamma \ln\left[\tfrac{p(f)_t}{p(h)_t}\right] + \ln C_t,^{4} \text{ and}$$

[4] The international real interest rate will be constant if technology grows at constant rates in both countries. Given the transversality condition, real consumption (C_t) will grow at the same rate as real income ($\frac{w_t}{P_t}$). Thus, if $(1+r)^{\sigma-1}\beta^{\sigma} < 1$ (so that consumption grows at a net rate below r according to Euler

(35) $$\ln EX_t = \varphi_x + \tfrac{1}{1-\theta}\ln n_t - (1-\gamma)\ln\left(\tfrac{P_{H,t}}{P_{F,t}}\right) + \ln C_t^*$$
$$= \varphi_x' + \tfrac{1-\gamma}{1-\theta}\ln n_t^* + \tfrac{\gamma}{1-\theta}\ln n_t - (1-\gamma)\ln\left[\tfrac{p(h)_t}{p(f)_t}\right] + \ln C_t^*,$$

where $\varphi_m, \varphi_m', \varphi_x$, and φ_x' are all constants. From eqs. (34) and (35), the sum of the "true" price elasticities is $-\gamma+(\gamma-1) = -1$ (the Marshall-Lerner condition is just satisfied). Thus, eq. (33) reduces to the original Krugman 45-degree rule if we plug in the "correct" price elasticities.

From eq. (23), there will now be relative price movements, as relative prices are the inverse of relative output.[5] Nevertheless, the import and export quantity demanded for a single product remains constant. When one country is growing faster than the other, its good becomes relatively cheaper. The demand for a given product will rise due to the income effect. At the same time, however, there are more product varieties from the fast-growing country and the demand for a given product will decrease due to the substitution effect. The two effects end up canceling out, leaving the demand for a given good unchanged. As a result, the expansion of the market of fast-growing countries is via increased product varieties instead of the deterioration of the terms of trade.

Finally, the measure of the terms of trade merits some discussions. As in Krugman (1989), we use the relative prices of representative Home and Foreign goods $\frac{p(h)_t}{p(f)_t}$ as the measure of the terms of trade, reflecting the logic of our thought experiment. This is clearest in *case 1* where all goods, regardless of the location of production, enter the utility function symmetrically.[6] In *case 2*, a natural alternative definition of the terms of trade would be the ratio of the Home and Foreign subindexes: $\frac{P_t^H}{P_t^F}$. The two measures are different because the number of products in Home and Foreign, n_t and n_t^*, are changing and therefore the composition of the bundles is changing. Specifically, as the price index is defined as the minimum expenditure needed to buy one unit of utility, the two measures differ as the result of consumer's love for variety which is incorporated within the CES preferences. However, imports and exports are measured in terms of the sum of individual goods instead of in consumption bundles. The terms of trade should be measured as the relative prices of representative Home and Foreign goods since all goods produced in the same country are sold at the same price. More importantly, the actual price indexes used to estimate trade equations ignore new product varieties, a point made forcefully by Feenstra (1994). Our thought experiment is to see what will happen if data generated from our model are

equation) real consumption will be $C_t = \left[1-\beta^{\sigma}(1+r)^{\sigma-1}\right](1+r)B_t + \frac{w_t}{P_t}$, where $\frac{w_t}{P_t}$ turns out to be proportional to $y_t^{\frac{\gamma\theta}{\theta-1}} y_t^{*\frac{(1-\gamma)\theta}{\theta-1}}$.

[5] Together with eq. (28), this implies that the value of exports and imports will grow at the same rate. Furthermore, external debt will grow at the same rate as consumption and income, resulting in a constant debt-to-GDP ratio. The current account will always be balanced if the initial debt is zero and the international bond market becomes redundant. This is the standard result with Cobb-Douglas preferences (e.g., Corsetti and Pesenti, 2001).

[6] $P_t = \left[\int_0^{n+n_t^*} [p(z)_t]^{1-\theta} dz\right]^{\frac{1}{1-\theta}}$.

used to estimate conventional trade equations. $\frac{p(h)_t}{p(f)_t}$ is the proper measure of the terms of trade for this purpose. Nevertheless one would still get an apparent 45-degree relationship between relative growth rates and relative income elasticities even if $\frac{P_t^H}{P_t^F}$ is used as the measure of the terms of trade.[7] This could potentially explain why Feenstra's (1994) effort of incorporating new product varieties into the existing price indexes was only partially successful.

IV. EMPIRICAL TESTS

A. Econometric Implications of the Model

In this section, we examine the relationship between income growth rates and estimated income (price) elasticities and test the "45-degree rules" derived in eqs. (32), (33), along with Krugman's original rule, eq. (3).

The spirit of the question whether the income elasticities are "structural" suggests that differences in elasticities should be associated with different GDP growth rates over time for a given country as well as across countries. In addition to analyzing the data for the whole time period, we further identify the years of structural change for relative growth rates and break the data into sub-periods to estimate elasticities for each sub-period. This allows us to estimate the 45-degree rules for the pooled sample of panel data. This also addresses the parameter stability issue discussed in the literature review.

B. Methodology, Data, and Specification

Earlier empirical estimates have often been done by simple OLS. This includes both Houthakker and Magee (1969) and Krugman (1989). Much of the more recent work, however, has used some form of cointegration technique. In this study, we estimate import and export equations using both OLS and cointegration analysis. For the latter, we apply the dynamic OLS (DOLS) procedure developed by Stock and Watson (1993). The dynamic OLS estimation simply adds leads and lags of differenced explanatory variables to a static cointegration regression so as to eliminate small-sample bias resulting from correlation between the error term and the explanatory variables.[8] The error terms in the dynamic OLS procedure are, however, serially correlated. The standard errors are therefore estimated using the Newey and West (1987) adjustment with a lag length of up to 2.

For the OLS regressions, we conduct the Durbin-Watson test for first-order autocorrelation (all tests in the paper are conducted at 5% level) and the Yule-Walker estimates are used when autocorrelation is detected.

[7] $\frac{\zeta_x+1+\frac{\theta}{\theta-1}(\varepsilon_x+\varepsilon_m)}{\zeta_m+1+\frac{\theta}{\theta-1}(\varepsilon_x+\varepsilon_m)} = \frac{\widehat{y_t}}{\widehat{y_t^*}}$. From eqs. (34) and (35), the sum of the "true" price elasticities is still -1.

[8] Monte Carlo experiments (Stock and Watson, 1993) show that the dynamic OLS estimator performs well relative to the other asymptotically efficient estimators including the fully modified estimator of Phillips and Hansen (1990).

