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International Status Seeking, Trade, and Growth Leadership*

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Abstract

This paper formalizes international status seeking in a two-country model of endogenous growth: utility of agents in developing countries is affected by consumption gaps with advanced economies. By distorting intertemporal choices, envy tends to revert growth differentials in favor of the developing country when traded goods are substitutes. Notably, asymmetric preferences with endogenous status desire generate (i) convergence in growth rates in the presence of structural gaps, and (ii) convergence in income levels, if productivity differences are absorbed by technology diffusion. This process is driven by declining terms of trade and faster capital accumulation of the status seeker. A calibration exercise shows that the model predictions are consistent with the stylized facts that characterized the growth performance of East Asian economies.

JEL Codes O33, F12, D91.

Keywords Endogenous Growth, International Trade, Consumption Externalities, Productivity Differences, Status Seeking, Technology Diffusion.

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1 Introduction

Capital sin or spirit of capitalism? Despite many censorious definitions, envy is a powerful economic incentive. Economists have long understood that human behavior is crucially driven by the subjective perception of social status (Veblen, 1899), and there is strong empirical evidence that individuals form such perceptions on the basis of interpersonal comparisons (Frank, 1997). In particular, status-seeking behavior has been regarded as a major ingredient of the spirit of capitalism, as it represents an additional motive for acquiring goods, beyond the 'purely physical' benefit that consumption actually provides (Cole et al. 1992; Bakshi and Chen, 1996). These considerations inspired early consumption theories in arguing that consumption choices are affected by the willingness to catch up on the social scale (Duesenberry, 1949). More recently, the theory of comparison utility has given explicit microfoundations to aggregate models where savings rates depend on relative, rather than absolute consumption levels. The growing body of literature on 'outward-looking preferences' (Carrol et al. 1997) shows that when intertemporal choices embody some degree of status desire, the long-run growth rate of the economy is modified (Alvarez-Cuadrado et al. 2004), and the economy may display dynamic inefficiency due to overaccumulation of capital (Alonso-Carrera et al. 2004). In this literature, status-seeking phenomena are essentially consumption externalities that drive the economy away from the social optimum: as shown by Dupor and Liu (2003), the laissez-faire equilibrium in the presence of 'jealousy' implies overconsumption. Further distortions induced by envy arise when utility is also affected by leisure, as in the optimal growth models with endogenous labor supply employed by Liu and Turnovsky (2005) and Alvarez-Cuadrado (2007a).

It should be stressed that all contributions mentioned above assume *within*-country spillovers - that is, agents evaluate their status on the basis of the average consumption level of the economy in which they live. It is however plausible that status-seeking phenomena also operate at the international level nowadays. One may recognize this as an aspect of globalization, i.e. a large-scale integration process which reshapes individual behavior by giving consumers new 'neighbors' to look at, and to compare with. Information delivered by global mass media and marketing activities of multinational firms, as well as tourism and migration, tend to affect consumption patterns in developing countries by creating a *foreign benchmark* that fuels consumers' expectations and desires (James, 2000). As pointed out by Sklair (1991), the status-leader role played by Western economies appears strengthened by the fact that consumers in developing countries perceive commodities produced in advanced economies as positional goods - that is, status-signalling devices. Developments in Central and Eastern European countries after the end of the Cold War, or in China and India in recent years, provide anedoctal evidence confirming this desire to 'have what they have'. Moreover, taking into account unequal distribution of income within countries, the importance of status consumption is not confined to high-income classes of emerging economies - i.e. those who can afford a standard of living comparable to the average consumer in advanced economies - since status desire directed towards positional goods is typically observed in low-income classes as well (Caplovitz, 1967; Belk, 1988). In other words, international consumption externalities exist; they influence consumption behavior over time; and they likely have macroeconomic consequences.

From a general equilibrium perspective, transboundary envy - or equivalently, *international status seeking* - may have relevant implications for the development path followed by open economies, since distortions in intertemporal choices affect accumulation rates and terms-of-trade dynamics. However, as noted above, a formal treatment of international status seeking is absent in the existing literature, where preferences are assumed to be interdependent among compatriots. This paper analyzes 'Catching-Up With The Joneses' phenomena occurring between trading economies, and investigates its consequences for the relative performance of developing countries.

In section 2, we formalize international status seeking in a two-country world: utility of agents in developing economies is affected by the consumption gaps that arise with advanced economies. A first, general result is that envy tends to revert growth differentials against the status leader, i.e. in favor of the developing economy, when traded goods are substitutes. In section 3 we apply this framework to standard growth models, showing that the distortions induced by status desire persist in the long run, and interact with productivity differences. Section 4 refines the model by endogeneizing the degree of status desire, and shows that two types of convergence may be induced by asymmetric preferences. More precisely, envy generates (i) convergence in growth rates by compensating for structural gaps, and (ii) convergence in income levels if productivity differences are absorbed by technology diffusion. The mechanism through which consumption grows at higher rates in the status-seeking economy is based on the intertemporal reallocation operated by forward-looking agents. The willingness to catch-up with the leader generates faster accumulation and higher growth rates for the developing country. As terms of trade decline during the transition, the output share of the status seeker increases until consumption levels are equalized.

The predictions of the model recall some major stylized facts of the growth performance of East Asian economies such as Hong-Kong, Singapore and Taiwan. There is wide consensus that the convergence process undertaken by the 'Asian Tigers' is mainly explained by the rise in factor inputs, whereas technology spillovers raising total factor productivity have played a minor role. Building on this point, section 5 performs a calibration exercise in which the transitional dynamics of the model reproduce the stylized facts that characterized the performance of Singapore relative to the US economy. The predictions of the model appear consistent with observed paths of output shares, accumulation rates, consumption propensities, and terms of trade. The main conclusions are summarized in section 6.

2 International Status Seeking

A central element of Veblen's theory of conspicuous consumption is the observation that individual behavior is driven by the perception of social status: beyond the material benefit that commodities provide, consumption demand is influenced by "the stimulus of an invidious comparison which prompts us to outdo those with whom we are in the habit of classing ourselves" (Veblen, 1899, p.103). A similar reasoning underlies the modern theory of comparison utility, according to which individuals display outward-looking preferences: personal satisfaction depends on the observed gap between agents' consumption and the *social benchmark*. The huge recent literature on 'Catching-Up With The Joneses' assumes that this benchmark is represented by the average consumption level of the economy (Carrol et al. 1997; Dupor and Liu, 2003; Alonso-Carrera et al. 2004; Alvarez-Cuadrado et al. 2004). Building on the idea that psychological benchmarks can also be provided by consumption levels in foreign countries, this paper formalizes the 'Catching-Up With The Joneses' phenomenon as an international externality between trading economies. We begin by describing consumers' behavior in a two-country world, abstracting from technological specifications.

2.1 Intertemporal Choices

Time is continuous and indexed by $t \in [0, \infty)$. The instantaneous variation of variable x is denoted by $\dot{x} = dx/dt$, and its growth rate by $\hat{x} = \dot{x}/x$. The world comprises two countries - or economic areas - indexed by $i = a, b$, specialized in producing heterogeneous goods. A first country, the 'status leader', produces good a, and a second country, labelled as the 'status seeker', produces good b. Agents are homogeneous within each economy, and international trade allows each consumer to enjoy both goods. For simplicity, population N_i is constant over time and equal between the two economies $N_a = N_b$, and capital is immobile at the international level. The consumption index is denoted by γ_i, and is represented by a composite good which combines the two commodities available in the world. Denoting by c_i^j the quantity of good j consumed by agents in country i, per capita imports in country i are represented by c_i^j with $j \neq i$. The consumption index reads

$$\gamma_i = \left[(c_i^a)^{\frac{\sigma-1}{\sigma}} + (c_i^b)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where the elasticity of substitution between traded goods, σ, is constant and differs from unity. When $\sigma < 1$, traded goods are perceived as complements, whereas $\sigma > 1$ implies that agents treat goods as substitutes. Individual consumption expenditure, expressed in terms of output produced in country i, is denoted by c_i. Denoting the respective prices by p_a and p_b, the expenditure constraint reads

$$p_i c_i = p_a c_i^a + p_b c_i^b. \tag{2}$$

The instantaneous utility functions are specified as

$$u_a(\gamma_a) = \frac{\gamma_a^{1-\nu} - 1}{1-\nu}, \tag{3}$$

$$u_b(\gamma_b, \bar{\gamma}) = \frac{\left(\gamma_b / \bar{\gamma}^{\theta}\right)^{1-\nu} - 1}{1-\nu}, \tag{4}$$

where $-\nu < 0$ is the elasticity of marginal utility. Preferences (3) postulate that agents' satisfaction in country a only depends on own consumption. Preferences (4), instead, comply with the specifications adopted in the literature on 'comparison utility', where $\bar{\gamma}$ is a psychological benchmark level by which consumers evaluate their status. Utility thus depends on a weighted ratio between own consumption, γ_b, and the reference level $\bar{\gamma}$, and parameter θ is the *degree of status desire.* With $\theta > 0$, and increase in the benchmark level decreases utility, $\partial u_b / \partial \bar{\gamma} < 0$. Letting $\theta \to 0$, benchmark levels are no longer important, and preferences (4) reduce to the standard form (3).

In the closed-economy setting, specification (4) has been used to describe two related phenomena, habit formation and 'Catching-Up With The Joneses' (Alonso-Carrera et al. 2004; Alvarez-Cuadrado et al. 2004). In the former case, $\bar{\gamma}$ is the weighted average of past consumption indices of the same agent. In the latter case, $\bar{\gamma}$ is the average level of consumption within the economy in which the representative agent operates. This paper considers relative consumption in a different context by formalizing asymmetric preferences between trading countries. In particular, consumers' behavior in economy b is driven by *international status seeking.* The underlying logic is that agents in emerging economies aim at achieving the living standards exhibited by consumers of more advanced economies. Formally, we assume

$$\bar{\gamma} = \gamma_a, \tag{5}$$

with $0 \leq \theta < 1$, $\nu > 1$. Throughout this section we assume that θ is constant and exogenous, and refer to this specification as 'envy with fixed parameters'. In section 4 we will argue that a sensible specification requires time-varying parameters, and extend the model to endogeneize status desire.

From (5), utility in country b is affected by consumption gaps with the status leader: instantaneous satisfaction reads $u_b(\gamma_b, \bar{\gamma}) = u_b(\gamma_b, \gamma_a)$, where foreign consumption γ_a is taken as given. An important restriction is that the elasticity parameter ν is assumed to exceed unity. Setting $\nu > 1$, the cross derivative $\partial^2 u_b / (\partial \gamma_b \partial \gamma_a)$ is strictly positive: a marginal increase in consumption of country a increases the marginal utility (from own consumption) of agents in country b. This guarantees that agents in country b display 'Catching-Up With The Joneses' behavior: an increase in the benchmark level stimulates the willingness of country b's residents to consume more, in order to catch-up with the status leader.

Following a standard procedure (e.g. Frenkel and Razin, 1985; Gardner and Kimbrough, 1990), the consumer problem is solved in two steps. First, each agent chooses how to allocate consumption expenditures between the two goods by maximizing u_i subject to (2), using c_i^a and c_i^b as control variables and taking expenditure c_i as given. Defining the terms-of-trade index as $p \equiv p_b/p_a$, first-step optimality conditions imply

$$c_i^a = c_i^b p^\sigma \tag{6}$$

in both countries. Substituting (6) in (1)-(2), we can define $\tau \equiv \left(1 + p^{\sigma-1}\right)^{\frac{1}{\sigma-1}}$ and write equilibrium consumption indices as

$$\gamma_a^* \left(c_a, p\right) = \frac{c_a \tau}{p} \text{ and } \gamma_b^* \left(c_b, p\right) = c_b \tau. \tag{7}$$

Ruling out international mobility of assets, balanced trade requires $c_a/c_b = p^\sigma$ at each point in time.[1] The growth rate of the price index is thus proportional to the growth differential in consumption expenditures,

$$\hat{p} = \hat{p}_b - \hat{p}_a = \frac{\hat{c}_a - \hat{c}_b}{\sigma}. \tag{8}$$

From (8), faster growth in country b's consumption expenditure implies a decline in its terms of trade - i.e. a decrease in the price of exported good, p_b, relative to that of the imported good, p_a.

Substituting (7) in (3)-(4) gives the indirect utility functions

$$u_a^* \left(c_a; p\right) = u_a \left(\gamma_a^* \left(c_a, p\right)\right) \text{ and } u_b^* \left(c_b; p, \bar{\gamma}\right) = u_b \left(\gamma_b^* \left(c_b, p\right), \bar{\gamma}\right)$$

where the price index is taken as given by each consumer, and benchmark levels $\bar{\gamma} = \gamma_a^* \left(c_a, p\right)$ are taken as given by agents in country b.

