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REGULAR ARTICLE

The role of domestic savings in outward-oriented growth strategies

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Abstract This paper presents a theory of technological catching-up in which local savings plays a key complementary role to international finance and foreign technology. Until now, the literature has primarily emphasized "outward orientation" as the key ingredient of catching-up success. It has indeed been argued that countries which have relied intensively on foreign technologies, either through capital goods imports or foreign direct investment inflows, have been successful while countries which have opted for inward-oriented growth strategy relying on domestic investment and import-substitution strategies have been unsuccessful. In this paper, we develop a sequential model of industrialization in which domestic savings is key to the success of outward-oriented growth strategies. Indeed, internal finance helps to overcome time-to-adjustment constraints which occur in the early phases of the catching-up process when both advanced foreign technologies and backward domestic ones co-exist. In this model, external finance, though international borrowing, and domestic savings are complementary, not substitutable, in the course of technological catching-up.

Keywords Catching-up · Growth · Technology transfers · Neo-Austrian theory

JEL Classification O11 · O33

1 Introduction

> *To industrialize, without the savings to support your industrialization, is to ask for trouble. That is a principle which practical economists have learned from experience. It deserves a place, a regular place, in academic economics also. (Hicks 1973, p. 110)*

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From 1950 onwards, initially similar backward economies have experienced very different performance in terms of technological catching-up and income growth. The predominant explanation for such disparities emphasizes the degree of international openness. Countries which relied intensively on external finance and foreign technology would have been more successful than countries which opted for inward-oriented growth strategy relying merely on local finance and protecting their domestic capital goods industries. This view has found support in the renewal of growth theory that occurred at the end of the 1980s and the early 1990s, from evolutionary technology-gap models (Fagerberg 1987, 1995; Verspagen 1991) to neoclassical "new growth" type models (Grossman and Helpman 1991; Lucas 1993).[1] In all those models, international openness, as the main vector of technology transfers, could not but play a key role in catching-up success.

However, empirical evidence is less conclusive. Despite the strong correlation found between the degree of openness and economic growth, a still lively debate exists on the direction of causality (Rodriguez and Rodrik 2000). Moreover, the catching-up literature has pointed out that another key factor should be added to the degree of openness to give a better account of catching-up successes and failures: the social capability of the country. This general concept, first introduced by Abramovitz (1986), encompasses various indicators, from the educational level (Verspagen 1991) to more complex measures of the socio–economic context (Temple and Johnson 1998) passing through technological congruence variables such as the initial level of industrialization. To add social capability measures to openness indicators has notably increased the ability of growth regressions to pick up winners and losers over the past 50 years.[2]

The joint explanation of catching-up based on "outward orientation" and "social capability" still remains, however, incomplete for a twofold reason. First, one cannot account for two countries, initially similar with respect to both sets of variables, exhibiting different performances in technological and economic catching-up. Second, one is left with only two alternatives: either an economy catches-up or it is left behind. There is no room for countries showing early signs of catching-up but proving to be unable to carry out the catching-up process to its completion. This scenario is, however, exactly what happened to many newly industrialized countries in Eastern Europe and Latin America. Those countries failed despite their opting for outward-oriented growth strategies in the 1960s and 1970s and despite their "social capability," especially given the fact that their initial educational level (in 1960) was considered higher than that of the successful East Asian countries. Specifically, most of those countries opted for import-led growth strategies and showed apparent success, especially countries in the Far East (see, Gomulka 1990). Then, in the late 1970s and during the 1980s, the same countries experienced large-scale recessions along with a severe foreign debt crisis.

In this paper, we propose a theory of technological catching-up which emphasizes the complementary role of national savings, outward orientation and social capability in determining catching-up successes and failures. Domestic savings has long been emphasized as a causal factor of growth. It plays a central role in growth

[1] This renewal took place after the contribution by Baumol (1986) has strongly revived the debate on economic convergence.

[2] See Temple (1999) for a general overview on the so-called "new growth evidence."

theory from the traditional neoclassical model of Solow (1956) to the more recent AK models a la Romer (1986).[3] Indeed, high saving rates have been one of the very distinguishing features of the successful East Asian countries, especially compared to the unsuccessful Latin American ones (see Stiglitz 1996). However, as recently re-emphasised by Aghion et al. (2006), when one comes to discuss the role of domestic savings in outward-oriented growth strategy, those models suffer from a principal shortcoming: they all are closed economy models. Extending them to the case of small open economies with international capital markets eliminates the effect of local savings on growth.[4] This underlying inconsistency echoes the recurrent debate in this field about the causality between savings and growth. As for openness, cross-countries econometric studies support a causality running from growth to savings rather than from savings to growth (see Caroll et al. 2000). Moreover, it is noticeable that the role of domestic savings in the success of Asian countries (i.e. the *accumulation account* of the East Asia Miracle*)* has often been opposed to a *productivity account* (see Collins and Bosworth 1996).