We use annual data of total merchandise trade from 1960 to 1998 to estimate standard export and import equations. In order to make the estimations for different countries more comparable, we only keep countries with at least 28 observations. This results in a sample of 35 countries. Most of the data are from the International Monetary Fund (IMF)'s *International Financial Statistics*, except the GDP data, which are from the World Bank's *World Development Indicators* and the bilateral trade data used in calculating the weights, which are from the IMF's *Direction of Trade Statistics.*

Import demand is a function of income and relative prices:

$$\ln IM_{it} = \beta_0 + \beta_1 \ln y_{it} + \beta_2 \ln RMP_{it} + u_{it}. \tag{36}$$

Here IM_{it} is the i^{th}country's real imports of merchandise goods during year t. It is calculated by using the value of total imports deflated by the index of unit value of imports (both measured in U.S. dollars). y_{it} is an index of country i's real GDP in local currency. RMP_{it} is the relative price of imports, which is calculated as the ratio of the index of unit value of imports (adjusted by exchange rate) to the GDP deflator. u_{it} is an error term.

Similarly we estimate the export equation as:

$$\ln EX_{it} = \gamma_0 + \gamma_1 \ln y^*_{it} + \gamma_2 \ln RXP_{it} + v_{it}. \tag{37}$$

Here EX_{it} is the i^{th}country's real exports of merchandise goods during year t, which is calculated by using the value of total exports deflated by the unit value of exports (both in U.S. dollars). Log foreign GDP ($\ln y^*_{it}$) is the weighted sum of an index of log GDP for the top 15 export market countries for country i, with weights equal to each country's 1980 share of total exports by country i to the 15 countries.[9]

$$\ln y^*_{it} = \sum_j a_{ij} \ln y_{jt}, \qquad \sum_j a_{ij} = 1, \qquad j = 1, ..., 15.$$

The relative price of exports is calculated as PX_{it}/PXW_{it}, where PX_{it} is an index of country i's unit value of exports in year t, and PXW_{it} is a weighted index of the export prices of 10 of its major competitors in each market:

$$PXW_{it} = \sum_j a_{ij} \sum_k \theta_{kj} PX_{kt}, \qquad \sum_k \theta_{kj} = 1, \qquad i = 1, ..., 15; \; k = 1, ..., 10.$$

PXW_{it} is obtained by a two-stage procedure: first a price index is constructed for each of the top 15 export markets of country i using the export prices of 10 other top exporters

[9]The top 15 markets usually account for a large share of the total exports of a country (more than 70% for the United States and Japan). The shares used are fixed and do not fully reflect the changes in the country composition of world trade. Experimentation with shares from alternative years, however, doesn't change the results.

to that market weighted by their share of exports in 1980, θ_{kj}.[10] The resulting 15 price indexes are then combined with the same weights used to calculate the foreign GDP for country i, a_{ij}. Thus, each exporter has a foreign income index which is a weighted average of the income index of 15 of its major markets and a price index comparing the exporter's price with the weighted average of the export prices of its 10 competitors in each of the 15 markets.

Next, the domestic and foreign trend growth rates are estimated by regressing

$$\ln y_{it} = \delta_0 + \delta_1 Trend + \eta_{it}, \qquad \text{and}$$
$$\ln y^*_{it} = \delta^*_0 + \delta^*_1 Trend + \eta^*_{it} \tag{38}$$

for each country over 1960-98, where δ_1 and δ^*_1 measure the domestic and foreign trend growth rates, respectively.

C. Testing the Krugman 45-Degree Rule

Testing for the Full Sample

We start by testing Krugman's original 45-degree rule. To conduct cointegration analysis, we first carry out the augmented Dickey-Fuller (ADF) unit-root tests for each of the variables in conventional trade equations (37) and (38). All regressions are estimated with one lag and a time trend is included in all regressions except for relative prices. The null hypothesis of a unit root cannot be rejected at the 5 percent level in all but the following cases: Korea and Nicaragua for imports; New Zealand and Philippines for exports; the United Kindom for real domestic GDP; Iceland, India, Morocco, Pakistan, and Philippines for relative import prices; and Denmark, Ireland, New Zealand, and Sweden for relative export prices. The evidence seems to suggest that all of the variables are nonstationary.[11] Next, we use the Johansen (1991, 1995) procedure to test for the existence of cointegration. The test is conducted using the trace statistics for a VAR of lag length 4, assuming a linear trend in the data, and an intercept but no trend in the cointegrating equation. For the import equation, we fail to reject the null hypothesis of no cointegration for 4 countries: Australia, Iceland, New Zealand and Syria. For the export equation, the null is not rejected for Greece.[12]

The estimated trend growth rates and the dynamic OLS estimates of income and price elasticities, with one lag and one lead of the first difference of the right-hand-side variables are reported in table 1. The OLS estimates (not reported) are broadly similar. For the OLS regressions, as a robustness check, we also estimated the trade equations including

[10] The top 10 exporters usually count for the majority of a country's imports (about 60% for the United States).

[11] Results are broadly similar at different lag length. The finding of a unit root in the relative price series for most countries is probably due to the low power of the ADF test.

[12] The results, however, are not indifferent to different lag lengths. For example, we would fail to reject the null hypothesis of no cointegration for more countries if we instead use 2 lags.

a lagged relative price variable in order to capture the possible lags in response to price movements. We then calculate long run price elasticities as the sum of the coefficients on the current and the lagged relative prices. The results (not reported) are also broadly similar.

Figures 1a and 1b plot the growth ratio versus the OLS and DOLS estimates of the income elasticity ratio. The straight line is the 45-degree line which goes through the origin and has a slope of one. The 45-degree line fits the data pretty well in both graphs.

Next, we regress relative income elasticities on relative growth rates. An intercept is included in the regression.[13] The OLS standard errors, however, do not take into account the fact that relative growth rates are constructed using coefficients from prior regressions, which are also estimated with errors (although these are always very small). Therefore, we also employ bootstrap techniques (Efron and Tibshirani, 1993) to obtain the standard errors.

Overall, the regression results, reported in columns (1) and (2) of table 2, seem to support Krugman's 45-degree rule. The slope coefficients are 1.313 and 1.03 using income elasticities from OLS and dynamic OLS regressions, respectively. The corresponding bootstrapped standard errors are 0.209 and 0.193. In both cases, the slope is significantly different from zero at the 1% level and not significantly different from one. In addition, in neither case can we reject the null hypothesis of a zero intercept. However, one can reject the joint hypothesis of a zero intercept and a unit slope in both cases. We also conduct the test using a log-linear specification and report the results in columns (3) and (4) of table 2. The slope coefficients are now 1.006 and 0.732 using OLS and DOLS elasticities, respectively, with corresponding standard errors of 0.132 and 0.164. Both coefficients are significantly different from zero and not significantly different from one. The joint hypothesis of a zero intercept and a unit slope can again be rejected at the 5% level in both cases although only marginally for the former. Finally, the regressions fit the data reasonably well with R^2 equaling 0.66 and 0.35 for the two linear regressions.