In the second step, agents choose the sequence of consumption expenditures $\{c_i\left(t\right)\}_0^\infty$ that maximizes the objective function

$$\int_0^\infty u_i^* \left(c_i\left(t\right)\right) e^{-\rho t} dt, \tag{9}$$

where $\rho > 0$ is the utility discount rate. Objective (9) is maximized subject to the dynamic wealth constraint

$$\dot{q}_i\left(t\right) = r_i\left(t\right) q_i\left(t\right) + w_i\left(t\right) \ell_i\left(t\right) - c_i\left(t\right), \tag{10}$$

where all variables are expressed in terms of output produced in country i. Private wealth per capita q_i is held in the form of assets yielding a rate of return equal to r_i, and labor income equals the wage rate w_i times units of labor efficiency supplied, ℓ_i. As shown in the Appendix, the optimality conditions of the second-step problem imply

$$\hat{c}_a = \nu^{-1} \left[R_a - (\nu - 1)\left(\hat{\tau} - \hat{p}\right)\right], \tag{11}$$

$$\hat{c}_b = \nu^{-1} \left[R_b - (\nu - 1)\hat{\tau}\right] + (\theta/\nu)(\nu - 1)\left[\hat{\tau} - \hat{p} + \hat{c}_a\right], \tag{12}$$

where we have defined *net interest rates* as $R_i \equiv r_i - \rho$. From (11)-(12), consumption dynamics in both countries are influenced by terms-of-trade effects, through $\hat{\tau}$ and $\hat{p}$.[2] In particular, the last term in expression (12) shows that, for any positive degree of status desire θ, the growth rate of consumption expenditure in country b is positively affected by that of country a: the willingness to catch-up with the leader implies that $\hat{c}_b$ is ceteris paribus higher the higher is $\hat{c}_a$. The general implications for real consumption gaps are described below.

2.2 Equilibrium Dynamics with Fixed Parameters

The dynamics of consumption indices and prices can now be obtained by substituting the equilibrium conditions in the world market in the optimality conditions for consumers. From $c_a = p^{\sigma} c_b$ and (7), the *real consumption ratio* equals

$$\frac{\gamma_a(t)}{\gamma_b(t)} = p(t)^{\sigma-1} \tag{13}$$

in each instant t. The growth differential in real consumption indices is thus proportional to the growth rate of the price index, and linked to the value of the elasticity of substitution,

$$\hat{\gamma}_a - \hat{\gamma}_b = (\sigma - 1)\,\hat{p}. \tag{14}$$

Given a positive consumption gap at time zero for the status leader, $\gamma_a(0) > \gamma_b(0)$, a declining (increasing) real consumption gap is obtained when $(\sigma - 1)\,\hat{p}$ is negative (positive) during the transition. Price dynamics, in turn, obey the differential equation (see Appendix)

$$\hat{p} = \frac{R_a - R_b - (\theta/\nu)(\nu - 1) R_a}{\nu\sigma - (\nu - 1)\left[1 + (\theta/\nu)\left(1 + p^{\sigma-1}\right)^{-1}\right]}, \tag{15}$$

where the denominator is assumed to be always strictly positive.[3] Expression (15) shows that the effect of envy on the dynamics of terms of trade is twofold. On the one hand, envy imposes an *interest rate effect* represented by the last term in the numerator of (15). On the other hand, status desire introduces an *elasticity effect* represented by the square brackets in the denominator of (15): θ modifies the elasticity of intertemporal substitution and, hence, the magnitude of $\hat{p}$ in response to a given interest rate differential. Setting $\theta = 0$ yields the growth rate of the price index without envy,

$$\hat{p}^{sf} \equiv \frac{R_a - R_b}{\nu\sigma - (\nu - 1)}. \tag{16}$$

Comparing (15) with (16), it follows that envy may revert the sign of $\hat{p}$ with respect to the status-free case. This result has an intuitive interpretation. In a status-free world with identical interest rates, the optimal growth rate of consumption expenditures is the same in both countries, so that the price index is time-variant and the real consumption gap (13) is constant over time. In the presence of envy, $R_a = R_b$ implies $\hat{p} < 0$ instead. Agents face the same rate of return to investment, but status desire induces consumers in country b to seek a higher growth rate in consumption expenditures, which implies a declining price index - see (8). Notice, however, that whether this process implies increasing or decreasing *real* consumption gaps depends on the elasticity of substitution. From (14), $\hat{p} < 0$ is associated with a declining consumption gap ($\hat{\gamma}_a < \hat{\gamma}_b$) only if traded goods are perceived as substitutes. In this regard, we will argue in section 3.1.1 that $\sigma > 1$ actually holds in the typical scenario in which envy arises.

The mechanism through which status-seeking agents attain higher expenditure growth rates involves a standard reallocation effect: given the intertemporal budget constraint, raising $\hat{c}_b$ requires reducing the initial expenditure level, which implies higher savings and faster wealth accumulation. We will show in section 4.2 that envy in fact generates U-shaped paths in consumption propensities - that is, hump-shaped paths in investment rates - during the transition.[4]

In the following sections, we assess the consequences of status seeking for growth differentials by making further assumptions regarding technologies and accumulation processes. In general, we will denote by Y_i aggregate physical output in country i, and the *growth differential* as

$$\Delta \equiv \hat{Y}_a - \hat{Y}_b - \hat{p},$$

where the first two terms represent the physical-output effect, while $\hat{p}$ is the terms-of-trade effect. The dynamics of the respective output shares are determined by the sign of the growth differential, since $\Delta > 0$ ($\Delta < 0$) implies that the value of output of country a increases (decreases) relative to world output. If the economies converge to a balanced growth equilibrium in the long run ($\hat{Y}_i \to \hat{C}_i$), we have

$$\lim_{t\to\infty} \Delta = \lim_{t\to\infty} (\sigma - 1)\,\hat{p} = \lim_{t\to\infty} \left(\frac{\sigma - 1}{\sigma}\right)\left(\hat{Y}_a - \hat{Y}_b\right). \tag{17}$$

When countries do not converge in growth rates, Δ differs from zero and one economy expands its market share at the expense of the other. Increasing shares and growth leadership are crucially determined by the elasticity of substitution: the physical-output effect dominates if goods are perceived as substitutes ($\sigma > 1$), whereas trading complements ($\sigma < 1$) would imply increasing shares for the country with slower growth in physical output.

In order to simplify notation, we will denote the numerator at the right hand side of (15) as $R_x \equiv R_a - R_b - (\theta/\nu)(\nu - 1) R_a$, and the price elasticity as

$$\epsilon(t) \equiv \left\{\nu\sigma - (\nu - 1)\left[1 + (\theta/\nu)\left(1 + p^{\sigma-1}\right)^{-1}\right]\right\}^{-1}, \tag{18}$$

so that the growth rate of the price index can be written as $\hat{p}(t) = \epsilon(t) R_x(t)$.

3 Envy and Uneven Growth

A central result of the literature on trade and growth is that convergence in growth rates obtains when backward countries share some of the technological improvements of advanced economies - e.g. through knowledge spillovers (Grossman and Helpman, 1991), flows of ideas (Rivera-Batiz and Romer, 1991), technology diffusion (Barro and Sala-i-Martin, 1997), or trade in intermediate inputs (Acemoglu and Ventura, 2002). The situation in which the production frontiers of lagging countries are improved by external factors can be labelled as *technological dependence* (a broad definition including trade in intermediates). If none of these opportunities for improvement is accessible for, or exploited by, lagging countries, permanent differences in productivity - *structural gaps*, henceforth - translate into persistent differences in growth rates (Rebelo, 1991), and market shares diverge despite free trade in final goods (Feenstra, 1996). This section shows that international status seeking interferes with these conclusions: envy may compensate for structural gaps, and generate switchovers in the growth leadership in the presence of technology diffusion. The analysis also suggests relaxing the assumption of fixed parameters: the necessary refinement will be discussed in section 4.

3.1 Status Seeking with Structural Gaps

3.1.1 A Learning-by-doing Model

The logic behind models with structural gaps is that barriers to knowledge and technology diffusion prevent trading economies from achieving uniform growth rates. The effects of status seeking in this context can be analyzed in a simple manner by assuming constant returns to aggregate capital. The model presented below features learning-by-doing, and can be considered a two-country version of Romer (1989) - see also Rebelo (1991) and Young (1991) - extended to include heterogeneous goods and international status seeking.

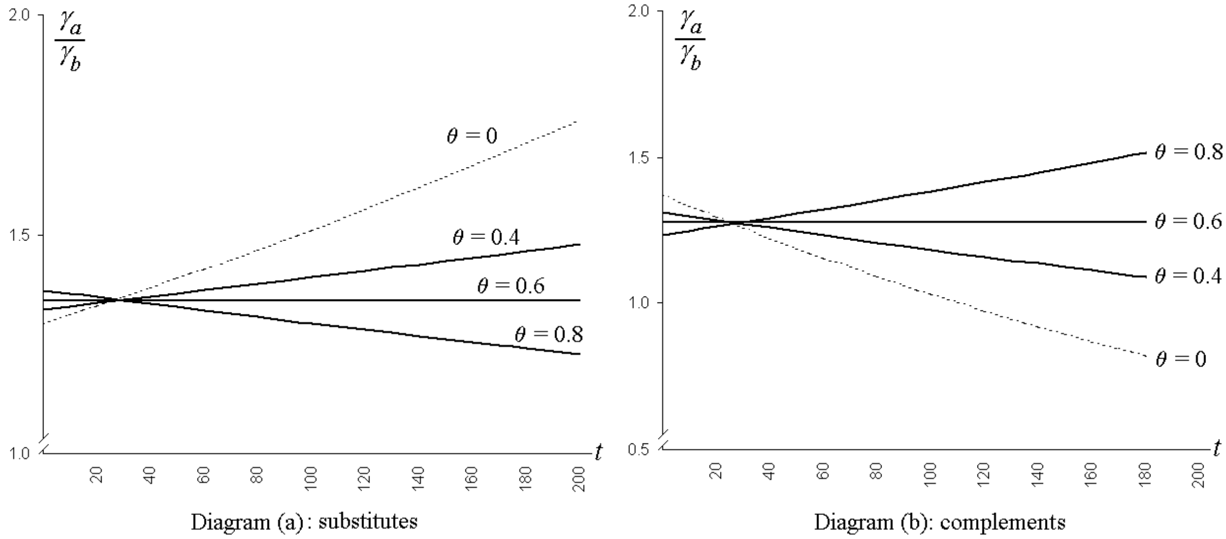

Figure 1: Dynamics of real consumption ratio with structural gaps. Diagram (a) assumes $\sigma = 1.2$, whereas Diagram (b) assumes $\sigma = 0.8$. Parameters are $R_a = .05$, $R_b = .04$, and $\nu = 1.5$. The resulting critical level is $\bar{\theta} = 0.6$.

