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An Empirical Investigation of a Set of Developing Countries

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Abstract:

This paper investigates the effects of learning and assimilating foreign technology on growth rates for a set of middle income countries. Techological assimilation is represented by the export performance of goods high in technological content. The evidence suggests a strong positive relationship between technolgy assimilation and growth of output per worker.

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Introduction.

Technological development is often considered a key to long run economic growth. If so, countries that lie behind the technological frontier will have to learn and imitate in order to catch up.

In the neo-Schumpeterian analysis followed by evolutionary economics, new inventions in industrialized countries create monopolistic rents. This in turn induces less developed countries to compete on international markets. In order to do so, they will engage in reverse engineering and imitation of the industrialized countries technological developments. The ability to imitate successfully and thus to enter competitively the international market is presented as an essential feature of the catching-up process.

In some open economy new growth theory models, where trade occurs between human capital abundant countries and labour or natural resource abundant countries, i.e. developing countries, long run growth is not necessarily an outcome for the labour abundant country. This occurs because, in the analysis, long run growth is due to the development of new technologies and their implementation in the production processes, fields in which developed countries might have a comparative advantage. A case in which a labour abundant country can experience long run growth effects, occurs if it is able to develop the production of a "technological good" in competition with the industrialized countries. This implies that the country has to develop a comparative advantage, i.e. efficient and competitive production, in a "technological good".

The role of technology in these endogenous growth processes is fundamental since it enables sustained rates of growth by generating increasing returns in the production function. The process of catching-up should then depend on the assimilation of technological developments.

Empirical investigators are faced with the problem of identifying adequate variables to represent technological development. In the evolutionary economics literature, the main indexes of technological progress are taken to be of R&D expenditures, and registered patents, (Dosi, Pavitt and Soete 1990). Innovations are considered the driving factor of technological progress. There are product innovations, which, for example, consist in a new variety, and process innovations, as could be a new organization of production; in each case innovations will produce monopolistic rents to the innovator. While it is asserted that process innovations can occur in all sectors, but are relatively infrequent, product innovations are frequent and are mostly concentrated in specific sectors. Empirical studies have often classified sectors as "technological" according to their R&D intensity, as defined by the expenditure in R&D over total costs, or according to the number of sectoral US registered patents per period of time over total US patent registrations. The sectors that have a high technological content are called the "engine of growth".

The aim of this paper is to construct an index to proxy a country's ability to successfully learn, and to efficiently and competitively reproduce foreign developed technology, and then to evaluate the impact of such an index on overall growth rates. For the sake of brevity, this will be called the index of assimilation. There are two basic hypotheses to be tested, a) whether assimilating has positive effects on long term growth and b) whether assimilating is rapid for countries which have more than a certain minimum level of technological ability, but then tends to die out in sectors when and where the country closes the technological gap. Evidence for strong technological diffusions effects on productivity growth will indicate in assimilation or adaptation an important feature of catching up. If assimilation effects were to show an upper bound, this would support the view that productivity increases obtained from assimilation of foreign technology are limited in the long run.

The paper is organized as follows: section 1 discusses the form and possibilities of an index of technology assimilation, and briefly presents the model, data sources and econometric techniques; section 2 presents the estimation results and compares with alternative indexes of technological diffusion; section 3 briefly draws some conclusions.

Section 1. Technological diffusion and assimilating ability.

Empirical investigators on technology face a common difficulty in choosing an appropriate representation for technological development and in identifying the specific sectors which embody most technology: the " Schumpeterian industries" (Klodt 1990). A common indicator chosen to represent technological content is the ratio of R&D expenditures over total costs. Recently, there have been several classifications for high tech goods developed in literature (OCDE, US Department of Commerce, Guerrieri Milana 1992). Within the category of high tech goods, those sectors for which technology can be "easily transferred", are of special interest given the problem to be addressed. These sectors will embody a high degree of technology, will have relatively low fixed capital costs, and skilled labour will not be a crucial factor in the production process. These sectors, where production can be completed away from the R&D activities, are called "mobile Schumpeter industries" (Klodt 1990).

A good source of information can be found in Dunning and Pierce 1981, who catalog the ratios of overseas production to total production, and parent export ratios to total production, for multinational enterprises producing overseas, by sector of production. Activities with the highest overseas production ratio are thought to use transferable technology. Such activities, according to Dunning and Pierce (1981), mostly lie in the category of Electronics and Electrical appliances.