We further divide our sample into a group of 20 OECD countries and the remaining 15 economies and test the 45-degree rule separately for each group. The results for the linear specification are reported in table 3. The regression slope is always highly significant and the single hypothesis of a zero intercept or a unit slope is not rejected at the 5% level in all regressions. The joint hypothesis of a zero intercept and a unit slope is rejected for the OECD sample but not for the non-OECD sample. Nevertheless, the overall evidence does not suggest that there are overwhelming differences between the two groups.

Evidence from the Pooled Sub-samples

We use the CUSUM of square test developed by Brown, Durbin, and Evans (1975) to test for the structural breaks.[14] After finding the first break we perform the test again for the years thereafter. As a result, we could have at most 2 breaks (thus 3 sub-periods) for

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[13] Although no intercept is predicted in the 45-degree rule, the relationship is a reduced form instead of a structural one. Therefore, it is more proper to include an intercept.

[14] The CUSUM of square test is based on recursive residuals and has the advantage (e.g., over Chow's

each country, as well as possibly no breaks at all. More explicitly, we estimate the following equation for each country i:

$$(39) \qquad \ln y_{it} - \ln y_{it}^* = \phi_0 + \phi_1 Trend + \epsilon_{it},$$

where ϵ_{it} is an error term. The slope coefficient ϕ_1 measures the trend of relative growth rates. We need to find the years for which there has been a structural change of ϕ_1. The identified structural break years are reported in the second column of table 4 and seem plausible. For example, the first structural break for the United States is 1973, at the time of the first oil crisis. The second break is 1992, before the apparent increase in U.S. productivity growth.

After identifying the structural breaks in the relative growth rates, we estimate the conventional trade equation for each sub-period (provided there are at least 6 observations). We only use OLS as the samples are now shorter while the degrees of freedom drop very quickly with dynamic OLS. The estimated income elasticities, together with growth rates for each sub-period, are reported in table 4. There seems to be a positive relationship between the relative growth rates and the relative income elasticities across different periods for a given country. For example, the ratio of the domestic growth rate to the foreign growth rate was 0.66, 0.85, and 1.65 for the United States for the periods of 1960-72, 1973-91, and 1992-98, while the ratio of relative income elasticities was 0.43, 0.68, and 1.39, respectively. Figure 2 plots the relationship for the pooled sub-samples. Apart from two "outlier" observations, the 45-degree line again fits the data well. The pooled regression results are reported in table 5. The slope coefficient is 1.710 with standard error 0.284 for the linear specification. However, as figure 2 shows, this is heavily influenced by the estimated negative income elasticities of Nicaragua (export demand, 1973-98) and India (import demand, 1960-71). When the negative income elasticities are dropped, the slope coefficient becomes 1.318 which is significantly different from zero but not significantly different from one at the 5% level (p-value is 0.07). Nevertheless, we could still reject the joint null hypothesis of a zero intercept and a unit slope. Column (3) of table 5 reports the log-linear regression. The slope coefficient is 1.009 with standard error 0.146 and we cannot reject the joint hypothesis of a zero intercept and a unit slope.

Since we have a panel data set, we can also estimate a random-effects specification, which is reported in the last 2 columns of table 4.[15] The coefficients are very similar to those of the OLS regressions. Indeed, the Breusch and Pagan test indicates that the OLS estimates are efficient.[16]

Testing the Alternative 45-degree Rules

test) that it allows the data to detect the break point without the need of any prior specification of when a structural change might have taken place. The test has been widely used to test model stability in the estimation of trade equations (Stern *et al.*, 1979; Haynes and Stone, 1983).

[15] Countries with regressions for only one period will be dropped in fixed-effects (with-in group) estimation, so we stick to a random-effects model.

[16] We have also tried to break the data into 3 sub-periods with the same length of years for each country (1960-72, 1973-85, and 1986-98). The 45-degree rule still holds for these sub-samples.

In summary, the evidence in the last section provides overall support to Krugman's 45-degree rule. We find a strong relationship between relative income elasticities and relative growth rates. This relationship is robust to various samples and estimation techniques.

In this section, we test the two other 45-degree rules derived earlier, eqs. (33) and (32), which we will call alternative 45-degree rule I and II, respectively. Figures 3a and 3b plot eq. (33) using OLS and DOLS elasticity estimates which also seems to fit the data except for a few "outliers." The regression results are reported in table 6. The statistical evidence here is more mixed but the overall evidence seems to support the alternative 45-degree rule I, especially if a few "outliers" are excluded. For example, if Hong Kong SAR, which has a left-hand-side variable that is more than ten standard deviations above the mean of the rest of the economies, is excluded the slope of the linear regression for the whole sample is 1.330 which is significantly different from zero but not from one. The null hypothesis of a zero intercept is also not rejected, although one can marginally reject the joint hypothesis of a zero intercept and a unit slope at the 5% level. For the pooled sub-samples, the slope of the linear regression is 1.342 (highly significant) if two observations of extreme value are excluded, and we do not reject the joint hypothesis that the relationship is a 45-degree line going through the origin.

The alternative 45-degree rule of eq. (33) reduces to the Krugman 45-degree rule if the sum of export and import price elasticities is minus one. Figure 4 plots the histogram of the sum of import and export price elasticities from the dynamic OLS regressions for the whole sample. The mean and median is -1.07 and -0.99, respectively.

Finally, we test alternative 45-degree rule II of eq. (32). The results for the linear specification are reported in table 7. The evidence suggests the existence a strong linear relationship but the slope seems to be less than one.[17]

IV. CONCLUDING REMARKS

If the income elasticities obtained from a conventional trade model are structural, the Houthakker-Magee effect implies that a country facing unfavorable income elasticities must either grow at a slower rate than its trading partners or experience a trend worsening of its current account. Using an intertemporal current account model we were able to show that the conventional income elasticities are in fact not structural. In particular, the model predicts a spurious relationship between relative income elasticities and relative growth rates. This is because fast-growing countries are able to occupy a larger share of the world market by expanding the range of goods they produce at a faster rate then the rest of the world. As a result, they appear to face high income elasticities of demand for their exports, while having low income elasticities of import demand. The specific form of such a relationship depends on the elasticity of substitution between home and foreign goods.

[17] Note if $\frac{\zeta_x}{\zeta_m} = \frac{\widehat{y_t}}{\widehat{y_t^*}}$ is correct, then $\frac{\zeta_x+1}{\zeta_m+1}$ will be smaller than $\frac{\zeta_x}{\zeta_m}$ for $\widehat{y_t} > \widehat{y_t^*}$ and larger than $\frac{\zeta_x}{\zeta_m}$ for $\widehat{y_t} < \widehat{y_t^*}$. Thus regressing $\frac{\zeta_x+1}{\zeta_m+1}$ on $\frac{\widehat{y_t}}{\widehat{y_t^*}}$ will yield a regression slope less than one.