In each country there are J identical firms, indexed by j, that produce $y_{i,j}$ units of final good i by employing $k_{i,j}$ units of capital and $\ell_{i,j}$ units of labor efficiency. Each firm's technology is represented by the well-behaved function $y_{i,j} = F^i(k_{i,j}, \ell_{i,j})$, homogeneous of degree one. Labor is supplied inelastically and is immobile at the international level. Normalizing work time to unity, efficient labor individually supplied, ℓ_i, is proportional to human knowledge, h_i, according to the relation $\ell_i = \eta_i h_i$, where η_i is a constant country-specific proportionality factor. The engine of growth is knowledge accumulation due to learning-by-doing: workers' knowledge is affected by an aggregated externality, which is taken as given by firms. In the competitive equilibrium, factor prices equal marginal productivities defined at given externalities:

$$r_i = F_1^i(k_{ij}, \ell_{ij}) \text{ and } w_i = F_2^i(k_{ij}, \ell_{ij}), \tag{19}$$

where F_1^i and F_2^i are partial derivatives with respect to the first and second argument, respectively. Since firms have identical size, they employ identical amounts of inputs and produce the same output level $y_{ij} = y_i$. Aggregate output $Y_i = Jy_i$ thus equals $Y_i = F^i(K_i, L_i)$, where $K_i = Jk_i$ is aggregate capital and $L_i = J\ell_i = \eta_i h_i N_i$ is aggregate efficient labor. Following Romer (1989), we assume that h_i is positively related to the aggregate capital stock K_i: assuming $h_i(t) = B_i K_i(t)$, constant $B_i > 0$ represents the intensity of learning-by-doing. Substituting this relation in the aggregate production function, we obtain

$$Y_i = A_i K_i, \tag{20}$$

where the marginal social return from capital, $A_i \equiv F^i(1, \eta_i B_i N_i)$, is constant over time. The marginal private return from capital, instead, equals the equilibrium interest rate

$$r_i^* = A_i - w_i^* \eta_i B_i N_i < A_i, \tag{21}$$

where $w_i^* = F_2^i(1, \eta_i B_i N_i)$ is constant as well. In order to have positive net interest rates, parameters must be such that $A_i - \eta_i B_i N_i > \rho$. Using (21), it follows that R_x is constant over time. As shown in the Appendix, this implies that the growth rate of the price index is constant in the long run:

Proposition 1 *The long-run price elasticity ϵ_∞ is constant and equal to*

$$\epsilon_\infty \equiv \lim_{t\to\infty} \epsilon(t) = \begin{cases} \epsilon'_\infty = \{\nu\sigma - (\nu-1)[1+(\theta/\nu)]\}^{-1} \\ or \\ \epsilon''_\infty = [\nu\sigma - (\nu-1)]^{-1} \end{cases} \tag{22}$$

depending on sign of R_x and the value of σ. In either case, $\hat{p}$ is constant in the long run:

$$\hat{p}_\infty \equiv \lim_{t\to\infty} \hat{p}(t) = \epsilon_\infty [R_a - R_b - (\theta/\nu)(\nu-1) R_a]. \tag{23}$$

Proposition 1 shows that distortions induced by status seeking persist in the long run. The consequences for growth differentials and market shares are as follows. Since individual wealth equals domestic capital per capita, $q_i = K_i/N_i$, the dynamic law (10) implies the standard aggregate constraint $\dot{K}_i = Y_i - C_i$, from which

$$\hat{Y}_i = \hat{K}_i = A_i - (C_i/K_i) \tag{24}$$

at each point in time. Proposition 1 and (11)-(12) imply that consumption expenditures grow at asymptotically constant rates.[5] As a consequence, the unique equilibrium compatible with (24) and intertemporal optimality conditions features balanced growth in the long run, and the asymptotic growth differential (17) reads

$$\lim_{t\to\infty} \Delta(t) = (\sigma-1)\epsilon_\infty [R_a - R_b - (\theta/\nu)(\nu-1) R_a]. \tag{25}$$

The comparison with the status-free case is now straightforward. Consider the assumption $R_a > R_b$ as the benchmark case. In the status-free model, this structural gap implies that country a displays higher physical productivity, and increases (decreases) its output share at the expense (in favor) of country b's share if the two goods are perceived as substitutes (complements). With international status seeking, instead, we have the following

Proposition 2 *When $R_a > R_b$, there exists a critical level of status desire*

$$\bar{\theta} = \frac{R_a - R_b}{R_a}\left(\frac{\nu}{\nu-1}\right) \tag{26}$$

such that: (i) if $\theta = \bar{\theta}$ then $\lim_{t\to\infty}\Delta(t) = 0$; (ii) if $\theta > \bar{\theta}$, the sign of the long-run growth differential is overturned by envy.

Proposition 2 shows that envy influences the link between trade and growth, and may even revert the growth differential between the two economies. If θ equals the critical level (26), growth rates converge despite technological independence: result (i) thus describes *convergence induced by envy*, where constant market shares are exclusively due to international status-seeking. In the present context it appears as a rather special case, but we will see in section 4 that, with a different specification, envy induces convergence under more general circumstances.

Result (ii) asserts that a sufficiently high degree of status desire reverts growth differentials. In particular, when traded goods are perceived as substitutes ($\sigma > 1$), envy generates a switchover in growth leadership in favor of country b. Numerical examples are given in Figure 1, that describes the time paths of the real consumption ratio, γ_a/γ_b, for different values of θ and σ. The initial price is numerically determined by verifying the equilibrium condition (see Appendix)

$$\frac{K_a(0)}{K_b(0)} = \frac{\int_0^\infty \left(\frac{\tau(T)}{p(T)}\right)^{\frac{1-\nu}{\nu}} e^{\int_0^T \left(\frac{R_a(t)}{\nu} - A_a(t)\right)dt} dT}{\int_0^\infty \left(\frac{\tau(T)}{p(T)}\right)^{\frac{1-\nu}{\nu}} p(T)^{-\sigma} e^{\int_0^T \left(\frac{R_a(t)}{\nu} - A_b(t)\right)dt} dT}. \tag{27}$$

The set of parameter values used in Figure 1 imply $\bar{\theta} = 0.6$. Diagram (a) assumes $\sigma > 1$. In a status-free world, higher rates of return generate ever-increasing real consumption shares: from (14) and (16), $R_a > R_b$ implies $\hat{p} > 0$, and the initial distance between leader and follower gets wider over time. Introducing a moderate degree of status seeking, $\theta = 0.4$, the positive trend in prices becomes less steep, slowing down the rate of divergence. Higher degrees of envy more than compensate for structural gaps. For $\theta = 0.6$ we obtain constant market shares, whereas for $\theta > 0.6$ country b becomes the growth leader: the price index decreases, and the real consumption ratio shrinks indefinitely. Diagram (b) assumes $\sigma < 1$. Since goods are complements, economy b would be the growth leader in a status-free world. Envy contrasts this trend by distorting growth differentials in favor of country a: with strong status desire, $\theta > \bar{\theta}$, the trend in real consumption shares now turns in disfavor of country b. However, it should be stressed that the case $\sigma < 1$ is not consistent with the 'typical scenario' where envy plausibly arises. We think that the status leader - i.e. the country with higher real consumption at time zero - is also the technological leader, displaying higher productivity and higher real income levels at time zero. These features do not seem altogether compatible when goods are complements: on the one hand, $\sigma < 1$ always implies that growth differentials are in favor of the country with slower growth in physical output; on the other hand, an initial equilibrium with $\gamma_a(0) > \gamma_b(0)$ and $\sigma < 1$ is generally associated higher real output for the status-*seeker* at time zero.[6] For this reason, all subsequent numerical examples will consider a *baseline scenario* where traded goods are substitutes, and country a is a technological leader enjoying positive differentials in physical productivity, real consumption, and real endowments (i.e. $K_a > pK_b$) at time zero.

3.1.2 Generalization to other environments

The previous results can be generalized to a wider class of endogenous growth models. Propositions 1 and 2 are robust to alternative specifications of the supply-side of the economy, as long as the time-path of net interest rates complies with minimal conditions of regularity:

Proposition 3 *Suppose that, for some $t_0 \geq 0$, we have either $R_x(\bar{t}) > 0$ or $R_x(\bar{t}) < 0$ for all $\bar{t} \in [t_0, \infty)$. Then, ϵ_∞ is constant and equal to (22), and $p_\infty = \epsilon_\infty \lim_{t\to\infty} R_x(t)$. In a balanced growth equilibrium, the long-run growth differential equals $(\sigma - 1)\, p_\infty$, still affected by status desire.*

Proposition 3 is proved without making any assumption about technology and accumulation processes. The only hypothesis is the absence cyclical switchovers in the sign of R_x from some point in time onwards. This implies that the same results derived in section 3.1.1 can be obtained in more sophisticated models where economies have a multi-sectoral structure, and the engine of growth is different - e.g. human capital formation, gains from specialization, R&D sectors, or vertical innovations.

3.2 Envy and Technological Catching-Up

3.2.1 Technology Absorption

An interesting extension of the basic model relates to the interaction between status seeking and technology diffusion. A central result of the literature on trade and growth is that if the lagging country exhibits technological catching-up, growth differentials disappear in the long run. This conclusion can be reached following different reasonings as regards the source of technology diffusion. In a one-good version of the expanding-varieties model, Barro and Sala-i-Martin (1997) describe the convergence process between a technological leader - who produces 'original innovations' and displays a comparative advantage in R&D - and a technological follower, who readapts the blueprints developed abroad, and catches-up with the leader by imitation. In this setting, the cost of imitation is a function of the observed gap in the number of existing intermediates, and the resulting process of endogenous technology diffusion brings about *(i) interest rate equalization, (ii) convergence in growth rates, and (iii) constant gaps in income levels* (see Barro and Sala-i-Martin, 1997). Results (i)-(iii) are equivalently obtained by postulating alternative mechanisms that equalize the rates of return to investment. As productivity differences vanish, net interest rates coincide and growth rates converge. In Feenstra (1996: sect.6.3), Bretschger and Steger (2004), Smulders (2004), this process is obtained by assuming knowledge spillovers that directly affect the productivity of firms in the lagging country. More generally, convergence can be induced by a generic process of technology absorption, e.g.

$$\dot{\kappa}_i = \psi \left(\kappa^* - \kappa_i \right)$$

where κ_i indicates a generic country-specific technological parameter and κ^* is the best practice technology available at the worldwide level. The absorption function, originally suggested by Nelson and Phelps (1966), formalizes catching-up as an adjustment process whereby technology in country i converges to the leading technology with a speed of adjustment equal to $\psi > 0$ - also called 'absorptive capability'.[7] As $\kappa_i \to \kappa^*$, productivity differences vanish, and net interest rates are asymptotically equal. From (16), this implies converging growth rates in a status–free world.

Including status seeking in the model affects the above conclusions. While technological catching-up implies interest rate equalization, envy distorts terms of trade, making the two economies diverge in the long run:

Proposition 4 *For any positive degree of status desire, interest-rate equalization implies asymptotic divergence. Terms-of-trade effects are strictly negative,*

$$\hat{p}_\infty = -\epsilon_\infty \left(\theta / \nu \right) \left(\nu - 1 \right) \lim_{t \to \infty} R_a \left(t \right) < 0, \tag{28}$$

and balanced growth equilibria feature

$$\lim_{t \to \infty} \Delta \left(t \right) = \left(\sigma - 1 \right) \hat{p}_\infty \neq 0. \tag{29}$$

Proposition 4 shows that technological catching-up induces negative terms-of-trade effects, by virtue of the mechanism described in section 2.2. The distortions generated by envy persist even if the economies share the same technological base, and convergence to balanced growth thus yields divergence in output shares for any positive degree of status desire. An application of Proposition 4 is provided below.

3.2.2 Converging returns and single-peaks

Consider a process of technology diffusion by which the marginal profitability of investment in country b converges to the level set by the status leader. Applying the absorption function to net interest rates, we have

$$\dot{R}_b(t) = \xi (R_a - R_b(t)), \tag{30}$$

where $\xi > 0$ is the speed of adjustment, and R_a is constant. Notice that the absorption function can also be specified with respect to other parameters - e.g. the intensity of learning-by-doing in the AK model of section 3.1.1, or the cost of R&D in a multi-sector economy with endogenous innovations - with identical results in terms of interest rate equalization. In the baseline scenario, we assume a positive productivity gap in favor of the status leader, $R_a > R_b(0)$. Substituting the solution of (30) in (15), we have

$$\hat{p}(t) = \frac{(R_a - R_b(0))\, e^{-\xi t} - (\theta/\nu)(\nu - 1) R_a}{\nu\sigma - (\nu - 1)\left[1 + (\theta/\nu)\left(1 + p(t)^{\sigma-1}\right)^{-1}\right]}. \tag{31}$$

From (31), the short-run behavior of terms of trade depends on the degree of status desire: if θ is relatively high, the numerator is already negative at time zero, implying an ever-decreasing price index. If θ is relatively low,[8] we have $\hat{p}(0) > 0$ and the time path of p is non monotonous. In this case, the price index is initially increasing, since the effects of the initial productivity gap dominate in the short run. However, as the rates of return get closer due to technology absorption, there exists a finite time

$$t_* = \ln\left[\frac{R_a - R_b(0)}{(\theta/\nu)(\nu - 1) R_a}\right]^{\frac{1}{\xi}} \tag{32}$$

in which terms-of-trade effects are zero, $\hat{p}(t_*) = 0$. After time t_*, associated with a peak in $p(t)$, technology absorption continues, the interest rate gap vanishes, and envy drives down the price index, which approaches zero asymptotically. Since $\hat{p} < 0$ holds indefinitely after the peak, this process yields a declining real consumption ratio - see (14) - and a switchover in growth leadership in favor of country b - see (17) - when traded goods are substitutes. This result is illustrated in Figure 2, which exploits the AK specification of section 3.1.1 and assumes $\sigma > 1$. Without envy, the price index grows in the short run, and achieves a steady-state equilibrium: growth rates are equalized, and the consumption gap remains in favor of country a. A positive degree of status desire, instead, implies that the consumption ratio γ_a/γ_b is strictly declining in the medium-long run. Country b will thus achieve (and eventually overcome, if preferences do not change) the consumption level enjoyed by the status leader.