In this paper, we propose a sequential model of technological catching-up in which domestic savings plays a causal role, although the growth strategy of the economy is strongly outward-oriented and technology-oriented. This model builds on the neo-Austrian approach of growth initiated by Hicks (1973) and further developed by, among others, Belloc (1980), Zamagni (1984), and Amendola and Gaffard (1988). This approach is specifically dedicated to an investigation of how an economy responds to technological shocks along traverse paths (as opposed to steady-state paths). This approach has been applied to development economics—i.e. how a backward economy responds to the importation of advanced technologies—by Cantalupi et al. (1992). The model proposed in this paper builds on this previous literature to investigate the dynamics of an industrializing economy which starts an import-led growth strategy consisting in reliance on debt-financed technology embodied in foreign capital goods.

Import-led-growth strategies have been particularly appealing for developing countries because of their self-contained nature. Indeed, technology transfers, financed by international borrowing, are paid back with a fraction of the additional output which can be directly or indirectly traced back to them. Obviously, the success of this type of strategies depends on the ability of the domestic firms to master the foreign technologies embodied in imported capital goods. Social capability, especially though technological congruence, is then a key ingredient of the success. Those requirements do not, however, need to be too high. First, mastering the use of advanced capital goods is not as demanding as mastering their conception or even their production.

[3] Higher saving rates boost growth in both types of models because it implies higher capital accumulation. Accordingly, the traditional Solowian view tells us that a low-income country will converge faster, the higher is its saving rate. The modern *AK* view tells us that, everything else being equal, a country with a higher saving rate will permanently grow faster.

[4] In the Solow model, any source of external finance accelerates the convergence rate. In the Romer model, in contrast, opening small backward economies to international capital markets induces domestic savings to flow outside the economy, inducing global divergence. Neither of these extreme predictions are empirically consistent (For general discussions on the role of finance in *AK*-type models, see also Levine (1997) and Bellone and Dalpont (2003). More generally, the role of domestic savings for growth has remained a controversial empirical issue.

Second, local firms in backward economies benefit from lower wages, and this cost advantage can compensate to a large extent some additional learning or adaptation costs. Here, we assume that the rate of return of the foreign technology operating in the small open economy (SOE) is high enough to cover the debt repayment. Despite these favorable conditions, I show that the availability of local savings is still crucial for the success of the growth strategy. Indeed, internal finance helps to overcome time-to-adjustment constraints which occur during the early phases of the traverse, i.e. as long as both advanced foreign technology and backward domestic production processes co-exist within the economy.

Emphasizing the role of domestic savings, our paper echoes the recent paper by Aghion et al. (2006) which also gives to local savings a key role in outward-oriented growth strategies. In their model, domestic savings and external finance complement each other as a consequence of imperfections in financial markets. It is assumed that any investment in the backward economy requires the involvement of a foreign investor, who is familiar with the foreign technology, together with a local bank that can directly monitor local projects. My approach differs from theirs mainly because I emphasize inter-temporal coordination failures instead of information-based market failures in driving the complementary role of internal and external finance. While both arguments are, in my view, relevant, only temporal coordination failures seem able to explain why some countries failed *despite* showing early signs of success. More generally, difficulties which arise in the course of the catching-up process usually require out-of-steady-state analysis, while steady-state paths are usually the only focus of "New Growth" type models.

The rest of the paper is organized as follows. "Section 2" presents the main features of the neo-Austrian approach of growth. "Section 3" presents a model of an SOE and addresses the conditions under which social capability and technological congruence requirements are fulfilled to initiate an import-led growth strategy. Especially, local wages have to be low enough to compensate for the return differential between the foreign technology in the advanced rest of the world (RoW) and the foreign technology in the SOE. "Section 4" focuses on the traverse path from the (low) autarkic steady-state to the (high) outward-oriented steady-state. Conclusions are to be found in "Section 5."

2 Theoretical Background

The neo-Austrian approach of growth was specifically designed by John Hicks in his book *Capital and Time*, published in 1973, in order to tackle a variety of issues involving out-of-steady-state analyses. The sequential view of the industrialization process which is proposed applies particularly well to thinking about the successes and failures of outward-oriented growth strategies. In this approach, production is described as a vertically integrated process and the technology used in the economy is entirely captured by the following

$$[a(u)\ ,\ b(u)]_0^n, \text{ with the assumptions :}$$

$$a(0) > 0 \qquad a(u) \geq 0 \qquad \forall u \in [0, n]$$
$$b(u) = 0 \quad \forall u \in]0, k] \qquad b(u) \geq 0 \qquad \forall u \in]k, n]$$

where $a(.)$ represents the temporal flow of original production factors, $b(.)$ the temporal flow of final consumption goods, and n is the duration of the elementary production process.[5] The original factors, as well as the final goods, are homogeneous. In the following, they will be respectively designated as “labor” and as the “final good.” $a(u)$ will then represent the labor quantity that has to be applied to a process aged u, and $b(u)$ the final good quantity that is produced by a process aged u. In this vertically integrated view of the production process, inter-industrial linkages are neglected in order to emphasise primarily inter-temporal linkages and time-to-build constraints. Those linkages are precisely the upshot of a growth strategy based on equipments imports and technology transfers:

> *Cumulative gain in outputs will be sufficiently high to leave a surplus after the payment for imports, any interest for credit, and any domestic production and transfer costs. At an economy-wide level, import-led-growth is thus a policy whereby there is initially a net inflow of resources, new technologies in particular, and in which, if the policy is successful, there is an acceleration of growth in both the short and long term, despite a net outflow of resources in the medium term. (Gomulka 1990, p. 220)*

Accordingly, the neo-Austrian approach allows us to point out two main rationales for relying on foreign capital goods: first, it bridges the distance between capital building and the actual production of final goods; second, it gives access to advanced foreign technology.