We then test the various 45-degree rules implied by the model. The empirical evidence strongly supports the existence of a systematic association between the two. This suggests that it will be misleading to treat the conventional income elasticities as structural and rely on them to conduct forecasts of current account movements.

The finding that the 45-degree rule holds almost as well for developing countries as for developed countries is a little bit surprising because intraindustry trade models suggest stronger support from the latter group. This "puzzle" has been observed before. For example, Hummels and Levinsohn (1995) find data from developing countries also support the prediction of a model of international trade generated by product differentiation (Helpman, 1987). Further investigation of the puzzle seems warranted.

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Table 1: Income and Price Elasticities (DOLS) and Growth Rates, Whole Sample (1960-98)

Country	Income elasticities of imports	Income elasticities of exports	Price elasticities of imports	Price elasticities of exports	Domestic growth rates	Foreign growth rates	Number of obs.
Australia	1.10 (0.08)	1.19 (0.15)	-0.30 (0.25)	-0.32 (0.40)	3.53	4.38	39
Belgium	1.96 (0.05)	2.06 (0.06)	-0.12 (0.05)	0.19 (0.17)	2.82	2.88	38
Brazil	1.13 (0.09)	1.89 (0.10)	-0.50 (0.37)	-0.87 (0.14)	4.90	2.99	34
Canada	1.61 (0.07)	2.09 (0.06)	-1.00 (0.09)	0.31 (0.22)	3.44	3.02	39
Colombia	1.14 (0.11)	1.71 (0.16)	-1.02 (0.13)	-1.04 (0.10)	3.97	2.52	29
Denmark	1.22 (0.05)	1.87 (0.08)	-0.41 (0.05)	-0.47 (0.33)	2.49	2.79	39
Finland	1.25 (0.04)	1.99 (0.16)	-0.14 (0.11)	-0.62 (0.29)	3.09	2.68	38
France	2.03 (0.05)	2.03 (0.04)	-0.10 (0.05)	-0.22 (0.29)	3.01	2.96	39
Germany	1.97 (0.09)	2.08 (0.06)	0.04 (0.14)	-0.33 (0.15)	2.88	2.86	39
Greece	1.39 (0.08)	2.43 (0.19)	-0.60 (0.07)	0.03 (0.33)	3.60	3.29	38
Hong Kong SAR	1.15 (0.06)	3.16 (0.21)	-1.49 (0.13)	-2.05 (0.63)	7.09	3.53	31
Iceland	0.95 (0.06)	1.52 (0.31)	-0.59 (0.23)	-0.73 (0.59)	4.02	2.86	38
India	1.25 (0.12)	1.06 (0.36)	-0.36 (0.30)	-2.26 (1.51)	4.34	3.63	39
Ireland	1.42 (0.06)	3.66 (0.15)	-0.06 (0.21)	-4.24 (1.26)	4.30	2.58	39
Israel	0.86 (0.06)	2.31 (0.11)	-0.62 (0.05)	-0.60 (0.33)	4.52	2.82	31
Italy	1.56 (0.04)	2.24 (0.06)	-0.31 (0.04)	-0.99 (0.23)	3.10	2.97	39
Japan	1.06 (0.04)	1.94 (0.05)	-0.34 (0.05)	-2.09 (0.15)	4.88	4.47	39
Kenya	1.33 (0.28)	0.78 (0.15)	-0.72 (0.16)	-0.27 (0.23)	4.79	3.33	35
Korea, Rep. of	1.68 (0.18)	3.77 (0.26)	0.44 (0.33)	-2.20 (0.96)	7.91	3.84	36
Mauritius	1.15 (0.04)	2.00 (0.23)	-1.10 (0.23)	0.10 (0.32)	4.73	2.40	38
Morocco	1.35 (0.09)	1.03 (0.17)	-0.77 (0.38)	-1.32 (0.27)	4.26	3.14	35
Netherlands	1.16 (0.18)	1.72 (0.14)	-0.16 (0.23)	1.50 (0.60)	2.97	2.91	37
New Zealand	1.56 (0.08)	1.20 (0.07)	-0.53 (0.08)	0.03 (0.18)	2.17	3.72	39
Nicaragua	1.21 (0.16)	1.49 (0.98)	0.07 (0.26)	2.92 (3.09)	2.01	3.44	29
Norway	0.67 (0.32)	2.62 (0.08)	-0.90 (0.57)	-0.28 (0.09)	3.62	2.51	39
Pakistan	0.95 (0.06)	1.26 (0.09)	-0.51 (0.20)	-1.61 (0.21)	5.58	4.15	29
Philippines	1.54 (0.14)	0.81 (0.13)	-0.90 (0.18)	-1.08 (0.17)	4.09	4.49	32
Spain	1.57 (0.13)	3.18 (0.12)	-0.95 (0.09)	-0.92 (0.17)	3.50	3.06	39
Sri Lanka	1.09 (0.19)	1.27 (0.06)	-0.47 (0.12)	1.16 (0.15)	4.46	3.99	38
Sweden	1.62 (0.07)	1.58 (0.08)	-0.35 (0.08)	-0.48 (0.27)	2.20	3.00	39
Switzerland	0.93 (0.16)	1.47 (0.06)	-1.47 (0.15)	0.25 (0.15)	2.17	3.59	28
Syria	0.91 (0.05)	2.11 (0.43)	-0.20 (0.11)	-0.79 (0.10)	5.32	2.79	30
Thailand	1.29 (0.06)	2.50 (0.38)	-0.85 (0.19)	0.53 (1.02)	7.19	4.57	39
United Kingdom	1.78 (0.03)	1.45 (0.06)	-0.23 (0.04)	0.28 (0.13)	2.21	3.04	39
United States	2.21 (0.04)	1.56 (0.17)	-0.15 (0.08)	-1.40 (0.34)	2.76	3.70	39

Notes: Trade equations are estimated by dynamic OLS. Newey-West standard errors with up to 2 lags are reported in parentheses.

Table 2: The Krugman 45-Degree Rule, Whole Sample (1960-98)

Dependent variable: ζ_x/ζ_m (linear or log-linear)

	(1)	(2)	(3)	(4)
Elasticities estimated by	OLS	DOLS	OLS	DOLS
Specification	Linear	Linear	Log-linear	Log-linear
Domestic growth rate/	1.313**	1.030**	1.006**	0.732**
Foreign growth rate	(0.209)	(0.188)	(0.131)	(0.169)
(linear or log-linear)	[0.209]	[0.193]	[0.132]	[0.164]
Constant	-0.178	0.271	0.114*	0.219**
	(0.216)	(0.207)	(0.045)	(0.068)
	[0.218]	[0.210]	[0.045]	[0.065]
R^2	0.66	0.35	0.63	0.31
No. of countries	35	35	35	35
p-value for H_0: slope = 1	*0.14*	*0.88*	*0.96*	*0.11*
p-value for H_0: slope = 1 and intercept = 0	*0.01*	*0.01*	*0.05*	*0.01*

Notes:

1. ζ_x and ζ_m are income elasticities of demand for exports and imports, respectively.
2. Robust OLS standard errors are reported in parentheses. Bootstrapped standard errors are reported in square parentheses (500 replications). Significance levels are based on bootstrapped standard errors. ** and * indicates significance at the 1% and 5% levels, respectively, for the null hypothesis of zero coefficient.