4 Endogenous Status Desire

The main results of section 3 can be summarized as follows. First, status seeking may revert the sign of growth differentials by compensating for structural gaps. Second, if productivity gaps disappear, envy drives consumption shares away from stationary equilibria. The specific conclusions about envy-induced convergence ($\theta = \bar{\theta}$ in Proposition 2) and permanent divergence (Proposition 4), however, hinge on the assumption that preferences remain asymmetric forever. We now address this point by considering a different preference specification.

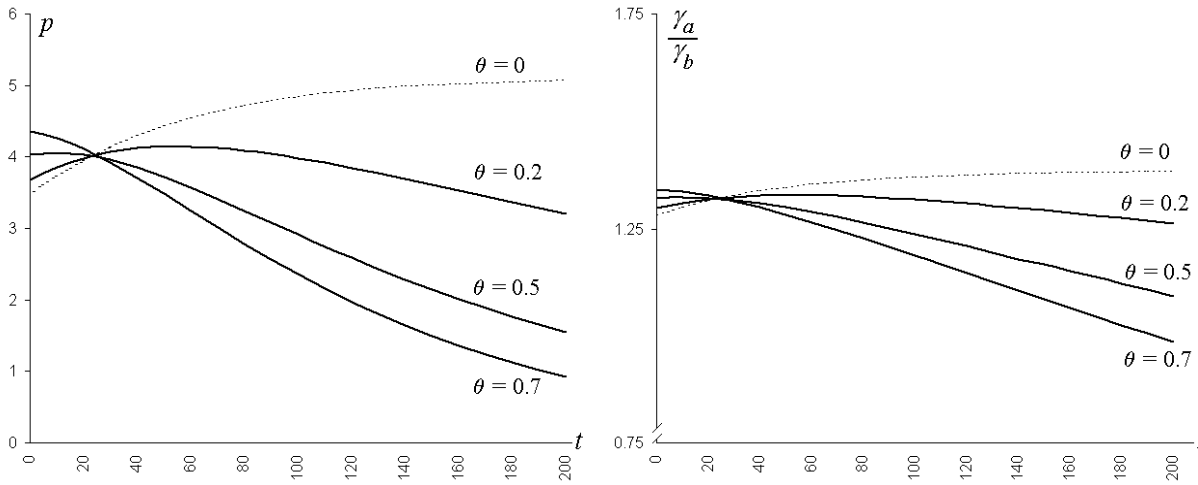

Figure 2: Terms of trade and real consumption ratio with technology absorption. Parameter values are $\sigma = 1.2$, $R_a = .05$, $R_b(0) = .04$, $\nu = 1.5$ and $\xi = .02$.

4.1 Modelling Transitory Envy

Propositions 2 and 4 represent a sort of 'convergence paradox': contrary to the standard result, technology diffusion implies divergence, whereas technological independence admits convergence. A first objection to this paradox is that envy-induced convergence is confined to be a very special case: in the presence of structural gaps, market shares are constant only if θ is exactly equal to the critical level $\bar{\theta}$. A second question relates to the fact that the various Propositions heavily hinge on the assumption of fixed parameters in country b's preferences. But will preferences be asymmetric forever? This is not a mere technical point. Recalling the example of Figure 2, if economy b becomes the growth leader, the real consumption ratio γ_a/γ_b eventually achieves unity, and further declines to zero if preferences do not change. But then, the logical reason for assuming envy does not hold anymore: once that country b enjoys the same standard of living, country a ceases to be the leader to admire.

These considerations suggest modifying preferences in order to make status desire an endogenous variable. We relax the assumption of fixed θ by assuming that the weight on benchmark consumption is itself linked to consumption gaps. Denoting by γ_i^e the average level of the consumption index observed in country i, a convenient specification is

$$\theta(t) = \begin{cases} \pi \left(\frac{\gamma_a^e(t)}{\gamma_b^e(t)} - 1 \right)^\alpha & \text{if } \gamma_a^e(t) \geqslant \gamma_b^e(t), \\ 0 & \text{otherwise.} \end{cases} \tag{33}$$

where $\pi > 0$ is a scale parameter. Following the standard reasoning of 'Catching-Up With The Joneses', the average consumption level in the economy is taken as given by each individual, and, due to the assumption of homogeneous agents, a symmetric equilibrium with $\gamma_i^e = \gamma_i$ arises. Given (33), envy operates only if consumption gaps exist, since the benchmark term is relevant as long as $\gamma_a > \gamma_b$. Parameter $\alpha > 0$ represents the sensitivity of envy to consumption gaps: status desire declines if the consumption gap shrinks over time, and preferences gradually become symmetric if γ_a/γ_b approaches unity monotonically.

As may be construed, the growth rate of θ affects terms-of-trade dynamics: optimality and equilibrium conditions now imply (see Appendix)

$$\hat{p} = \frac{R_a - R_b - \left(\frac{\nu-1}{\nu}\right)\overbrace{R_a \pi \left(p^{\sigma-1}-1\right)^{\alpha}}^{\text{Interest rate effect}}}{\nu\sigma - (\nu-1)\left[1 + \frac{\pi(p^{\sigma-1}-1)^{\alpha}}{\nu(1+p^{\sigma-1})}\right] + \underbrace{\frac{\alpha\pi(\sigma-1)(\nu-1)p^{\sigma-1}}{\left(p^{\sigma-1}-1\right)^{1-\alpha}}\ln\gamma_a}_{\text{Elasticity extra-term}}}. \tag{34}$$

Comparing (34) with (15), it follows that the difference with respect to the model with fixed parameters is twofold. First, the interest rate effect is now endogenous, and disappears if the consumption gap vanishes. Second, the elasticity effect features an extra-term which explicitly depends on consumption levels in the status leader.

For the sake of clarity, it is instructive to consider the implications of endogenous status desire by ruling out productivity differences, extending later the analysis to technology absorption and structural gaps. Setting $R_a = R_b$, the numerator of (34) reads

$$-\left(\frac{\nu-1}{\nu}\right) R_a \pi \left(p^{\sigma-1}-1\right)^{\alpha}. \tag{35}$$

In the baseline scenario, $\gamma_a(0) > \gamma_b(0)$ and $\sigma > 1$ imply that $p(0)^{\sigma-1} > 1$. Hence, expression (35) is strictly negative, and yields $\hat{p} < 0$ at least in the short run. However, endogenous status desire makes this process exclusively transitional, since growth rates will converge in the long run. To verify this conclusion, notice that the long-run behavior of the price index is determined by two different forces in (34). The first is represented by the interest rate effect: as the price index declines, $\gamma_a/\gamma_b = p^{\sigma-1}$ moves towards unity from above. Taken in isolation, this process would imply *convergence in growth rates as well as in levels*, since expression (35) is strictly negative during the transition, but gradually approaches zero as $p^{\sigma-1} = \gamma_a/\gamma_b \to 1$. In other words, envy makes the status seeker grow faster, but the degree of status desire falls during the transition, and completely disappears when consumption levels are equalized.

The second mechanism at work - the extra term in the elasticity effect - reinforces the result of convergence in growth rates, though it may render convergence in levels slower. Given a positive growth rate in the status leader, $\ln\gamma_a$ tends to infinity in the long run. Hence, if the growth of $\ln\gamma_a$ is relatively fast, the extra term

$$\frac{\alpha\pi(\sigma-1)(\nu-1)p(t)^{\sigma-1}}{\left(p(t)^{\sigma-1}-1\right)^{1-\alpha}}\ln\gamma_a(t)$$

may become huge in relatively short time, implying an increase in the denominator of (34) that drives $\hat{p}$ towards zero independently of the value of the real consumption ratio. While this mechanism reinforces convergence in growth rates (it further pushes $\hat{p}$ towards zero), it tends to delay convergence in levels: if the elasticity effect brings $\hat{p}$ already close to zero in the medium run - that is, with γ_b still far below γ_a - the interest rate effect is weakened. The numerator of (34) is negative, but it produces only small reductions in the price index due to a huge denominator. Whether this delay-effect can be substantial is a matter of parameters. This issue will be addressed numerically in the more general model with technology diffusion presented below.

4.2 Endogenous Envy and Technology Absorption

Consider the model of section 3.2 under the new preference specification. The net interest rate in country b converges to R_a with adjustment speed ξ by virtue of the absorption function (30). The numerator of expression (34) thus reads

$$(R_a - R_b(0))\, e^{-\xi t} - \left(\frac{\nu - 1}{\nu}\right) R_a \theta(t) \,. \tag{36}$$

The baseline scenario with $\sigma > 1$ and $R_a > R_b(0)$ yields the following results. In the short run, the behavior of the price index is quite similar to that described in Figure 2: if the interest rate gap is small relative to the initial status desire (now endogenously determined), the price index begins to decline immediately after time zero. If $R_a - R_b(0)$ is relatively huge, the price index grows in the short run, achieves a peak, and declines henceforth. The only difference is that the peak time is now endogenous.[9] As may be construed, the crucial difference with respect to section 3.2 is the long-run behavior of the consumption ratio. Since (36) becomes strictly negative, the dynamics of p and γ_a/γ_b after the peak are qualitatively the same as those obtained before with identical interest rates. The interest rate effect induces convergence in growth rates and in consumption levels, but whether convergence in levels is achieved in 'reasonable time', or is substantially delayed by fast growth in the status leader, depends on the strength of the elasticity effect.

In order to assess the plausibility of convergence in levels, we can follow a simple reasoning. The interest rate effect is *ceteris paribus* stronger the higher is the initial level of status desire, $\theta(0)$. That is, the elasticity effect matters more the lower is $\theta(0)$. Hence, if the γ_a/γ_b approaches unity even with modest values of $\theta(0)$, it is fair to conclude that endogenous status seeking generally induces convergence in levels. A numerical example of this reasoning is reported in Figure 3. Diagram (a) shows that the elasticity effect is indeed more relevant the lower is $\theta(0)$. This graph is obtained by assuming three different values of α in association with the same initial consumption gap ($\gamma_a(0)/\gamma_b(0) = 1.3$ and $\alpha = 0.1, 0.2, 0.3$). The resulting values of $\theta(0)$ are those reported next to the respective curves, and confirm that the real consumption ratio approaches unity at faster pace the higher is the initial status desire. Convergence in levels obtains even for the modest value $\theta(0) = 0.34$. We further reduce the initial status desire in diagram (b), which compares endogenous envy with the model with fixed parameters. The exogenous case, represented by curve I, assumes $\theta = 0.4$ and predicts a permanent growth leadership for country b. The endogenous case, represented by curve II, is obtained by setting $\pi = 0.5$ and $\alpha = 0.4$, which implies $\theta(0) = 0.3$. Despite the fact that status desire is initially lower in the endogenous case, the average speeds of decline in the consumption ratio are similar. Most importantly, endogenous envy yields equal consumption levels in the long run, thereby ruling out the logical inconsistencies generated by persistent asymmetries in preferences. In view of these results, which are confirmed by using alternative sets of parameters, we may conclude that

Proposition 5 *With technology absorption, endogenous envy generally implies convergence in real consumption levels. During the transition, the growth differential is in favor of the status seeker, and status desire falls. In the long run, preferences become symmetric and output shares are stabilized.*

Proposition 5 emphasizes the fact that specification (33) generates a type of convergence which still differs from that obtained in a status-free world with technology diffusion. Recalling section 3.2, the status-free model predicts convergence in growth rates but not in levels, so that income gaps persist. With endogenous status seeking, instead, output shares converge, and the growth differential is in favor of country b during the transition. This last result is described in Figure 4, which provides a more complete summary of the predictions of the status-free model versus endogenous status desire. We use the same parameters of the calibration presented in section 5, and report the dynamics of output shares, s_a and s_b, respectively defined as

$$s_i = \frac{p_i Y_i}{p_a Y_a + p_b Y_b}, \quad i = a, b. \tag{37}$$

Diagram (a) in Figure 4 shows that, in the status-free model (SF), country b grows faster only in the short run, by virtue of technology diffusion: the output share s_b slightly improves only for a short period, and consumption and output levels remain higher in country a. With endogenous status desire (ED), instead, convergence in consumption levels requires that the initially poor country grow faster during the transition: higher growth rates in consumption call for faster capital accumulation, and result into converging output shares. The effects of the intertemporal reallocation operated by consumers in country b are made explicit in diagrams (b) and (c) of Figure 4. Since consumption levels must be initially reduced in order to generate high savings, the consumption propensity in country b falls short of the long-run level during the transition, and converges to the asymptotic equilibrium from below. Symmetrically, the investment rate exceeds its long-run value during the transition, reflecting the need to accumulate capital at faster pace. Consequently, as shown in diagram (d), the real endowment ratio K_a/pK_b declines towards unity, implying identical output shares in the long run. This phenomenon does not arise without envy: in the status-free model, the propensity to consume approaches the long-run value from above and in relatively short time, since saving rates are not influenced by status desire.