A second advantage of the neo-Austrian approach is that it offers a suitable framework for examining how an economy evolves out of steady-state growth paths, during the time when its productive capacity adjusts to foreign technology imports. Cantalupi et al. (1992)[6] are the first authors to address this issue in the frame of a subsistence economy which initiates an industrialization process based on international borrowing and capital goods imports. In their model, international borrowing allows coverage of the entire capital construction period of the foreign production process. However, because of the total absence of prior savings, the economy proves to be unable to comply with the debt temporal repayment profile implied by the borrowing strategy. To avoid the steady increase of the debt burden, the only solution for their modelled economy is to implement secondary import substitution. This will reduce the flows of imports and consequently lighten the debt burden. Mastering the production of capital goods becomes then a viability issue for the indebted economy. While illuminating on one of the plausible cause of the failures of the growth strategies of some newly industrialized countries of the 1960s and 1970s, this view ignores the specific role of domestic savings. The main issue in our paper will then be to explain why the high savings rates in East Asian countries have been a key component of their catching-up success, and not only their greater ability to reverse engineer imported capital goods. Here, we model an industrializing (not a subsistence) economy which

[5] This duration may correspond to the physical life of the process or to an optimal lifetime if one allows for truncation. It is the later assumption that will prevail in the model.

[6] CNR (1992) henceforth.

has already reached an initially sufficient level of development and thus possesses both an industrial base and prior domestic savings before opening to trade.[7]

3 An import-led growth strategy

We model a SOE which imports foreign capital goods from a more advanced RoW. Payment for capital goods imports is ensured by loans. Domestic firms contract such loans only if their expected return from the use of the advanced technology is higher than the financial cost made up of the price of capital plus the interests paid for imports.

Assuming $[a_1(u), b_1(u)]_0^{n_1}$ is the technique which prevails in the RoW, we have:[8]

$$\begin{array}{lll} a_1(0) > 0 & a_1(u) \geq 0 & \forall u \in [0, n_1] \\ b_1(u) = 0 & \forall u \in [0, k_1] & \\ b_1(u) \geq 0 & \forall u \in]k_1, n_1] & \end{array}$$

The price of imported capital goods at time of purchase, P, is the present value of the stream of net outputs which are generated during the entire utilization period $[k_1, n_1]$:

$$P = \int_0^{n_1 - k_1} q_1(k_1 + u) e^{-\hat{r}u} \, du \tag{1}$$

where $q_1(.) = b_1(.) - \hat{w} a_1(.)$ is the net output of an elementary production process, and $\hat{w}$ the wage rate prevailing in the RoW, the final good being taken as the standard of value.

Assuming that firms in the SOE are not able to influence the terms of the financial transactions, it is likely that the repayment for the loan, inclusive of both capital and interest, is to take place through constant instalments, these instalments being equal to:

$$v = \frac{P}{\int_0^m e^{-iu} \, du}$$

where m is the maturity period and i the interest rate.[9]

Let $[a(u)\ ,\ b(u)]_{k_1}^{n}$ stand for input and output flows during the utilization period when the foreign technique is operating in the SOE. Note, first, that the duration of the imported process in the SOE, n, has to be superior or equal to n_1 in order to warrant debt repayments.[10] Second, it is likely that the technology, when operating

[7] Actually, this situation is closer to the actual position of Latin America and East European countries in the early 1960s than the situation of a subsistence economy.

[8] Subscript 1 refers to the production process operating in the developed environment of the RoW, which is supposed to operate on a steady-state growth path.

[9] Note that variables m and i are not given. They correspond to loan conditions prevailing for the RoW. It is possible to show that $i = \hat{r}$ and $m = n_1 - k_1$, where $\hat{r}$ is the internal rate of return of the technique operated within the developed environment (see CNR (1992) for a proof).

[10] Empirical evidence show that the duration of production process is usually longer in developing countries compared to developed countries as the costs of maintenance (mainly labor costs) are lower in low-wage countries.

in the backward SOE, is less productive than the same technology operating in the advanced RoW. Finally, some adaptation costs may be associated to the technology transfer. Normalizing output flows when they are positive, $b(u) = b_1(u) = b \; \forall u \in \,]s, n]$, the productivity gap and adaptation costs can be specified as follows:

$$a(u) > a_1(u) \quad \forall u \in [k_1, n] \tag{2}$$

$$b(u) = 0 \quad \forall u \in [k_1, s] \tag{3}$$

$$\delta a(k_1 + u)/\delta u < 0 \tag{4}$$

Equation 2 tells us that, for each age u in a given process, more labor is required to operate the process in the SOE in comparison to the RoW. Equation 3 states that a short but not inconsiderable period, s, is necessary for installing imported processes before they produce any positive output. Finally, Eq. 4 states that learning takes place in the course of the utilization period: labor requirements decrease with the age of the process. All in all, the productivity differential between implementing the process in the RoW and implementing it in the SOE is captured by comparing flows $a(k_I{+}u)$ and by measuring time s.