Table 3: The Krugman 45-Degree Rule, Whole Sample (1960-98) by Income Group

Dependent variable: ζ_x/ζ_m (linear)

	(1)	(2)	(3)	(4)
Sample	OECD	OECD	Non-OECD	Non-OECD
Elasticities estimated by	OLS	DOLS	OLS	DOLS
Domestic growth rate/	1.334**	1.900**	1.714**	1.220**
Foreign growth rate	(0.184)	(0.583)	-0.354	(0.362)
	[0.195]	[0.642]	[0.390]	[0.382]
Constant	-0.090	-0.425	-0.918	-0.260
	(0.180)	(0.541)	-0.48	(0.584)
	[0.190]	[0.596]	[0.551]	[0.607]
R^2	0.81	0.53	0.67	0.50
No. of countries	20	20	15	15
p-value for H_0: slope = 1	*0.10*	*0.18*	*0.06*	*0.57*
p-value for H_0: slope = 1 and intercept = 0	*0.00*	*0.00*	*0.17*	*0.68*

See footnotes to table 2.

Table 4: Income and Price Elasticities (OLS) and Relative Growth Rates
Subsamples

Country	Sample year	Income elasticities of exports	Income elasticities of imports	Relative income elasticities	Domestic growth rates	Foreign growth rates	Relative growth rates
Australia	60-73	1.11	1.20	0.92	5.32	6.55	0.81
Australia	74-87	0.59	1.06	0.55	2.99	3.68	0.81
Australia	88-98	1.90	1.75	1.09	3.19	3.26	0.98
Belgium	60-72	2.15	1.90	1.13	4.63	4.59	1.01
Belgium	73-98	1.96	1.80	1.09	1.93	2.25	0.86
Brazil	60-81	2.27	1.43	1.59	7.83	3.88	2.02
Brazil	82-98	1.51	1.33	1.14	2.52	2.83	0.89
Canada	60-71	1.89	1.29	1.47	5.14	4.49	1.14
Canada	72-85	1.96	1.34	1.46	3.05	2.44	1.25
Canada	86-98	2.04	2.94	0.69	1.87	2.68	0.70
Colombia	60-98	2.19	1.24	1.77	3.97	2.52	1.57
Denmark	60-79	1.58	1.70	0.93	3.40	3.76	0.90
Denmark	80-98	2.18	1.82	1.20	2.18	2.35	0.93
Finland	60-76	1.68	1.56	1.08	4.43	3.84	1.15
Finland	77-86	2.09	1.10	1.91	3.39	1.93	1.76
Finland	87-98	2.54	1.98	1.28	0.74	1.97	0.37
France	60-72	1.91	2.00	0.95	5.26	4.61	1.14
France	73-89	1.83	1.87	0.98	2.25	2.24	1.00
France	90-98	2.65	2.65	1.00	1.50	1.81	0.83
Germany	60-72	1.99	2.12	0.94	4.17	4.79	0.87
Germany	73-82	1.75	2.14	0.82	2.08	2.21	0.94
Germany	83-98	2.32	1.67	1.39	3.24	2.18	1.49
Greece	60-72	1.99	1.25	1.59	7.26	4.97	1.46
Greece	73-98	1.25	1.41	0.89	2.05	2.55	0.80
Hong Kong SAR	60-77	1.73	0.84	2.07	8.25	3.96	2.08
Hong Kong SAR	78-92	3.84	1.40	2.73	6.69	3.46	1.93
Hong Kong SAR	93-98	1.47	2.17	0.67	3.17	3.83	0.83
Iceland	60-84	1.27	1.02	1.24	5.03	3.31	1.52
Iceland	85-98	0.58	0.89	0.65	1.59	2.45	0.65
India	60-71	0.64	-0.26	-2.43	3.73	5.66	0.66
India	72-98	1.87	1.50	1.25	4.99	2.94	1.70
Ireland	60-72	2.13	1.84	1.16	4.13	3.78	1.09
Ireland	73-82	4.49	1.41	3.18	4.40	1.74	2.54
Ireland	83-98	4.44	1.30	3.40	5.67	2.35	2.41
Israel	60-98	2.23	0.95	2.35	4.52	2.82	1.61
Italy	60-81	2.18	1.67	1.31	4.33	4.03	1.07
Italy	82-98	2.27	2.80	0.81	1.91	2.47	0.78
Japan	60-71	2.85	1.61	1.77	9.64	5.44	1.77
Japan	72-83	1.70	0.74	2.29	3.66	4.01	0.91
Japan	84-98	0.71	1.90	0.37	2.86	4.20	0.68

Table 4: Income and Price Elasticities (OLS) and Relative Growth Rates
Subsamples (Concluded)

Country	Sample year	Income elasticities of exports	Income elasticities of imports	Relative income elasticities	Domestic growth rates	Foreign growth rates	Relative growth rates
Kenya	60-81	0.66	1.28	0.52	6.75	4.05	1.67
Kenya	82-98	1.51	1.38	1.09	3.29	3.01	1.09
Korea, Rep. of	60-98	4.42	1.35	3.27	7.91	3.84	2.06
Mauritius	60-98	1.75	1.15	1.51	4.73	2.40	1.97
Morocco	60-98	1.16	1.27	0.91	4.26	3.14	1.36
Netherlands	60-98	1.84	1.38	1.33	2.97	2.91	1.02
New Zealand	60-98	1.06	1.47	0.72	2.17	3.72	0.58
Nicaragua	60-72	2.24	1.34	1.66	5.95	4.83	1.23
Nicaragua	73-98	-2.45	0.52	-4.76	-1.80	2.28	-0.79
Norway	60-72	2.33	1.13	2.07	4.13	3.70	1.12
Norway	73-84	2.89	0.57	5.09	3.75	1.60	2.34
Norway	85-98	3.35	2.44	1.37	2.91	2.20	1.33
Pakistan	60-77	1.19	1.73	0.69	3.81	4.38	0.87
Pakistan	78-91	1.44	0.60	2.39	6.25	4.10	1.52
Pakistan	92-98	1.61	0.99	1.62	3.57	3.61	0.99
Philippines	60-71	0.65	1.31	0.49	4.80	6.43	0.75
Philippines	72-81	2.04	1.04	1.97	5.65	3.74	1.51
Philippines	82-98	1.34	3.20	0.42	1.50	4.05	0.37
Spain	60-75	2.52	1.92	1.31	6.38	4.66	1.37
Spain	76-98	3.55	2.80	1.27	2.44	2.26	1.08
Sri Lanka	60-76	-0.18	-0.38	0.48	4.17	4.85	0.86
Sri Lanka	77-98	1.59	1.18	1.34	4.44	3.60	1.24
Sweden	60-98	1.64	1.56	1.05	2.20	3.00	0.73
Switzerland	60-73	1.79	2.07	0.86	4.15	4.98	0.84
Switzerland	74-98	1.50	2.45	0.61	1.32	2.30	0.57
Syria	60-98	2.38	0.76	3.15	5.32	2.79	1.90
Thailand	60-72	0.83	0.80	1.04	7.74	6.43	1.20
Thailand	73-82	2.29	1.13	2.02	6.94	4.04	1.72
Thailand	83-98	3.62	1.52	2.38	7.80	3.95	1.98
United Kingdom	60-71	1.01	1.88	0.54	2.85	4.69	0.61
United Kingdom	72-98	1.69	1.91	0.88	2.05	2.44	0.84
United States	60-72	0.98	2.26	0.43	3.88	5.86	0.66
United States	73-91	1.34	1.97	0.68	2.46	2.91	0.85
United States	92-98	3.23	2.33	1.39	3.73	2.26	1.65