With regard to Figure 4, the inverted-U shape of the transitional path followed by the investment-GDP share in country b deserves particular attention. Similar hump-shaped paths can in fact be obtained in closed-economy models with 'Catching-Up With The Joneses', and the same qualitative dynamics characterized the behavior of saving rates in South Korea (Chari et al. 1996), Japan (Christiano, 1989) and Western Europe in the post-war period (Alvarez-Cuadrado, 2007b). According to Carroll (2000) and Alvarez-Cuadrado (2007b), this stylized fact is one signal of the existence of time-dependent preferences. Following a similar reasoning, in section 5 we perform a calibration exercise to compare the convergence process induced by international envy with the main stylized facts observed in fast-developing East Asian economies.

4.3 Endogenous Envy and Structural Gaps

Assume $\sigma > 1$ and $R_a > R_b$, with R_a and R_b constant over time. Expression (34) then characterizes a model with structural gaps and endogenous envy. Exploiting the definition of critical status desire (26), the main results can be described as follows. First, assume that parameters are such that $\theta(0) < \bar{\theta}$. In this case, (34) implies $\hat{p}(0) > 0$, and the consumption gap widens in the short run ($\hat{\gamma}_a > \hat{\gamma}_b$). However, this process comes to a halt: since θ grows in response to increasing consumption gaps (interest rate effect)[10], there generally exists an instant t' at which status desire compensates productivity differences, i.e.

$$\theta(t') = \bar{\theta} = \frac{R_a - R_b}{R_a}\left(\frac{\nu}{\nu - 1}\right). \tag{38}$$

In this situation, the price index is constant, $\hat{p}(t') = 0$, and the consumption gap is constant as well. This implies that status desire remains fixed at the critical level $\bar{\theta}$ from time t' onwards: the

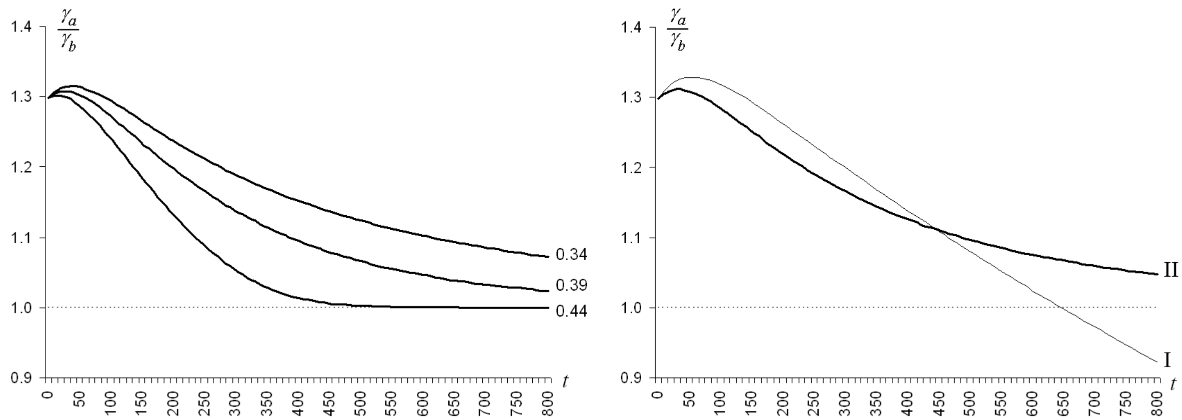

Figure 3: Endogenous envy. Diagram (a): the elasticity effect is stronger the lower is initial status desire. Diagram (b) Case I assumes fixed parameters ($\theta = 0.4$). Case II assumes endogenous status desire ($\pi = 0.5$ and $\alpha = 0.4$). Other parameters are as in Figure 2.

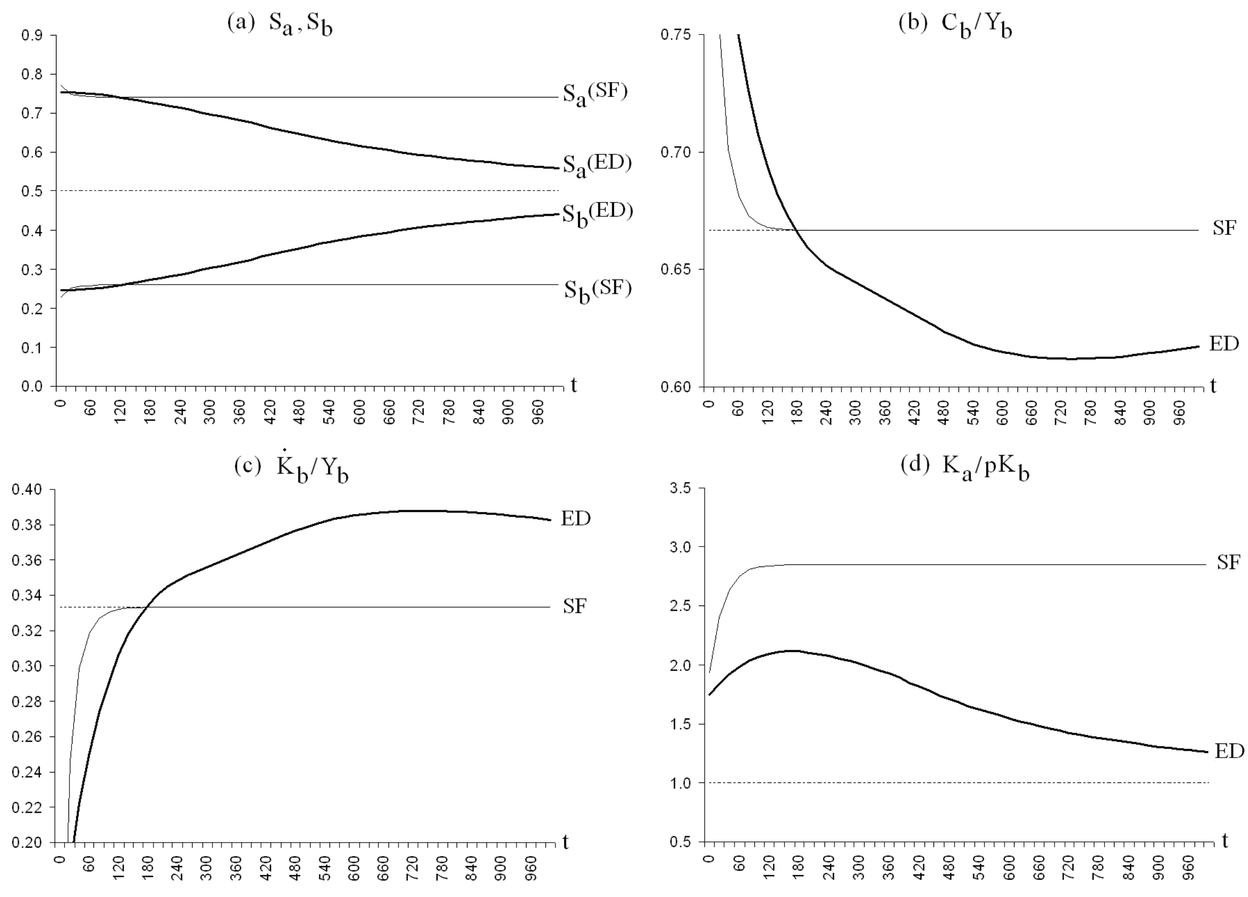

Figure 4: Status-free model versus endogenous benchmarks (parameter values: see section 5).

two economies exhibit identical growth rates, and persistent income gaps in the long run. Notice that this process is 'favorable' to country b, since the same initial situation with fixed parameters ($\theta < \bar{\theta}$) would imply persistent divergence in favor of the status leader a. Hence, endogenous status desire erodes the growth leadership of country a during the transition.

In the opposite case, $\theta(0) > \bar{\theta}$, the mechanism is specular: the price index declines in the short run and country b is the growth leader. However, the consumption gap and the degree of status desire decline. There exists an instant t' at which expression (38) holds true, with θ approaching $\bar{\theta}$ from above. Hence, consumption and output shares of country b are improved during the transition, but long-run consumption levels are not equalized because productivity gaps in favor of country a persist. Since structural gaps would imply divergence in a status-free world, these results can be summarized as follows: *if productivity differences persist, endogenous envy induces convergence in growth rates, and reverts growth differentials in favor of the status seeker during the transition if the initial degree of status desire is sufficiently high.*

5 Relative performance and convergence

5.1 The East Asian Experience

In the early Nineties, the vast empirical evidence documenting cross-country differences in income levels stimulated a huge literature on international trade and economic growth. A first strand of literature focused on the persistence of income gaps observed between advanced and less-developed economies (Temple, 1999; Acemoglu and Ventura, 2002). At the same time, the striking results achieved during the 1970-90s by Hong-Kong, South Korea, Singapore, and Taiwan, inspired a parallel literature that analyzed the growth performance of the so-called Asian Tigers. For nearly three decades, average growth rates in these countries remained well above those achieved by Western industrialized economies, implying substantial catching-up in income levels.

		Total Factor Productivity Growth		Real Output Growth
Country	*Period*	*Young (1995)*	*Hsieh (2002)*	*Young (1995)*
Hong Kong	1966-91	2.3	2.7	7.3
Singapore	1966-90	0.2	2.2	8.7
South Korea	1966-90	1.7	1.5	10.3
Taiwan	1966-90	2.6	3.7	9.4
		Dougherty (1991)	*Jorgenson-Yip (2001)*	*Jorgenson-Yip (2001)*
G-7 Average	1966-89	1.33	1.28	3.6

Table 1. Average annual real growth rates and estimated TFP growth rates (sources indicated).

There is wide consensus that the convergence process of East Asian economies has not been primarily led by technological progress. This conclusion, originally put forward by Young (1995), builds on the observation that total factor productivity (TFP) growth in Asian economies appeared only slightly higher than in OECD countries during the 1966-1990 period (see Table 1). The limited gap in TFP growth is confirmed by subsequent studies - e.g. Hsieh (2002) - and suggests that growth in East Asia has been fundamentally driven by the rise in factor inputs. The overwhelming growth observed in output and manufacturing exports thus appears tangled to the pace of capital accumulation, rather than explained by technology spillovers.

The East Asian experience is of particular interest in the present context. Asymmetric preferences are a potential root of 'capital booms', and the main stylized facts that characterized the performance of the Asian Tigers appear consistent with the predictions of the model with endogenous envy. As shown in section 4.2, technology spillovers do not suffice to eliminate income differentials, whereas endogenous status desire generates convergence in consumption and output levels in the long run. In particular, technology spillovers may imply slightly higher TFP growth rates for the follower in the short-medium run, but catching-up in real incomes is actually achieved by means of faster accumulation of physical capital. In the following section, we argue that international differences in saving rates induced by asymmetric preferences may be part of the explanations for the relative performance of Asian Tigers.

5.2 Calibrated Transitional Dynamics

In this section we calibrate the model with endogenous status desire (ED) presented in section 4.2 in order to obtain transitional dynamics consistent with the stylized facts that characterized the performance of Singapore (country b) relative to the United States (country a). The general aim is to (i) obtain transitional dynamics that reproduce historical trends in output and consumption shares, and (ii) verify the qualitative predictions of the ED model with observed trends in accumulation rates, consumption propensities, terms of trade and indices of exports and imports in Singapore. We will emphasize the role played by asymmetric preferences by also reporting the predictions of the status-free (SF) model with technology diffusion.