Considering both the acquisition and the adaptation costs of the foreign technology, and letting w be the *fixed* wage prevailing in the SOE,[11] one can write the financial constraint of a firm operating in the SOE as:

$$\int_0^m q(k_1 + u)e^{-\widehat{r}u}\, du \geq P \text{ where } q(.) = b(.) - w\, a(.).$$

Replacing $q(.)$ by its value gives:

$$w \leq \frac{\int_0^m b(k_1 + u)e^{-\widehat{r}u}\, du - P}{\int_0^m a(k_1 + u)e^{-\widehat{r}u}\, du} \quad or \quad w \leq \frac{\int_0^m (b(k_1 + u) - v)e^{-\widehat{r}u}\, du}{\int_0^m a(k_1 + u)e^{-\widehat{r}u}\, du} \tag{5}$$

Equation 5 expresses that the productivity disadvantage of the SOE, related to both the prevailing environment and the installation and learning lags, can be compensated for by low wages. We then assume that the wage rate in the SOE is low enough to allow that the returns of the foreign technology in the SOE are at least equal to the returns earned in the RoW.[12]

[11] The fixed wage assumption is appropriate to developing countries, at least in the early phases of industrialization, when large reserves of labor in rural areas exist which are ready to move to industrial areas for wages only slightly superior to those prevailing in the traditional agricultural sector. Usually, increasing pressure on real wage appears only later in the course of the catching-up process.

[12] Very specific assumptions regarding $a_1(u)$ and $a(u)$ flows would be required in order to guarantee that the relation between w and $\widehat{w}$ be such that $r = \widehat{r}$. Instead of making such peculiar assumptions, it will be supposed that there is no international mobility of capital assets. Then, even if the wage advantage endows the SOE with an effective return that is higher than the one prevailing in the RoW, firms of the RoW cannot take advantage of this occurrence by way of direct foreign investment. An alternative assumption could be that delocalization costs are high enough to destroy RoW firms' incentives to invest their assets in the SOE.

Two last conditions need to be fulfilled in order to allow that the import-led growth strategy is sustainable in the long-run. First, an effective demand for the goods produced with foreign technology must exist both on domestic and international markets. To fulfil this condition, I assume, for the sake of simplicity, that both domestic and foreign demands perfectly adjust, the first to the share of production that will be left over for domestic consumption,[13] and the second to the share of final production that has to be exported in repayment of imports. The international and domestic price of final goods are assumed to be equal.

A second condition to allow that the incentive to shift from the autarkic growth path to the outward-oriented growth path is effective, is that the rate of return of the technology in the SOE, r, is higher than the rate of return of the domestic technology, r^*.

The internal rate of return of the imported processes is to be inferred from:

$$w = \frac{\int_0^{n-k_1} b(k_1+u)e^{-ru}\,du - \int_0^{m} v\,e^{-ru}du}{\int_0^{n-k_1} a(k_1+u)e^{-ru}du}$$

Note that r depends not only on the technique and the wage rate but also on the loan conditions (m and i). Therefore, $dr/dv_0<0$ while $dv_0/di>0$.[14] The higher the interest rate in the RoW, the lower the internal rate of return of the imported technology in the SOE for a given wage rate.

Investigating the parameter values under which r is superior to r^* amounts to discussing the *nature of technological change* involved in the outward-oriented strategy. Actually, two different types of technology transfers can be distinguished: *pure technology transfers* and *forward-biased technology transfers*.

Let us start from the typology of technological change first introduced by Hicks (1973) and further extended by Belloc (1980). Assume that the imported technique, compared to the one prevailing in autarky, allows economizing on labor in all the production process phases: $a(k_1+u) < a^*(u) \quad \forall u \in [0, \inf(n-k_1, n^*)]$. This corresponds to *pure* technological progress according to the Belloc (1980) classification. Technology transfer is not, however, costless. Both the acquisition costs (debt repayments) and the adaptation costs impact the flows of *effective net outputs* ($q(u)-v$) which, consequently, can still be higher or lower than the net output flows prevailing in autarky.

Consider two production processes, one of the domestic-type, corresponding to the autarky situation, and one of the imported-type. Recall that output flows are normalized: $b^*(u) = b(u) = b\forall u$. Suppose that the processes start simultaneously at time t_1. Despite the fact that $a(k_1+u) < a^*(u) \quad \forall u \in [0, \inf(n-k_1, n^*)]$, it is not assured that $a(k_1+u) + v/w < a^*(u)$ will also hold at each period over the same interval.

[13] This assumption, known as the Full Performance hypothesis (Hicks (1973), "Chapter V"), is explicited below.

[14] See CNR (1992) for a proof.