Table 5: The Krugman 45-Degree Rule, Pooled Subsamples (1960–98)

Dependent variable: ζ_x/ζ_m (linear or log-linear)

Methodology in testing specification sample	(1) OLS Linear	(2) OLS Linear Drop neg. elasticities	(3) OLS Log-linear	(4) Random effects Linear Drop neg. elasticities	(5) Random effects Long-linear
Domestic growth rate/	1.710**	1.318**	1.009**	1.307**	1.009**
Foreign growth rate	(0.290)	(0.183)	(0.137)	(0.122)	(0.099)
(linear or log-linear)	[0.284]	[0.175]	[0.146]	[0.202]	[0.147]
Constant	-0.761*	-0.204	0.067	-0.192	0.067
	(0.374)	(0.192)	(0.046)	(0.161)	(0.043)
	[0.364]	[0.181]	[0.045]	[0.230]	[0.045]
R^2	0.64	0.63	0.60	0.63	0.60
No. of obs.	74	71	72	71	72
No. of countries	35	35	35	35	35
p-value for H_0: slope = 1	*0.01*	*0.07*	*0.95*	*0.13*	*0.95*
p-value for H_0: slope = 1 and intercept = 0	*0.01*	*0.01*	*0.26*	*0.00*	*0.26*
p-value for Breusch and Pagan test				*0.86*	*0.69*

Notes:

1. See footnotes to table 2.
2. Income elasticities are estimated by OLS.
3. Estimated negative income elasticities include Nicaragua (1973-1998) and Sri Lanka (1960-1976) for export demand and India (1960-1971) and Sri Lanka (1960-76) for import demand.
4. Breusch and Pagan Lagrangian multiplier test for random effects: y(i,t)=Xb+u(i)+e(i,t); H_0:Var(u)=0.

Table 6: The Alternative 45-Degree Rule I

Dependent variable: $(1+\zeta_x+\varepsilon_x+\varepsilon_m)/(1+\zeta_m+\varepsilon_x+\varepsilon_m)$, linear or log-linear

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Elasticities estimated by	OLS	OLS	DOLS	DOLS	OLS	DOLS	OLS	OLS
Specification	Linear	Linear	Linear	Linear	Log-linear	Log-linear	Linear	Log-Linear
Sample	1960-98	1960-98, drop Hong Kong	1960-98	1960-98, drop Switzerland	1960-98	1960-98	Pooled subsamples	Pooled subsamples
Domestic growth rate/	2.200**	1.330**	0.138	0.657	1.192**	0.038	1.342**	0.954**
Foreign growth rate	(0.836)	(0.264)	(0.628)	(0.409)	(0.254)	(0.416)	(0.314)	(0.178)
(linear or log-linear)	[0.807]	[0.257]	[0.571]	[0.397]	[0.252]	[0.386]	[0.350]	[0.178]
Constant	-1.042	-0.166	1.381	0.607	0.108	0.214	-0.136	0.122
	(0.850)	(0.267)	(0.848)	(0.465)	(0.091)	(0.137)	(0.368)	(0.068)
	[0.814]	[0.264]	[0.778]	[0.460]	[0.088]	[0.131]	[0.395]	[0.071]
R^2	0.39	0.51	0.00	0.08	0.41	0.00	0.23	0.39
No. of countries	35	34	35	34	35	34	72	68
p-value for H_0: slope = 1	*0.15*	*0.21*	*0.14*	*0.39*	*0.45*	*0.02*	*0.28*	*0.80*
p-value for H_0: slope = 1 and intercept = 0	*0.08*	*0.05*	*0.08*	*0.37*	*0.26*	*0.04*	*0.14*	*0.17*

Notes: 1. See footnotes to table 2.
2. ζ_x and ζ_m are income elasticities of demand for exports and imports, respectively; ε_x and ε_m are price elasticities of demand for exports and imports, respectively.
3. The left-hand-side (LHS) value for Hong Kong in column (1) is more than ten standard deviations above the mean. The LHS value for Switzerland in column (3) is more than three standard deviations above the mean.
4. For the pooled subsamples, the LHS variable for Hong Kong (1978-92) and Pakistan (1978-91) is more than thirty standard deviations below the mean and are not included in the regressions.

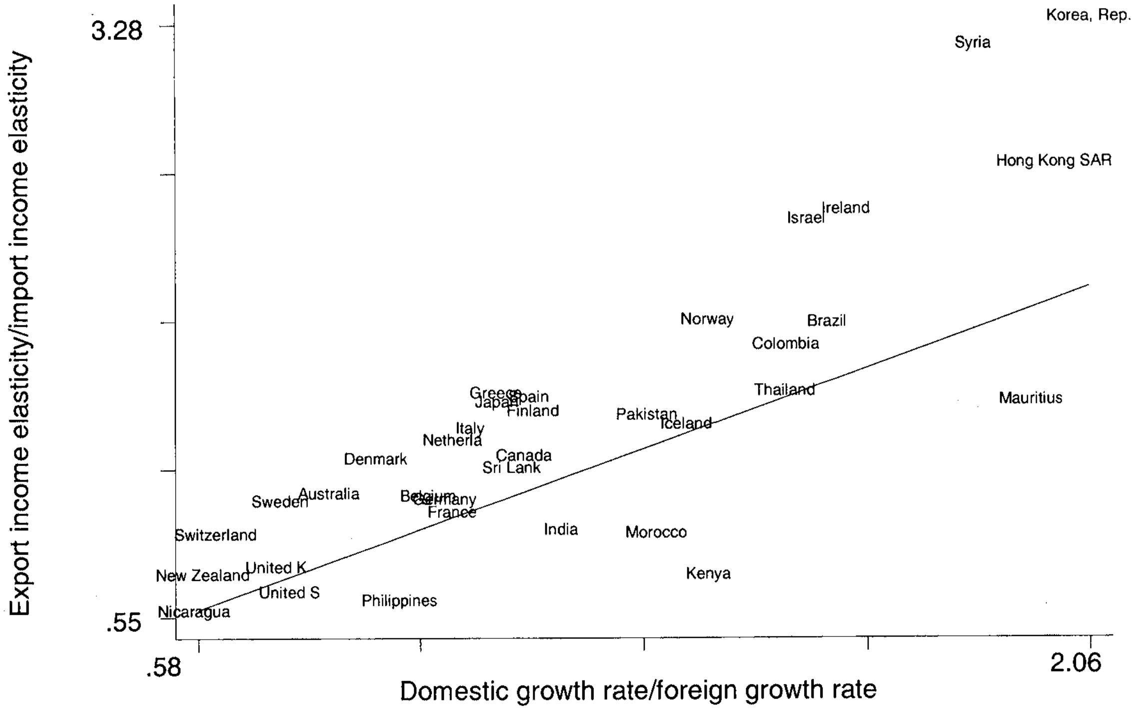
Table 7: The Alternative 45-Degree Rule II