The choice of Singapore is in part suggested by the availability of data, but also due to the consistency between our previous assumptions and two peculiar facts. The first, emphasized by Hsieh (2002), is that, during the crucial period 1970-90, the return to capital in Singapore has remained remarkably constant, despite the high rate of capital accumulation indicated by national accounts. We relate this stylized fact to the plausibility of the AK production function assumed in this paper. The second fact, pointed out by Young (1995), is that Singapore outperformed OECD countries in terms of TFP growth only at the beginning of the take-off period: total factor productivity has been growing substantially only in the late 1960s, so that output growth during the 1970-1990 period can be almost exclusively explained by factor accumulation.[11] These findings are consistent with the absorption process (30), that generates exogenous growth gaps in favor of country b only in the short run. More generally, the main stylized facts that characterized the relative performance of Singapore can be summarized as follows:

Stylized fact #1. Real consumption expenditures and output shares per capita exhibit convergence in levels relative to the US from 1960 onwards. TFP growth has been substantially higher in Singapore only during the 1960s.

Stylized fact #2. The consumption-GDP ratio, exceeding 0.8 in 1960, shrank dramatically during the 1970s and fell short of that in the US; symmetrically, the share of gross capital formation over GDP rose substantially, exceeding that in the US.

Stylized fact #3. The growth process was accompanied by a declining trend in terms of trade, and a rising export-import ratio in terms of quantum/quantity indices (see below).

Parameters	A_a	R_a	ν	ξ	α	π	σ	$A_b(0)$	$R_b(0)$
Calibration	0.10	0.06	1.80	.004	0.60	0.50	1.50	0.06	0.03

Table 2. Calibration of parameters.

The reference period for the simulation is 1960-2004, with $t = 0$ associated with 1960 and $t = 1000$ with 2010. For comparison, we use time-series data from the World Bank (2007), that provide a complete set of measures of consumption and investment aggregates, as well as homogeneous series for terms of trade and export-import indices. For output shares, we use PPP-adjusted series of real GDP from the Penn World Tables (Heston et al. 2006).[12] The calibration strategy is as follows. As shown in Table 2, we begin by fixing $A_a = 0.10$, an initial output-capital ratio which is consistent with a broad concept of capital that applies to the current AK specification (cf. Alvarez-Cuadrado, 2007: Tab.4), and choose R_a and ν in order to approximate the average consumption-GDP share observed in the status leader. Setting $R_a = 0.06$ and $\nu = 1.8$, the status leader exhibits a long-run propensity to consume $C_a^{\infty}/Y_a^{\infty} = 0.66$, and an asymptotic growth rate $R_a/\nu = 0.033$, both consistent with the average consumption-GDP share (65%) and the average growth rate of real output (3.3%) in the US during the 1960-2004 period. Technological parameters in country b are set in order to generate an initial equilibrium matching the four observed values reported in Table 3, i.e. the consumption and output shares in per capita terms, and the respective propensities to consume. In the ED specification, we are able to reproduce this initial equilibrium by setting $R_b(0) = 0.03$, the associated social return $A_b(0) = 0.06$, and the other parameters reported in Table 2.[13] The speed of absorption $\xi = 0.4\%$ suffices to minimize the effects of the initial productivity gap by the end of the first decade, so that the transitional growth differentials obtained from 1970 onwards are fundamentally driven by asymmetric accumulation rates. Initial endowments satisfy $K_a/pK_b = 1.7$ and the values of consumption expenditures, propensities and output shares are in line with the baseline 1960 values: see Table 3.

Initial Equilibrium	C_a/pC_b	Y_a/pY_b	C_a/Y_a	C_b/Y_b
ED model: $t = 0$	2.3	3.1	0.66	0.86
Data: 1960	2.3	3.2	0.64	0.88

Table 3. Equilibrium versus observed values (per capita) at time zero.

The initial level of status desire implied by these parameters is $\theta(0) = 0.59$, and the speed of convergence in output levels is empirically consistent: the average annual growth differential between country a and country b predicted by the ED model is -1.7%, and the observed value is -1.9% (Heston et al. 2006). In the ED model, the stylized facts mentioned above are matched by the following predictions: as productivity growth gaps vanish, consumption levels and output shares converge; the process is driven by faster capital accumulation in the status seeker - that exhibits lower consumption propensities, declining terms of trade and an increasing export-import ratio during the transition. Specifically, stylized fact #1 is analyzed in Figure 5: the ED model approximates well the speed of convergence in output and consumption (per capita) shares observed between Singapore and US. In contrast, the SF model predicts a permanently low output share for Singapore, as convergence obtains only in growth rates, and is exclusively induced by technology diffusion.[14]

Stylized fact #2 is considered in Figure 6. Diagram (a) depicts the ratio between investment-output shares (US/Singapore) in the model, calculated as $(\dot{K}_a/Y_a)/(\dot{K}_b/Y_b)$. Without envy, Singapore's saving rate adjusts to that in the US in the short run. With status desire, the dynamics clearly indicate extra-saving in country b: the investment-GDP share in Singapore goes above that in the US during the transition, and converges to the status-free level in the long run. The behavior of consumption propensities is obviously specular: diagram (c) reports the ratio between consumption-GDP shares of US and Singapore during the relevant period. The right graphs of Figure 6 show that observed investment and consumption shares obeyed the same qualitative dynamics. Diagram (b) reports Gross Capital Formation as percentage of real GDPs (ratio between

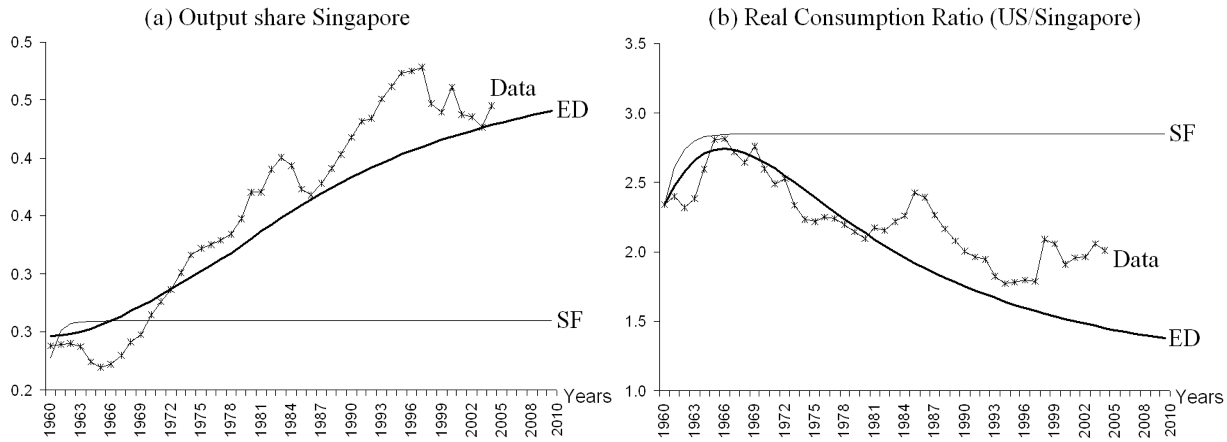

Figure 5: Simulation results and historical trends. (a) output shares in Singapore and dynamics of s_b. (b) ratio in real consumption expenditures per capita and dynamics of $p_a c_a / p_b c_b$.

US and Singapore). The extra-saving effect in Singapore is confirmed, and appears quantitatively stronger than that predicted by the model. As accumulation rates have been exceptionally high, consumption propensities have been exceptionally low: diagram (d) shows that households' expenditure shares of GDP in Singapore declined dramatically relative to the US, remaining quite low even in recent times (the US/Singapore ratio is still well above unity).

Stylized fact #3 is described in Figure 7: the decline in the price index and the rise in the export-import ratio in Singapore is represented by the transitional dynamics of $p = p_b/p_a$ and $c_a^b/c_b^a = p^{-1}$. Our proxies are represented by the series of Net Barter Terms of Trade for Singapore, and the Export-Import ratio obtained from the respective Quantum-Quantity indices. In both cases, the longest homogeneous time-series available are those reported by the World Bank (2007), respectively covering the periods 1980-2005 and 1980-2001. Diagrams (b) and (d) suggest consistency with observed terms-of-trade dynamics - the price of exports relative to that of imports has been declining in Singapore - as well as the trend in the export-import ratio, which displays a negative slope.

The calibration exercise suggests that asymmetric preferences with status desire allow us to reproduce the main characteristics of the growth performance of Singapore. Most of these stylized facts represent a general feature of the East Asian experience, and it seems fair to argue that the behavior of saving rates in certain fast-developing economies can be rationalized in terms of asymmetric intertemporal preferences. The obvious caveat is that the scope of calibration is to verify compatibility: while the above results suggest consistency between theoretical predictions and historical trends, the question of whether, and to what extent, status desire has been crucial for the rise in accumulation rates is obviously an empirical question. To my knowledge, this specific issue has not been addressed at the empirical level so far, and represents an interesting topic for future applied research on intertemporal preferences.

5.3 Remarks and connections with previous literature

Nowadays, preferences are likely to be interdependent among trading countries. While the view that status seeking has already crossed the borders is discussed in development studies, and advocated by sociologists, a formal treatment of international status seeking in a general equilibrium

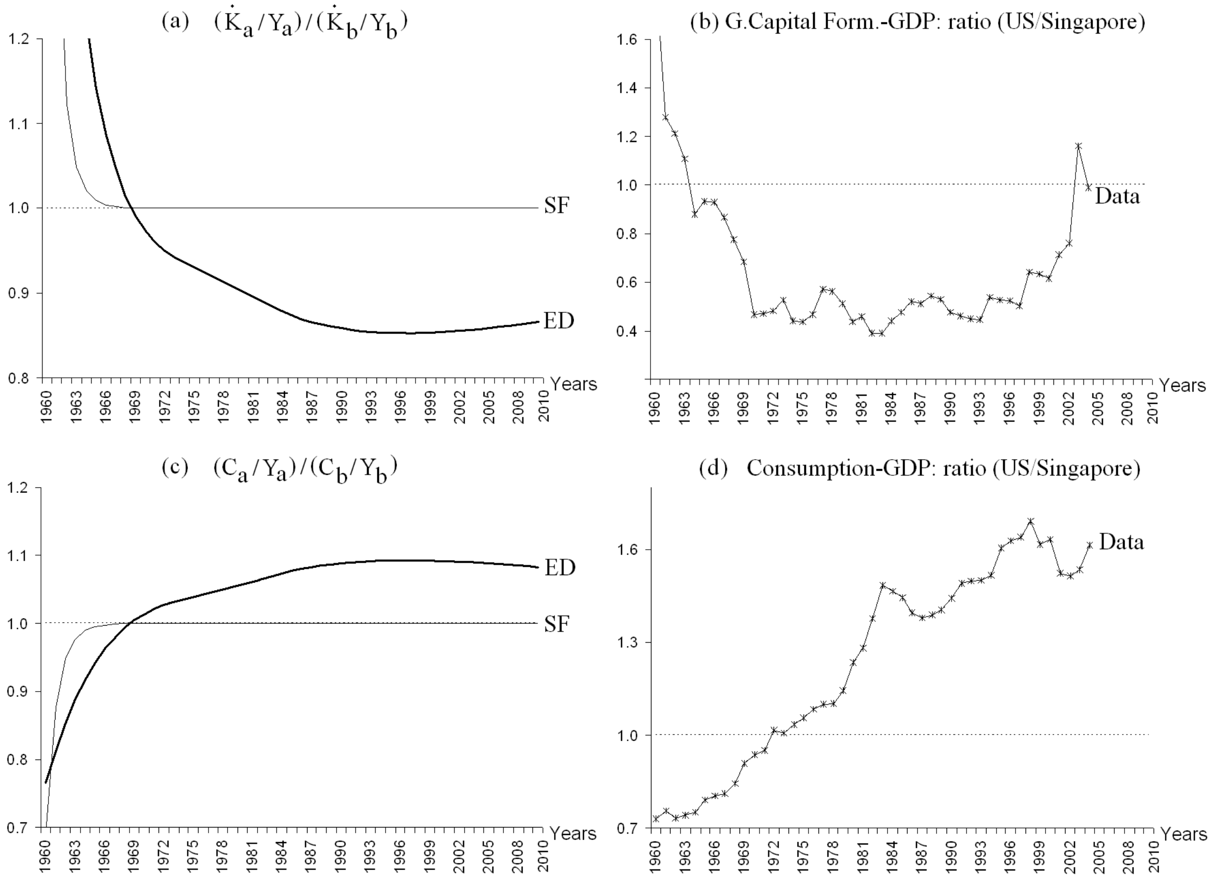

Figure 6: Simulation results and historical trends. (a) dynamics of $\dot{K}_a Y_b/\dot{K}_b Y_a$. (b) Gross Capital Formation as a share of GDP: ratio US/Singapore. (c) dynamics of $C_a Y_b/C_b Y_a$. (d) Consumption expenditures as a share of GDP: ratio US/Singapore.