Actually, it is meaningful for the traverse analysis to distinguish two cases:

$$\textit{Pure Technology transfer}: \; q(k_1+u)-v > q^*(u) \quad \forall u \in [0, \inf(n-k_1, n^*)]$$

$$\textit{Forward}-\textit{Biased Technology transfer}: \; \begin{array}{ll} q(k_1+u)-v < q^*(u) & \forall u \in [0, s] \\ q(k_1+u)-v > q^*(u) & \forall u \in [s, \inf(n-k_1, n^*)] \end{array}$$

The first case corresponds to a situation where, despite the cost of indebtedness, the imported technique is productive enough for all *effective net outputs* to be greater than the ones generated by the domestic production processes. The second case corresponds to a situation where, because of debt repayment, the initial investment required to initiate production from an imported process, $(wa(k_1+u)+v)$ $\textit{for}\, u \in [0, s])$, is higher than the initial investment required to begin the construction phase of a domestic-type process $(wa^*(u)\,\textit{for}\, u \in [0, s])$. After the initial period, the imported process generates a positive output that is high enough to ensure that the effective net output flows are systematically higher than those generated by the domestic process. We recognize here a transfer-type akin to the *forward-biased technological change* defined by Belloc (1980).[15]

As the debt instalments, v, influence the nature of the transferred technological progress, it is important to emphasize what determines its level. v increases with the return differential between operating the technique in the developed environment of the RoW and operating it in the SOE. In consequence, anything which lowers the cost of the technology transfer (thanks to social capability and/or technological congruence) makes more likely the unbiased nature of technology transfers.

The last step in this section consists in characterizing the long-run steady-state which corresponds to the long-run outcome of the outward-oriented strategy. With $x(t)$, the number of starts of imported processes at any time t, $A(t)$ and $B(t)$, respectively employment and total production, are:

$$A(t) = \int_{t-n}^{t} a(t-u)x(u)du$$

$$B(t) = \int_{t-n}^{t} b(t-u)x(u)du$$

$B(t) - wA(t)$ represents total net output at time t.

In the modelled economy, we have two types of revenues: revenues from workers (wages) and revenues from capital. The later are given by $rK(t)$ where $K(t)$ is the aggregate current value of the stock of capital available at the date t:

$K(t) = \int_{t-(n-k_1)}^{t} k_u(t-u)x(u)du$ where $k_u = \int_{u}^{n} q(u)e^{-ru}du$ is the current value of capital of a process aged $k_1 + u$.

Both types of revenues can either be consumed or saved. Let us assume, for the sake of simplicity, that the marginal propensity to consume of workers is one. Savings corresponds then to the share of capital revenues which are not consumed. Assumed that a constant proportion s of those revenues are saved at each date t, savings is equal to *srK(t)*.

Finally, we follow Hick (1973) in defining as a full performance path, a path along the rate of start of new processes is always at the maximum rate allowed by

[15] It corresponds to the *strongly* forward biased technological change in the Hicksian classification.

available savings. In other words, the current output which is not paid in wage to operate existing output and which is not absorbed in "other types of consumption", let say capitalist consumption, will be invested in new processes. According to this assumption and noting $C(t)$ the capitalist consumption, the full performance assumption can be written:

$$\begin{aligned} &B(t) - wA(t) = C(t) \\ &with\, C(t) = (1-s)\, rK(t). \end{aligned} \tag{6}$$

For the sake of simplicity, assume that imported processes are run over the same time span in the SOE and in RoW, i.e. $n=n_1$. Equation 6 can be rewritten as follows:[16]

$$n = n_1 \qquad \int\limits_{t-(n-k_1)}^{t} [q(t+k_1-u)-v]\, x(u)du = C(t) \tag{7}$$

In this framework, it is easy to demonstrate that, on the steady-state path, all aggregate variables grow at the same rate $g=sr$[17]. For a given saving propensity, this growth rate is higher than the autarky growth rate $g^* = sr^*$ as $r>r^*$. Moreover, the lower the capitalist consumption; the higher the growth rate. The maximum growth rate is given by $g=r$,. i.e. when the revenues of capital are entirely saved and re-invested. It is important to observe that g, through r, depends on loan conditions. The heavier is the debt burden, i.e. the lower is the social capability and technological congruence in the country, the lower will be the growth potential associated with the importation of foreign technologies.

Finally, recall that the new steady-state path will be reached only after the imported technology has been generalized, which means that all the processes *alive* at that date will be imported processes:

> *From an actual position, in which only a few of the processes that are alive are modern processes, such a position is unattainable immediately—whatever the rate of interest, or rate of wages or rate of saving. The path that is followed, or the paths that may be followed, from such a position, need a different and more complex investigation. (Hicks 1973, p. 72)*

The next section is entirely dedicated to this investigation.

4 Adjusting to foreign technology: analysing the traverse path

We are now ready to work out the fixed wage path the SOE will follow starting from $t=0$, the date when capital goods importation begins. The introduction of foreign production processes primes adjustment mechanisms. Indeed, from $t=0$ onwards,

[16] This simplifying assumption will be relaxed afterwards. Note that if $n>n_1$ Eq. 7 becomes: $\int\limits_{t-(n-k_1)}^{t-m} q(t+k_1-u)\ x(u)\,du + \int\limits_{t-m}^{t} [q(t+k_1-u)-v]\ x(u) = C(t)\cdot$

[17] See Hicks (1973, "Chapter V") for a full description of the steady-state.

domestic-type processes will no longer be started, since they have become obsolete. The resources which would have been used for replacement of domestic capital goods, or for investment in such capital goods, are to be transferred to finance the installation of imported capital goods.[18] The upshot is the following: while imported processes are financed by international borrowing, their starting rate during the traverse path still depends on the savings generated within the SOE.