Empirical studies on the impact of R&D on export performance provide a different way of looking for sectors in which technological transfer is likely to occur. Most of the studies on the impact of R&D, generally report a strong positive correlation between sectoral expenditure in R&D and export performance. At times, a few sectors fail to present such evidence. In a study by Pavitt and Soete (1980) across 20 OECD countries and 40 industrial branches, the categories of Electrical goods, Office Computing and Communication showed significant positive correlations with R&D expenditure for the period 1964-74. Later data analyzed by Magnier (1994) for the period 1975-87 on the 5 major OECD countries and 20 industries present a non significant correlation between R&D expenditures and Electronics, Communications and Electrical machinery exports. Recent studies by Wakelin and Verspagen (1993), and Wakelin (1994) for 9 OECD countries and 22 industries on the period 1980-88 report a significant negative correlation between R&D expenditures and export shares for the same sectors and also for Textiles, Food and Drink and Oil Refining. (These categories will not be taken into consideration here since the degree of technological content is too low and because oil refining activities depend on specific country advantages). These results appear to indicate that, over the last decades, the monopolistic rents accruing to countries by R&D in electronics have been decreasing. This could imply that, in the time span over which the analysis by Wakelin (1994) was performed, the mark-up deriving from specific innovations, has been eroded by foreign competition, and that the speed at which such margins have eroded has increased since the early study of Pavitt and Soete (1981). Evidence for this kind of hypothesis is weak but it might still be worth consideration from a theoretical point of view.

Finally, an efficient and internationally competitive engineering sector, which includes, by definition, the categories of the Light Electrical and Electronics, is often thought to be a necessary condition for long term growth, since it is the site of productivity increases deriving from process innovations, learning by doing and learning by watching. An analysis of the learning activities within this sector is of interest both because of their relevance to the general economy and because they might be the precondition for spillover effects to other sectors.

The review of these arguments, especially the first one, led to the choice of an the index of technology assimilation represented by export success. This is the ratio of exports in a set of mobile technology sectors over total exports. Exports are taken as an index of competitive and efficient production. International competitiveness in a high technology sector is taken as a measure of having learned, and successfully implemented a given type of technology. This ability is assumed to be a factor of long run growth, as discussed in Chapter II, Part A, of this thesis.

1.1 Sample selection.

In order to perform an empirical estimation, a sample of 15 countries was selected. The sample has been cut along the following lines:

a) The year of the sample selection is 1960, the closest possible to the beginning of the period of interest. As noted by De Long (1989) and Taylor (1980), in this way the sample will not exclude countries that theoretically could have developed high growth rates, i.e. presented the same features as those that did grow, and yet failed to do so.

b) Countries in the sample are middle income. This was set to ensure that countries had reached a minimum level of income and of technological capability that would allow them to catch-up. For this reason, the poorest 30% of countries, in the distribution of income per capita, were excluded from the sample. Former communist countries and oil exporting countries were also excluded. The richest 20% of countries, in the distribution of income per capita, were also excluded because developed, human capital abundant countries were not of interest to this analysis.

c) The set only includes countries: i) that belong to the highest 60% in the distribution of total gdp, ii) where the manufacturing sector represents at least 10% of total gdp; and iii) where total imports of the country exceed at least 0.5% of total imports in the developing world in the year of sample selection. Following Balassa 1978, these size requirements were introduced in order not to include in the sample specific cases of very small economies.

1.2 Data sources and quantitative methods[1].

The data covers the period between 1955-1990 for 15 countries at five year intervals. The estimation period, however, is only 1960-1990 to allow for some lagged period variables.

Data on gdp per worker, the investment share of gdp, income and per worker and the productivity gap were drawn from the Summers and Heston compilation of PWT5. Labour data for 1955 were taken from the ILO Yearbook of Labour Statistics. Data on schooling were taken from the World Bank Indicators of Social Development, and completed with the UNESCO yearbook of statistics. Data on trade were taken from the UN Yearbook of International Trade Statistics, the index was constructed using three digit series (specification in Appendix A).

The dependent variable was chosen to be growth of real gdp per worker. It was constructed using yearly growth rates, these were then averaged over each five year period. Since these growth rates presented a considerable amount of variance, logarithmic transformations of the levels were introduced so that the growth rate was then calculated as the difference of the log values; once more, the five year period growth rate was calculated as the average of the annual growth rates.

Investment, calculated as shares of gdp, was introduced at the beginning of the estimation period values, to reduce simultaneity problems. In the same way, data on imports of equipment (SITC 7) and investment net of imports of equipment were taken as shares of gdp and at the beginning of period values.