Dependent variable: $(1+\zeta_x)/(1+\zeta_m)$

	(1)	(2)	(3)	(4)
Elasticities estimated by	OLS	DOLS	OLS	DOLS
Sample	1960-98	1960-98	1960-98	Pooled subsamples
Domestic growth rate/	0.704**	0.550**	0.724**	0.695**
Foreign growth rate	(0.111)	(0.095)	(0.094)	(0.073)
	[0.110]	[0.096]	[0.095]	[0.078]
Constant	0.367**	0.600**	0.331**	0.352**
	(0.117)	(0.111)	(0.122)	(0.081)
	[0.117]	[0.110]	[0.121]	[0.085]
R^2	0.66	0.40	0.64	0.69
No. of countries	35	35	74	71
p-value for H_0: slope=1	*0.01*	*0.00*	*0.01*	*0.00*

Notes: 1. See footnotes to table 2.
2. Negative income elasticities from the subsamples are dropped. These include Nicaragua (1973-1998) and Sri Lanka (1960-1976) for export demand and India (1960-1971) and Sri Lanka (1960-76) for import demand.

Figure 1a: Krugman's 45-Degree Rule, Whole Sample (1960-98), OLS Elasticity Estimates



Notes: The straight line is the 45-Degree line which goes through the origin and has a slope of one.

Figure 1b: Krugman's 45-Degree Rule, Whole Sample (1960-98), DOLS Elasticity Estimates