Two steps on the traverse path will be distinguished. The first, the *early* phase, begins at time $t=0$ and is characterized by the co-existence of both types of processes (domestic and imported). The second, the *late* phase, begins when the last domestic process dies and is thus characterized by the exclusive use of imported production processes. As usual in the traverse approach, difficulties are going to occur during the early phase which will be our principal focus.[19]

Let us first re-emphasize two of our working assumptions. First, we assume that consumption does not change after time $t=0$. Then, in the final consumption market, everything will work out as if the effective "capitalist" demand was determined by the level corresponding to the reference path (the autarky situation): $C(t) = C^*(t)$. Second, we assume that $n=n_1$. Production processes are not operated on a longer time span in the SOE compared to the RoW. These conservative assumptions ease the comparison of the traverse path with the reference steady-state path. However, both variables, i.e. the duration of production process and consumption behaviors, are control variables. Both of them, especially the later, can be oriented by appropriate policies. The implication of relaxing each of these assumptions will then be studied later on.

The traverse phases The early phase can be separated into two sub-periods: during the first, all processes imported at time $t=0$ are still *alive*, while during the second, some of these processes have already died.

$$t \in [0, n-k_1[\quad \int_0^t [q(t+k_1-u)-v]x(u)du + \int_{t-n^*}^0 q^*(t-u)x^*e^{gu}du = C^*(t) \tag{8}$$

$$t \in [n-k_1, n^*[\quad \int_{t-(n-k_1)}^t [q(t+k_1-u)-v]x(u)du + \int_{t-n^*}^0 q^*(t-u)x^*e^{gu}du = C^*(t) \tag{8'}$$

[18] Actually, another adjustment is likely to take place. Indeed, it might become profitable to truncate the domestic processes still in operation at time $t=0$. This in turn will set free resources that will be used for initiating imported processes. For simplicity, however, this indirect effect of change is not considered here. See Belloc (1980) and Zamagni (1984) for an examination of this issue. This does not affect the economic meaning of the results to be presented below.

[19] Studying the late phase is then a matter of asserting under which conditions it is possible to prove the convergence of the traverse to the new steady-state $g=sr$. As Zamagni (1984, p. 148) points out however "*what emerges from traverse theory is the substantial irrelevance of the problem of convergence as such. At best, the convergence of the late phase to a new equilibrium would take a long time and before the economy has entered the late phase and before that time has elapsed, a myriad of phenomena of various kinds would certainly have occurred to modify the basic relations of the economy.*"

The *late* phase is characterized by:

$$t \in [n^*, \infty[\qquad \int_{t-(n-k_1)}^{t} [q(t+k_1-u)-v]x(u)du = C^*(t) \tag{8''}$$

Obviously, Eq. 8 presents some analogy with Eq. 14 of CNR (1992). It also shares the same characteristics as the path studied by Belloc (1980) when account is taken of the impact of an exogenous technological shock.[20] Specifically, the Volterra integral equation of the second kind that corresponds to Eq. 6.1 of Belloc is given by the derivation of Eq. 8:

$$x(t) + \int_0^t \frac{q'(t+k_1-u)}{q(k_1)-v} x(u)du = \frac{C^{*\prime}(t)}{q(k_1)-v} - g \int_t^{n^*} \frac{q^*(u)}{q(k_1)-v} x^* e^{g(t-u)} du + \frac{q^*(t)}{q(k_1)-v} x^* \tag{9}$$

with $I(t)=0$, if $t<n-k_1$, and $I(t)=1$ elsewhere.

The convolution kernel of this equation is:

$$N(t+k_1) = \frac{q'(t+k_1)}{q(k_1)-v}$$

Let f(t) be the known term, that is, the right-hand side of Eq. 8. We then need to resolve:

$$x(t) + \int_0^t N(t+k_1-u)x(u)du = f(t)$$

The solution to this equation, following Belloc, is given by:

$$x(t) = f(t) + \int_0^t S(t+k_1-u) f(u)\, du$$

where $S(t+k_1) = \sum_{i=0}^{\infty} (-1)^{i+1} N^{(i)}(t+k_1)$ is the resolved kernel and $N^{(i)}(t+k_1)$ the iterated kernels defined by:

$$N^{(1)}(t+k_1) = \int_0^t N(t+k_1-u)N(u)du$$

$$N^{(2)}(t+k_1) = \int_0^t N(t+k_1-u)N^{(1)}(u)du$$

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$$N^{(i)}(t+k_0) = \int_0^t N(t+k_1-u)N^{(i-1)}(u)du \quad et \quad N^{(0)}(t+k_1) = N(t+k_1)$$

[20] See Eq. 6.0, p. 128 of Belloc (1980).

Sufficient conditions that guarantee that the rate of starts of imported processes along the traverse path will be always positive take on, in the present setting, the following form:

1. $q(k_1) - v < 0$
2. $q'(k_1 + u) \geq 0$

Condition 1 is verified, since $a(k_1)>0$ and $b(k_1)=0$. Here, however, the upshot is that the existence of a prior industrial structure (technique*) will ensure that the initial investment, $wa(k_1 + u) + v, u \in [0, s]$, will be made possible for a positive number of processes. Concerning condition 2, it implies that net output flows generated by imported processes have to be an increasing function of the age of processes. Although restrictive, such an assumption finds a particular justification in this model, since learning is to take place during the productive process, ensuring $a'(k_1 + u) < 0$ and, thus, $q'(k_1 + u) \geq 0$. The main issue, however, is whether the positive number of starts of imported process will be higher or lower in the early traverse path than in the reference steady-state path. Indeed, if $0 < x(t) < x^* e^{gt}$, then the productive activity level will drop compared to that in the autarky situation, leading to an increase in unemployment, at least temporarily. But, in order to investigate this issue, the two types of technology transfers specified in the last section have to be distinguished.