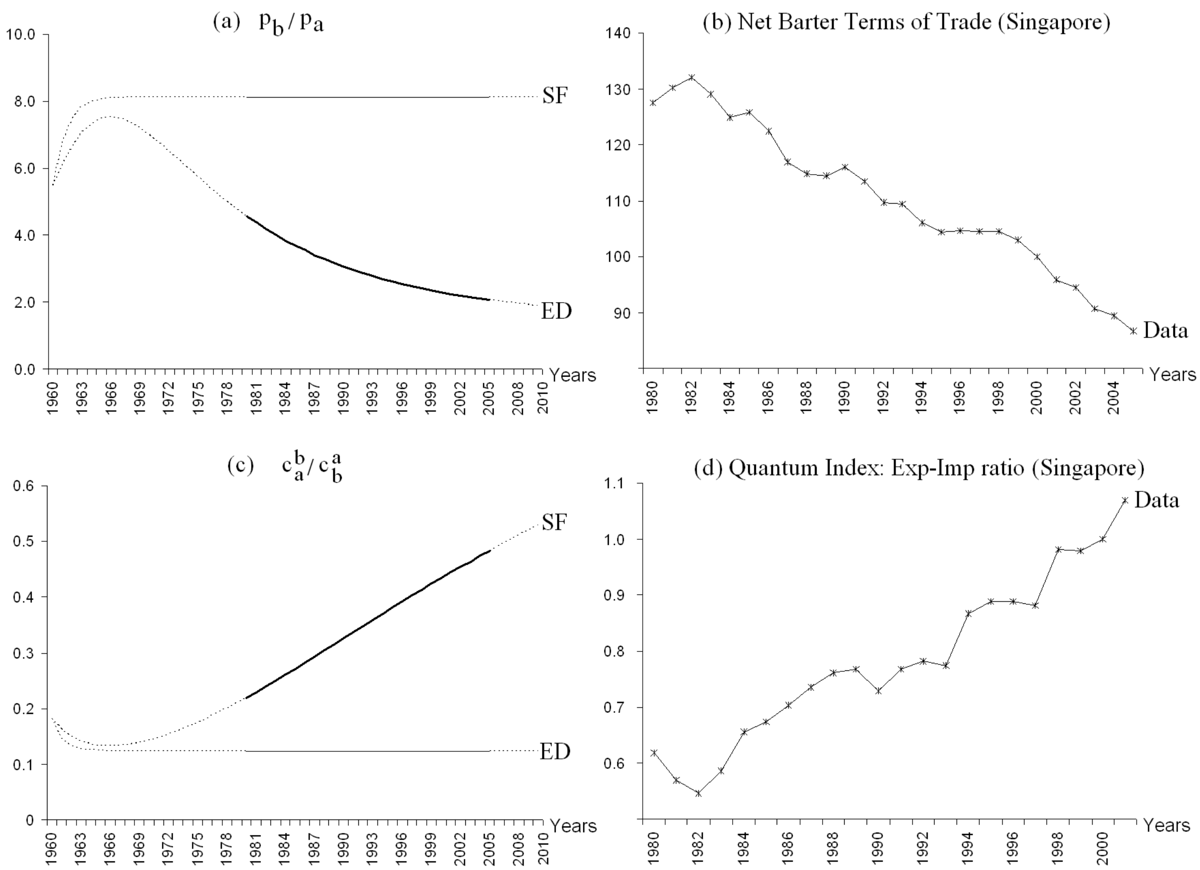

Figure 7: Simulation results and historical trends. (a) Time-path of p. (b) Observed Net Barter Terms of Trade in Singapore (base year: 2000). (c) Time-path of the (physical) export-import ratio, p^{-1}, in country b. (d) Observed ratio between Exports and Imports Quantum/Quantity indices in Singapore (base year: 2000).

perspective is lacking in the literature. This paper builds on related works on *intra*-national status seeking, and exploits the general features of recent models with 'Catching-Up With the Joneses', though it differs in the focus, and hence in the nature of predictions. The present analysis investigates the effects of asymmetric preferences between trading economies in terms of international convergence and relative performance; closed-economy models emphasize the peculiar behavior of saving rates implied by time-dependent preferences, and its policy implications. A major similarity is represented by the intertemporal reallocation effect described in section 4.2: both frameworks predict that status-related preferences generate faster growth in consumption, hump-shaped transitional dynamics in saving rates, and (generally positive) growth effects.[15] The main differences can be summarized as follows.

A first peculiarity of transboundary envy is that capital booms are explicitly 'directed' at reducing international differentials. In a closed-economy setting, the behavior of saving rates depends on internal benchmarks and habit-related parameters - e.g. the adjustment speed to the reference stock - whereas, in our analysis, accumulation rates reflect the willingness to achieve foreign standards, with long-run equilibrium propensities determined by the status leader. This implies that consumption and investment dynamics must be interpreted in relative terms. This point can be clarified by comparing our calibration exercise with related works of Carroll (2000) and Alvarez-Cuadrado (2007b). These authors respectively analyze the development paths of Japan and Western Europe in the post-war period, and calibrate closed-economy models with internal benchmarks to reproduce the main stylized facts - in particular, hump-shaped paths of saving rates. Also the present model yields inverted-U dynamics for investment shares in the status seeker (cf. Figure 4), but this is not the crucial condition for international catching-up. Since utility depends on external benchmarks, what matters for convergence is the hump-shaped path of the *ratio* between the saving rates of countries b and a. The effect of transboundary envy is indeed captured by the gap between the respective accumulation rates, and convergence is typically characterized by higher investment shares in country b during the transition (cf. Figure 6.a).

The second peculiarity of our model is that whether faster accumulation actually induces convergence in real income *levels* depends on the interactions between status desire, structural gaps, and the nature of traded goods. Productivity differences must be small relative to status desire - which generally requires some degree of technology diffusion - and goods must be perceived as substitutes in order to drive terms-of-trade effects in the favorable direction. These results add a trade-related interpretation of the convergence process: higher consumption growth rates in certain developing countries drive down terms of trade, thereby increasing their export-import ratio while improving output shares. Notice that also this prediction seems to fit with the East Asian experience, where the rise in exports that accompanied output growth has been "virtually unprecedented" (Young, 1995). More generally, the interaction between asymmetric preferences, terms of trade and relative growth performance is a promising topic for future research, since empirical evidence suggests that terms-of-trade effects actually matter for growth, and are "quantitatively important in understanding the observed patterns of cross-country income differences" (Acemoglu and Ventura, 2002: p.681).

A final remark relates to the assumption of balanced trade. In our model, domestic capital is owned by residents in each economy, so that private wealth consists of immobile assets. With some modifications, the analysis of section 2.1 can be applied to a different setup *à la* Feenstra (1996), where bonds representing ownership of firms are freely traded across borders. Assuming a perfectly integrated capital market, uncovered interest parity would imply $R_a - R_b = \hat{p}$. In this case, the optimality conditions yield

$$\hat{\gamma}_a - \hat{\gamma}_b = -\frac{\theta(\nu-1)}{\nu}\hat{\gamma}_a. \tag{39}$$

On the one hand, expression (39) clarifies that a positive degree of status desire induces declining real consumption gaps even without balanced trade. On the other hand, since agents are able to borrow and lend, the market-clearing conditions for the world equilibrium imply that expressions (8), (14) and (15) do not hold anymore. More precise conclusions regarding the implications of envy for growth-rates differentials thus require further analysis - an issue which is left for future research.

6 Conclusions

This paper analyzed two-country models of endogenous growth where preferences display international status seeking - i.e. 'Catching-Up With The Joneses' phenomena occurring between trading economies. When the utility of agents in developing countries is affected by consumption gaps with advanced economies, status desire raises consumption growth rates and distorts terms of trade. If traded goods are substitutes, envy tends to revert growth differentials in favor of the status seeker. In particular, we have shown that two types of convergence may be induced by asymmetric preferences. Endogenous status desire generates (i) convergence in growth rates by compensating for structural gaps, and (ii) convergence in income levels if productivity differences are absorbed by technology diffusion. These processes are driven by faster capital accumulation in the status seeker: lower consumption propensities and higher savings yield positive growth differentials for the developing economy during the transition.

The main predictions of the model recall the main stylized facts that characterized the growth performance of East Asian economies. For more than three decades, the 'Asian Tigers' displayed higher growth rates with respect to Western industrialized economies, and the steady decline in per capita income gaps was accompanied by high accumulation rates. Calibrating the model with endogenous status desire and technology diffusion, we obtain transitional dynamics consistent with the behavior of output shares, accumulation rates, consumption propensities, and terms of trade observed in Singapore in the 1960-2004 period. A question that naturally arises is whether the role of status desire can be confirmed by empirical evidence. In particular, the idea that international status seeking may boost consumption growth rates appears plausible with special regard to big countries that are rapidly catching up in the stages of economic development, such as India and China. Addressing this issue at the empirical level seems an interesting topic for future research, and would shed more light on the scope and relevance of consumption externalities in today's globalized world.

Notes

[1] Trade balance requires that the value of aggregate imports in country a match that of aggregate imports in country b - that is, $p_b c_a^b N_a = p_a c_b^a N_b$. Substituting this condition in (6) and (2) we obtain $c_a = p^\sigma c_b$.

[2] Terms-of-trade effects in (11)-(12) vanish as $\nu \to 1$. In this case, utility becomes logarithmic and the growth rates of consumption expenditures in both countries obey the standard Keynes-Ramsey rule, $\hat{c}_i = R_i$. The logarithmic case, however, is not interesting for the aim of the present analysis, since $\nu \to 1$ would imply that consumers in country b do not display 'Catching-Up with the Joneses' behavior.

[3]A sufficient condition to rule out the degenerate case of a negative price elasticity (see (18) below) is

$$\frac{\nu}{\nu-1}\left[1+\nu\left(\sigma-1\right)\right]>\theta.$$

Since $\nu>1$ and $\theta<1$, the above inequality is easily met for a wide range of parameters (in particular, it is necessarily satisfied when traded goods are substitutes, $\sigma>1$) and is assumed to hold throughout the rest of the paper. Most related literature ignores similar restrictions by assuming logarithmic intertemporal utility, $\nu=1$. In this case, the price elasticity, $1/\sigma$, is a positive constant by construction.

[4]Consumption levels at $t=0$ in the two countries are respectively chosen by private agents as in the standard Ramsey model. The initial price is associated with the resulting consumption ratio through $c_a\left(0\right)/c_b\left(0\right)=p\left(0\right)^{\sigma}$. An explicit characterization of the relation between $p\left(0\right)$ and initial wealth is provided in section 3.1.1 for the AK model - see (27) below - and will be exploited to perform the simulations presented in this paper (see Appendix).

[5]Since ϵ_{∞} is constant, $\hat{p}$ and $\hat{\tau}$ are constant in the long run. From optimality conditions (11)-(12), $\hat{C}_a$ and $\hat{C}_b$ also converge to stationary values.

[6]In Figure 1, in order to obtain initial equilibria with $\gamma_a\left(0\right)>\gamma_b\left(0\right)$ we assumed $K_a\left(0\right)/K_b\left(0\right)=4$ for $\sigma>1$, and $K_a\left(0\right)/K_b\left(0\right)=0.25$ for $\sigma<1$. Numerical substitutions conducted with $\sigma<1$ show that deflating the initial endowment ratio by the price index always yields $K_a\left(0\right)<p\left(0\right)K_b\left(0\right)$ and, for the assumed values of social returns to capital, $Y_a\left(0\right)<p\left(0\right)Y_b\left(0\right)$. The opposite results hold with $\sigma>1$, since country a always displays higher real output and consumption at time zero.

[7]See Abramovitz (1986). Empirical estimations of absorptive capability are presented in Hansson and Henrekson (1994), and applications to international technology diffusion are discussed in Rogers (2003).

[8]The peak exists if $\theta>\frac{R_a-R_b(0)}{R_a}\left(\frac{\nu}{\nu-1}\right)$, which implies $t_*>0$ from (32). In Figure 2, the critical inequality is $\theta>0.6$. For $\theta=0.2$ and $\theta=0.5$, the price index increases in the short run, and declines after the peak. For $\theta=0.7$, the short-run increase in p is deleted, and terms-of-trade effects are always negative due to strong status desire.

[9]As p grows in the short run, the consumption gap widens, but status desire grows accordingly, so that an exact compensation between productivity gaps and status desire is achieved through both the reduction in productivity gaps and the rise in the degree of envy. That is, if expression (36) is initially positive, it becomes zero because the first term declines while the second term increases.