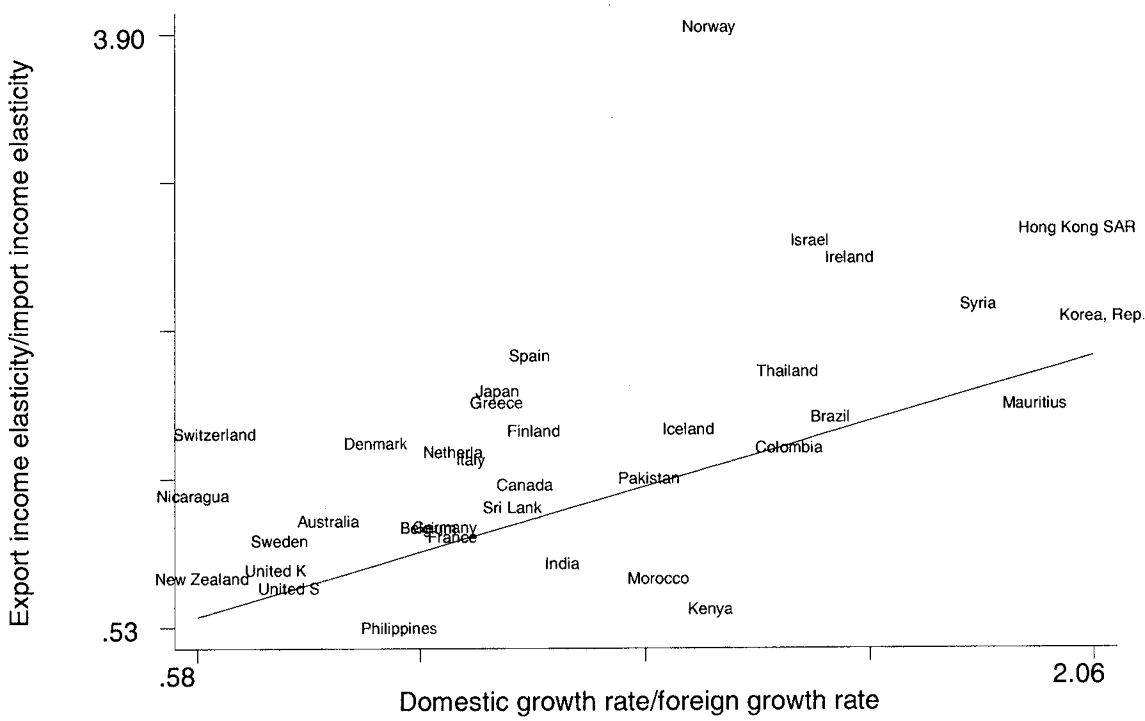


Figure 2: Krugman's 45-Degree Rule, Pooled Sample, OLS Elasticity Estimates

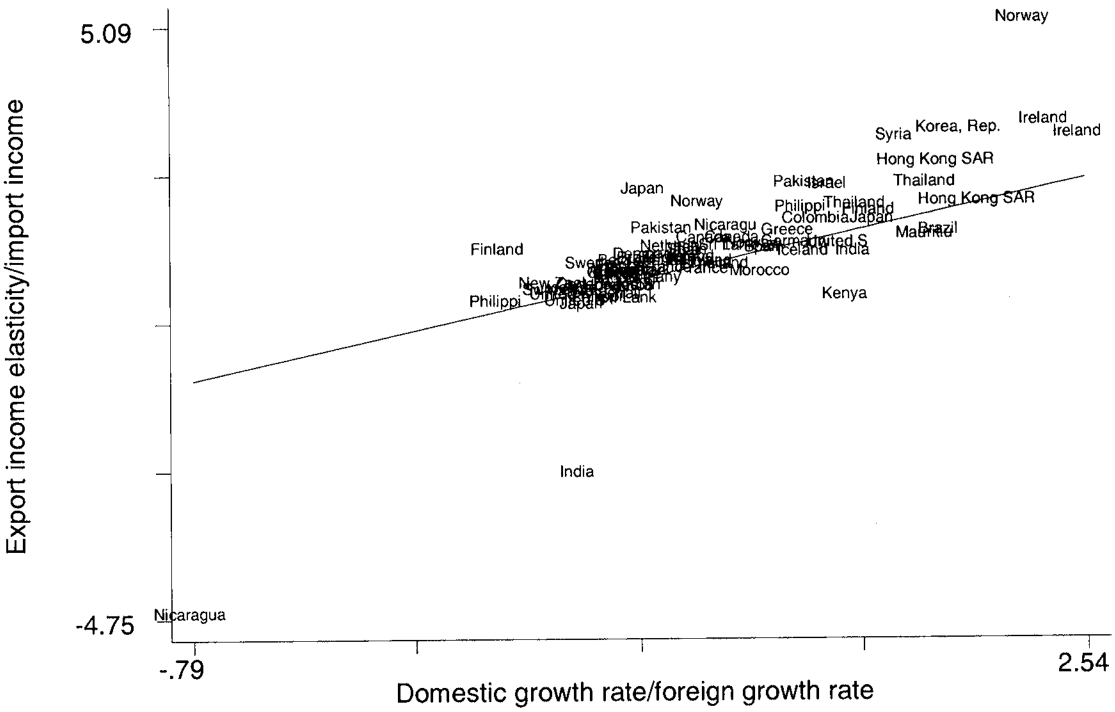


Figure 3a: The Alternative 45-Degree Rule I, Whole Sample (1960-98), OLS Elasticity Estimates

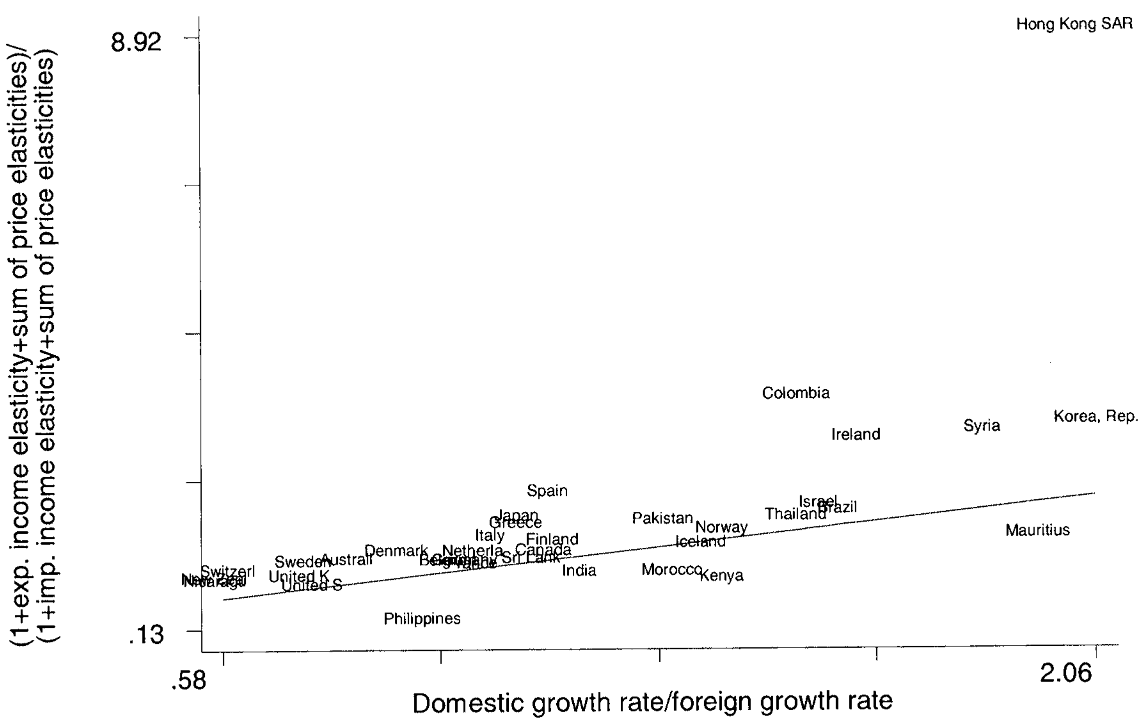


Figure 3b: The Alternative 45-Degree Rule I, Whole Sample (1960-98), DOLS Elasticity Estimates

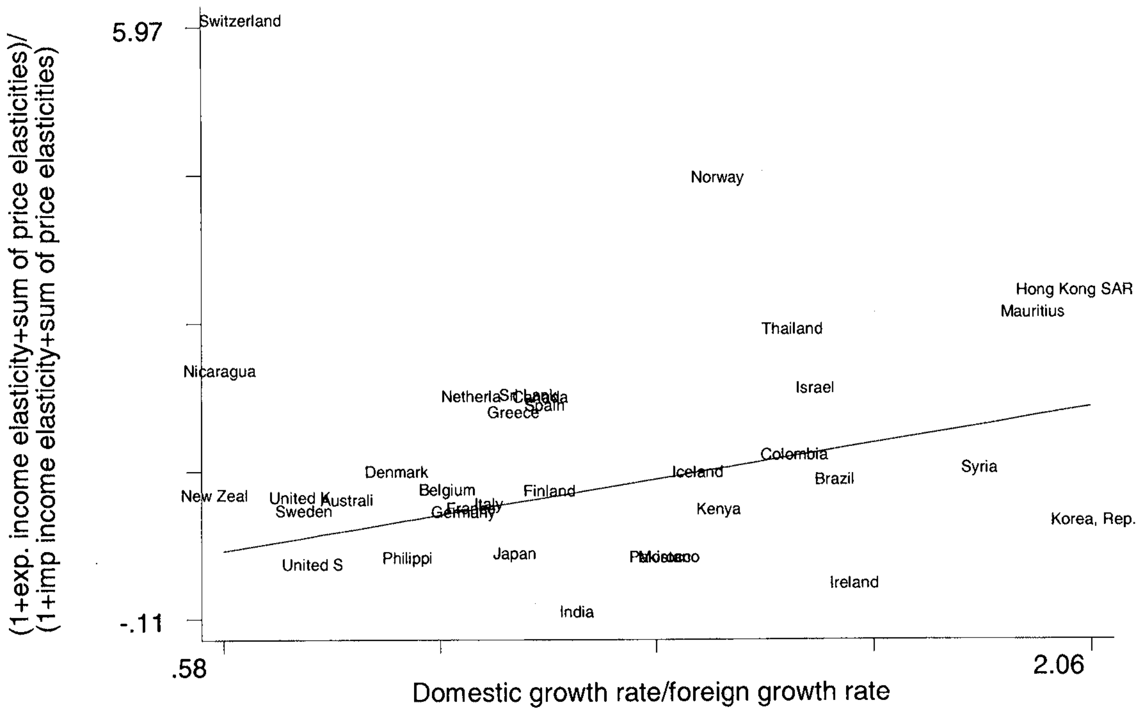


Figure 4: Histogram of the Sum of Price Elasticities, Whole Sample (1960-98), DOLS Elasticity Estimates