Pure technology transfer Under this assumption, it is possible to infer that a drop in the general level of activity will prevail after the *death* of the first imported processes, i.e. at time $t=n-k_1$ (a formal study using again the Belloc equations adapted to the present framework, is given in the "Appendix"). Indeed, at time $t=0$, the resources available for initiating imported processes are given by the existing capacity of production. However, each of these processes requires fewer resources than the domestic ones. In consequence, at time $t=0$, more processes can be initiated in the traverse path compared to the reference path. Then, each operated imported process yielding a higher net output than the one yielded by domestic processes, it is possible to maintain and start a larger number of processes. However, as the life of imported processes is shorter than that of domestic processes, two elements are expected to induce a fall of the number of starts under the reference level. First, there is the effect caused by the cessation of processes aged $n-k_1$. As they are more numerous than the domestic processes aged $n-k_1$ on the reference path, and as they generate more output, their cessation causes a decrease of available resources and, then, a drop in the number of starts in the traverse path. Moreover, in the reference path, processes aged more than $n-k_1$ yield positive net outputs. This also creates a downward trend in the activity level and, consequently, in the employment level.

Forward-biased technology transfer Since the duration of the imported processes in the SOE, $n-k_1$, is shorter than the duration n^* of the domestic processes, and recalling the definition of the biased transfer, this case corresponds to the following assumptions:

$$q(k_1 + u) - v < q^*(u) \quad \forall u \in [0, s]$$
$$q(k_1 + u) - v > q^*(u) \quad \forall u \in]s, n - k_1]$$

We are in the case described by Belloc (1980, p. 149), where the new processes imply a forward-biased technological progress and have a shorter duration than the old-type processes. Thus, inferring from Belloc's results, it is very likely that the general level of activity will decrease during the very early phase of the traverse, $t\in[0, s]$. Then, while becoming higher than the reference level for some time, this level will show a new decrease after date $t=n-k_1$, i.e. after the *death* of the first imported processes. The explanation is as follows: At time $t=0$, as each of the imported processes requires, to be initiated, more resources than the domestic ones, fewer processes can be started during the traverse path, in comparison with the reference path, at least until $t=s$. Then, moving from $t=s$, as the imported processes yield an effective net output that is higher than the corresponding aged domestic processes, available resources will increase and it is expected that $x(t)$, compared to $x^*(t)$, will begin to grow faster up to date t^*, when the general level of activity will become higher in the traverse path relatively to the reference path. But, since $n-k_1<n^*$, the dynamics may reverse again between date $t=n-k_1$ and $t=n^*$. Indeed, two opposing effects prime adjustments during this period. First, taking into account the rates of starts, the loss of resources is lower when processes aged $n-k_1$ are ended on the traverse path than when corresponding aged processes are ended on the reference path. This implies that resources available for initiating new processes are higher in the traverse path. However, a second effect operates in the opposite direction. Indeed, while processes aged under $n-k_1$ would still have yielded positive net output on the reference path, such processes would be ended on the traverse path. This implies a loss of available resources in the traverse path, compared to the reference path, and therefore a tendency to begin fewer processes. As previously, this qualitative interpretation also applies to the evolution of the employment level.

Effects of a longer duration of imported processe The previous analysis was carried through under the assumption that the optimal duration of the imported process was exactly the same whether the technique was entirely operated in the RoW or partly in the SOE. It is more likely, however, that n should be actually higher than n_1. What implications could there be for this longer duration of imported processes? It is clear that its effects would operate in a positive way. In both the cases of pure transfers and of forward-biased transfers, the available resources generated by such processes would show a substantial increase leading to an acceleration of the number of starts of imported processes after time $t=n_1-k_1$. The reason is that imported processes aged more than n_1-k_1 would still yield a positive net output by the time their payment had been entirely completed. The important point remains, though, that n is still smaller than n^*. Then, even in the case of a pure technological transfer, the fact that n is greater than n_1 cannot allow avoidance of the problems of temporal complementarities that emerged in the previous scenario.

Effects of an higher saving rate Financial difficulties arise in the economy in part because saving behaviors do not adapt themselves in the course of the catching-up process. Let us assume, alternatively, that the saving rate increases in the early phase of the traverse.[21] Then, more resources are available to sustain the outward-oriented

[21] The impact of changes in the savings behaviors in a neo-Austrian framework has already been conducted in other areas than development theory. See, in particular, Nardini (1993) and Amendola et al. (2001).

growth strategy, and the drop in the general level of output and employment expected later on, in the course of the traverse, may simply not occur. All East Asian countries experienced rapid increase in their savings rate at the beginning of the catching-up process. As documented in detail by Stiglitz (1996), most of those countries implemented economic policies which, either directly or indirectly, were all savings-promoting. Here, we have a strong rational in favour of such policies. They play a central role to *sustain* the outward-oriented growth strategy in the medium-run. Let us emphasis that, in our approach, high domestic savings are not as much important to *initiate* a catching-up dynamics. To rely on foreign technology and international borrowing is more important. The key role of domestic savings appears afterwards, i.e. in the course of the catching-up processes. If the SOE does not succeed to increase domestic savings in the early phase of the traverse, it is likely that the economy will run into foreign debt crisis.