[10]For the sake of clarity and brevity, the discussion implicitly assumes that elasticity effects are relatively weak. As for the case with technology absorption, it can be shown that this actually the case for various combinations of parameters. Moreover notice that strong elasticity effects would not alter the main conclusions of section 4.3, since they reinforce convergence in growth rates.

[11]Using the primal approach, Young (1995) estimates that total factor productivity in Singapore grew at 4.6% during the 1966-70 period, in contrast with -0.9% in the 1970s and -0.5% in the 1980s (ibid. p.658: Table VI). Over the whole 1966-90 period, the average TFP growth rate estimated by Young (1995) is 0.2%. According to Hsieh (2002), these numbers are increased by 2% using the dual approach of growth accounting. On the one hand, the fact that TFP growth drove the process only in the 1960s remains after re-scaling. On the other hand, the dual approach is more suitable to deal with constant returns to capital (see Hsieh, 2002), and implies an average 2.2% growth over the 1966-90 period - in line with the values exhibited by Hong-Kong and Taiwan.

[12]The World Bank (2007) dataset includes complete 1960-2004 series for consumption and investment flows, exports-imports and terms of trade. I have identified consumption expenditures with Households' Final Consumption, and calculated the consumption-GDP shares C_i/Y_i accordingly. Since World Bank (1997) series of PPP-adjusted GDP only cover the 1980-2004 period, output shares are calculated from Heston et al. (2006).

[13]Having to assume identical technologies, we equalize R_i/A_i in both countries, so that we obtain the social marginal product in country b by calculating $A_b\left(0\right)=R_b\left(0\right)A_aR_a^{-1}\simeq0.06$.

[14]In this section, we are comparing the ED model with a status-free variant that features the same initial consumption ratio and identical parameter values. In particular, we choose initial conditions in order to equalize the consumption ratio in both the ED and SF model. In the SF specification, an identical real consumption ratio is obtained by setting $K_a/pK_b=1.9$. Alternatively, we could fix equal initial endowments in the two models and obtain different initial consumption ratios. The difference in the results is almost nihil, given the negligible difference we are assuming in initial endowments.

[15]See Carroll et al. (1997), Alonso-Carrera et al. (2004) and Alvarez-Cuadrado et al. (2004). Similar connections and conceptual differences may be traced with respect to the literature where status seeking is modelled according to the *relative wealth approach* (Corneo and Jeanne, 1997; Futagami and Shibata, 1998; Fisher, 2005; Fisher and Hof, 2005). In this framework, the benchmark term depends on the gap between individual and average per capita asset holdings (instead of consumption levels), and this type of preferences may also induce equilibria with overconsumption. Fisher (2005) and Fisher and Hof (2005) apply the relative wealth approach to open-economy models,

but again assume *intra*-national status seeking: both papers consider a small open economy where the benchmark level is determined within the country, and address different issues with respect to those tackled here.

7 Appendix

The second-step problem. Consider the general case with endogenous status desire (section 4). From (7), the first-step problem yields the indirect utility functions

$$\begin{aligned} u_a &= \left[c_a^{1-\nu}\tau^{1-\nu}p^{\nu-1}-1\right](1-\nu)^{-1}, \\ u_b &= \left[c_b^{1-\nu}\tau^{1-\nu}\gamma_a^{-\theta(1-\nu)}-1\right](1-\nu)^{-1}. \end{aligned}$$

The resulting optimality conditions of the second-step problems respectively yield

$$\hat{\mu}_a = -R_a \text{ and } \mu_a = c_a^{-\nu}\tau^{1-\nu}p^{\nu-1}, \tag{A1}$$

$$\hat{\mu}_b = -R_b \text{ and } \mu_b = c_b^{-\nu}\tau^{(1-\nu)}\gamma_a^{-\theta(1-\nu)}. \tag{A2}$$

From (A1) we have

$$\nu\hat{c}_a = R_a - (\nu-1)(\hat{\tau}-\hat{p}). \tag{A3}$$

Since θ is time-varying, we can take logarithms and time-differentiate (A2) to obtain

$$\hat{\mu}_b = -\nu\hat{c}_b + (1-\nu)\hat{\tau} + \theta(\nu-1)\hat{\gamma}_a + \delta$$

where we have defined $\delta \equiv \dot{\theta}(\nu-1)\ln\gamma_a$. Substituting $\hat{\mu}_b = -R_b$ and $\hat{\gamma}_a = \hat{c}_a + \hat{\tau} - \hat{p}$ yields

$$\nu\hat{c}_b = R_b + (1-\nu)\hat{\tau} + \theta(\nu-1)\left[\hat{c}_a + \hat{\tau} - \hat{p}\right] + \delta. \tag{A4}$$

Using (A3) to substitute for $\hat{c}_a$ yields

$$\nu\hat{c}_b = R_b - (\nu-1)\hat{\tau} + \theta(\nu-1)\frac{R_a}{\nu} + \frac{\theta(\nu-1)}{\nu}(\hat{\tau}-\hat{p}) + \delta. \tag{A5}$$

Subtracting term by term, (A3) and (A5) imply

$$\nu(\hat{c}_a - \hat{c}_b) = R_x + (\nu-1)\hat{p} - (\theta/\nu)(\nu-1)(\hat{\tau}-\hat{p}) - \delta. \tag{A6}$$

Notice that time-differentiation of τ implies

$$\hat{\tau} - \hat{p} = -\frac{1}{1+p^{\sigma-1}}\hat{p}. \tag{A7}$$

Plugging (A7) in (A6), and substituting $\nu(\hat{c}_a - \hat{c}_b) = \nu\sigma\hat{p}$, we can rearrange terms to write

$$\hat{p} = \frac{R_a - R_b - (\theta/\nu)(\nu-1)R_a}{\nu\sigma - (\nu-1) - \frac{(\theta/\nu)(\nu-1)}{1+p^{\sigma-1}} + \frac{\delta}{\hat{p}}}. \tag{A8}$$

Derivation of (11)-(12) and (15). The model with fixed parameters features $\dot{\theta} = 0$ and hence $\delta = 0$. Indeed, setting $\delta = 0$, expression (A8) reduces to (15), and expressions (A3)-(A4) yield (11)-(12).

Derivation of (34) Time-differentiating (33) we have

$$\hat{\theta} = \alpha \left(\frac{\dot{\gamma}_a}{\gamma_a - \gamma_b} - \frac{\dot{\gamma}_b}{\gamma_a - \gamma_b} - \hat{\gamma}_b \right).$$

Substituting $\gamma_a = \gamma_b p^{\sigma-1}$ and rearranging terms yields

$$\hat{\theta} = \alpha \frac{p^{\sigma-1}}{p^{\sigma-1}-1} \left(\hat{\gamma}_a - \hat{\gamma}_b \right) = \alpha \frac{p^{\sigma-1}}{p^{\sigma-1}-1} \left(\sigma - 1 \right) \hat{p}. \tag{A9}$$

Expression (A9) implies that $\delta \equiv \dot{\theta} \left(\nu - 1 \right) \ln \gamma_a$ can be rewritten as

$$\delta = \theta \alpha \frac{p^{\sigma-1} \left(\sigma - 1 \right) \hat{p}}{p^{\sigma-1}-1} \left(\nu - 1 \right) \ln \gamma_a.$$

Substituting (33) we thus have

$$\frac{\delta}{\hat{p}} = \frac{\alpha \pi \left(\sigma - 1 \right) \left(\nu - 1 \right) p^{\sigma-1}}{\left(p^{\sigma-1} - 1 \right)^{1-\alpha}} \ln \gamma_a,$$

which can be substituted in the denominator of (A8) to obtain (34).

Proof of Proposition 1. First assume $R_x > 0$. In this case, expression (15) implies $\hat{p} > 0$ and $p_\infty = +\infty$. If $\sigma > 1$, we have $\lim_{t \to \infty} \left(1 + \bar{\omega} p^{\sigma-1} \right)^{-1} = 0$, which implies $\epsilon_\infty = \epsilon''_\infty$. If instead $\sigma < 1$, we have $\lim_{t \to \infty} \left(1 + \bar{\omega} p^{\sigma-1} \right)^{-1} = 1$, implying $\epsilon_\infty = \epsilon'_\infty$. Now assume $R_x < 0$. In this case, $\hat{p} < 0$ implies $p_\infty = 0$. If $\sigma > 1$ we have $\lim_{t \to \infty} \left(1 + \bar{\omega} p^{\sigma-1} \right)^{-1} = 1$, which implies $\epsilon_\infty = \epsilon'_\infty$. If instead $\sigma < 1$, we have $\lim_{t \to \infty} \left(1 + \bar{\omega} p^{\sigma-1} \right)^{-1} = 0$, implying $\epsilon_\infty = \epsilon''_\infty$. In either case, $\hat{p}_\infty$ is constant.

Proof of Proposition 2. Being R_a and R_b constant, the proof follows from (15) and (17).

Derivation of (27). Integrating $\dot{K}_i = A_i K_i - C_i$ and applying the transversality condition we obtain

$$\int_0^\infty C_i \left(T \right) e^{-\int_0^T A_i(q) dq} = K_i \left(0 \right). \tag{A10}$$

Considering economy a, integrate (11) between time 0 and T to obtain

$$c_a \left(T \right) = c_a \left(0 \right) \left(p \left(0 \right) / \tau \left(0 \right) \right)^{\frac{1-\nu}{\nu}} \left(\tau \left(T \right) / p \left(T \right) \right)^{\frac{1-\nu}{\nu}} e^{\int_0^T \frac{R_a(t)}{\nu} dt}. \tag{A11}$$

Normalizing population to unity, $c_i = C_i$, expressions (A10)-(A11) imply

$$c_a \left(0 \right) = \frac{K_a \left(0 \right) \left(\frac{\tau(0)}{p(0)} \right)^{\frac{1-\nu}{\nu}}}{\int_0^\infty \left(\frac{\tau(T)}{p(T)} \right)^{\frac{1-\nu}{\nu}} e^{\int_0^T \left(\frac{R_a(t)}{\nu} - A_a(t) \right) dt}}. \tag{A12}$$

From $c_a / c_b = p^\sigma$ we can substitute $c_a \left(T \right) / c_a \left(0 \right) = c_b \left(T \right) / c_b \left(0 \right) \left(p \left(T \right) / p \left(0 \right) \right)^\sigma$ in (A11) to obtain

$$c_b \left(T \right) = c_b \left(0 \right) p \left(0 \right)^\sigma \left(\frac{p \left(0 \right)}{\tau \left(0 \right)} \right)^{\frac{1-\nu}{\nu}} \left(\frac{\tau \left(T \right)}{p \left(T \right)} \right)^{\frac{1-\nu}{\nu}} p \left(T \right)^{-\sigma} e^{\int_0^T \frac{R_a(t)}{\nu} dt}. \tag{A13}$$

Substituting (A13) into (A10) with $i = b$ we obtain

$$c_b(0)\,p(0)^{\sigma} = \frac{K_b(0)\left(\frac{\tau(0)}{p(0)}\right)^{\frac{1-\nu}{\nu}}}{\int_0^{\infty}\left(\frac{\tau(T)}{p(T)}\right)^{\frac{1-\nu}{\nu}} p(T)^{-\sigma}\, e^{\int_0^T\left(\frac{R_a(t)}{\nu}-A_b(t)\right)dt}dT}. \tag{A14}$$

From (A12), (A14) and $c_a = p^{\sigma}c_b$ we obtain expression (27) in the text. This condition has been used to verify the optimality of the initial price found in numerical simulations: given the endowment ratio K_a/K_b at time zero, the initial equilibrium price $p(0)$ is the unique value that generates, through the differential equation (A8), time-paths of $\tau(t)$ and $p(t)$ that satisfy (27).

Proof of Proposition 3. Even with R_x time-varying, if its sign does not change along the equilibrium path from some point in time onwards, p converges to the same limit values indicated in the proof of Proposition 1 for the various cases ($R_x \lesseqgtr 0$ and $\sigma \lesseqgtr 1$). This implies ϵ_{∞} constant. In a balanced growth equilibrium, (17) implies $\Delta_{\infty} = (\sigma - 1)\,p_{\infty}$.

Proof of Proposition 4. If $R_a = R_b$ from some t_0 onwards, equation (15) implies $R_x(\bar{t}) < 0$ and $\hat{p}(\bar{t}) < 0$ for all $\bar{t} \in [t_0, \infty)$. Proposition 3 then implies ϵ_{∞} constant and equal to (22), from which expression (28). From (17), balanced growth implies (29).

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