5 Conclusion

Because of their self-contained nature, import-led growth strategies have often been advocated to promote rapid industrialization. Indeed, technology imports are paid for thanks to the production stemming directly or indirectly from them. These strategies are, however, far from being unconditionally successful. First, strong requirements in terms of social capability and technological congruence must be fulfilled. Second, this paper has shown that, even when these requirements are fulfilled, important difficulties might still arise during the course of the industrialization process. These difficulties occur via the financing constraints that appear during the early phase of the traverse.

Specifically, the imported processes are substituted for the capital goods produced in the SOE. This effect is not, however, instantaneous. During some period, domestic processes and imported ones will co-exist. Consequently, the SOE is both constrained by the productive capacity structure resulting from its past decisions and by time needed for adjustment. Those constraints make likely the occurrence of periods of a general drop in activity and employment levels. This bad side effect of outward-oriented growth strategies occurs even when the debt burden induced by the need to finance the equipment imports is low enough that it constricts forward-biased technological change.

All in all, this paper points out that the degree of trade openness and access to external finance is not a sufficient condition to warrant technological catching-up success. Adjustment policies, especially the ones which determine the provision of local finance, are also important components of technological catching-up. International borrowing and foreign embodied technology, on the one hand, and domestic savings, on the other hand, are complementary—not substitutable—in the course of technological catching-up.

Appendix

In order to compare the number of starts of new processes on the traverse path with those on the reference path, a variable that will represent the resulting gap is needed.

Taking Eq. 8 and replacing $C^*(t)$ with its value $\int_{t-n}^{t} q^*(t-u)x^*e^{gu}du$, we obtain: $\int_{t-\inf(t,n-k_1)}^{t} q^*(t-u)x^*e^{gu}du = \int_{0}^{t} [q(t+k_1-u)-v]x(u)du$ which is equivalent to:

$$\int_{t-\inf(t,n-k_1)}^{t} [q(t+k_1-u)-v]x(u)du - \int_{t-\inf(t,n-k_1)}^{t} [q(t+k_1-u)-v]x^* e^{gu}du$$
$$= \int_{0}^{t} q^*(t-u)x^* e^{gu}du - \int_{t-\inf(t,n-k_1)}^{t} [q(t+k_1-u)-v]x^* e^{gu}du$$

Integrating by parts the left-hand side of the latter equation and transforming the right-hand side by a change in variable (u becomes $t-u$), we obtain a formulation that is akin to Eq. 9:

For $t<n-k_1$

$$Y(t) + \int_{0}^{t} \frac{q'(t+k_1-u)}{q(k_1)-v} Y(u)du = \frac{1}{q(k_1)-v}\left(\int_{0}^{t} [q^*(u)-(q(u+k_1)-v)]x^*e^{g\,(t-u)}du\right) \tag{10}$$

For $n-k_1<t<n^*$

$$Y(t) + \int_{0}^{t} \frac{q'(t+k_1-u)}{q(k_1)-v} Y(u)du = \frac{1}{q(k_1)-v}\left(\begin{array}{c}\int_{0}^{n-k_1} (q^*(u)-[q(u+k_1)-v])x^*e^{g(t-u)}du + \\ \int_{n-k_1}^{t} q^*(u)x^*e^{g(t-u)}du + q(n-k_1)Y(t-n+k_1)\end{array}\right)$$

This Volterra integral equation of the second kind has the same convolution kernel as Eq. 9. The unknown variable is $Y(t)$ and we are, in fact, interested in is studying its sign. As the resolved kernel is positive, this study boils down to finding the sign of the right-hand side of Eq. 8. Indeed, by expressing the latter by $h(t)$, we have:

$$Y(t) = h(t) + \int_{0}^{t} S(t+k_1-u)h(u)du$$

The expression of $h(t)$ in Eq. 10 is:

$$h(t) = \left(\int_{0}^{t} \frac{[q^*(u)-(q(u+k_1)-v)]}{q(k_1)-v} x^*e^{g(t-u)}du\right)$$

It is positive whatever $t<n-k_1$ and, thus, $Y(t)>0$ whatever $t<n-k_1$.

Moreover, we have $h'(t) = gh(t) + \frac{q^*(t)-q(k_{1+t})}{q(k_1)-v}x^* > 0 \quad \forall t < n-k_1$ and, then, $Y'(t) = x(t) - x^*e^{gt} > 0\,\forall t < n-k_1$.

For $t \in [n-k_1, n^*]$, $h(t)$ takes another form:

$$h(t) = \frac{1}{q(k_1)-v} \int_0^{n-k_1} \frac{\left(q^*(u)-[q(u+k_1)-v]\right)x^* e^{g(t-u)} du}{q(k_1)-v} + \int_{n-k_1}^{t} \frac{q^*(u)x^* e^{g(t-u)} du}{q(k_1)-v} + \frac{q(n-k_1)}{q(k_1)-v} Y(t-n+k_0)$$

The two last terms of the right-hand side are negative. It is then possible that $h(t)$, and consequently $Y(t)$, becomes negative between $t=n-k_1$ and $t=n^*$.

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