The growth of human capital was proxied by the growth rates in

[1] See Appendix A for detailed data description and sources.

secondary school enrollment ratios, it was then lagged to represent the growth rate over the 5 years preceding the beginning of the estimation period. The variable was lagged so as to allow people time out of school before entering actively the production process. The growth rates were calculated as the average over the five years, given the beginning and end of period values.

The level of human capital, to represent initial conditions, was proxied by the levels of secondary school enrollment ratios, which were also entered lagged five years.

Labour data, as proxied by total active population, were also entered as lagged period growth rates so as to prevent simultaneity.

The index of learning and efficiently and competitively reproducing foreign technology, i.e. the assimilation index, was defined as the export share (taken to represent international competitiveness) of a series of technological goods which belong to the "mobile Schumpeter industries" category. They were interpreted in the above discussion as goods for which technology can be easily transferred. The index was built as the export share over total exports of the sum of several three digit categories of export data (SITC 714, 7222, 723, 724, 725, 726, 729). The definition was made wide enough to include the label "Light Electrical and Electronic" in all the definitions of such a category found in early and recent literature. The index was also calculated as the share over gdp of the same export categories. This was found to be 95% correlated with the index calculated as a share of total exports. Some regressions were run using this as an alternative formulation of the assimilation index (assml(alt)). However, the index calculated as a share of total exports was thought to be a better index of export performance since it excludes factors which might affect both general exports and exports within certain categories at the same time.

The assimilation index was then entered at five years lagged values so as to reduce possible endogeneity problems.

The openness index was constructed as the sum of total imports to total export divided by total gdp: the trade dependency ratio. It was entered the regressions at five year lagged values also so as to reduce possible simultaneity problems.

Finally, the productivity gap variable, defined as the ratio of a country's output per worker to output per worker in the US, was taken at beginning of period values. It was also entered in logarithmic transformations, so that its coefficient would come to represent the speed of catching up, as argued in De Long and Summers (1992).

In its simplest version the growth equation estimated is described by:

$$Y_{i,t}=C+C_i+C_t+\beta_1 prgap+\beta_2 invs+\beta_3\Delta h+\beta_4\Delta l+\beta_5 assiml+\varepsilon_{i,t}$$

where lgap, is the initial productivity gap, h is secondary school enrollment ratios, l labour and assml is the assimilation index.

Section 2. Econometric Methods.

The model was set up as a panel of 15 countries pooled over 7 periods. Tests for countrywise and periodwise poolability led me to consider the two-way fixed country and period effects model as an adequate econometric representation.

Equation (1) was initially estimated allowing for fixed country and time effects. The regressions are reported in Table 1[2]. Sensitivity analysis was then performed by including alternative variables in the regression. In particular alternative proxies for technological transfer processes: i) openness, which is used as a possible proxy for learning possibility in other empirical studies; and ii) imports of equipment, also interpreted as a possible channel for the transfer of technology, as discussed in Chapters II and III, Part B, of this thesis.

A set of regressions was then run allowing for fixed time and continental effects[3] rather than country effects (Table 2). Finally, some regressions were run including only fixed time effects and by allowing for autocorrelation in the time structure of errors, which implies GLS estimation of coefficients and standard errors (Table 3). This kind of estimation appears to give the best fit, but the estimated coefficients are not considerably different.

[2]See Appendix A for definition of variable names.

[3] Continental effects are represented by dummies for Latin America, Asia and Europe.

Table 1[*].

Dependent variable: growth of log real gdp per worker.

Period: 1960-1990

Econometric technique:
(a) fixed time and country effects

lprgap	-.036 (.021)	-.041 (.023)	-.046 (.023)	-.039 (.021)	-.046 (.007)	-.048 (.007)	-.036 (.018)
invs	.076 (.069)		.081 (.069)			.076 (.062)	.053 (.083)
h	.159 (.069)	.147 (.071)	.159 (.069)	.157 (.069)	.147 (.069)	.157 (.071)	.166 (.069)
lab	.163 (.189)	.124 (.25)	.124 (.25)	.131 (.27)	.23 (.27)	.124 (.25)	.170 (.25)
assml	.262 (.122)	.260 (.124)	.235 (.124)	.219 (.124)	.341 (.099)	.253 (.124)	
open					.002 (.168)		
imeq			.044 (.069)	.083 (.069)			
ineq				.018 (.046)			
secer						-.2E-03 (.5E-03)	
assml (alt)							.48 (.19)
R^2 AR^2	.63 .48	.62 .47	.63 .48	.63 .48	.63 .48	.63 .48	.64 .50

* standard errors in parenthesis

Definitions and sources in Appendix A.

Table 2[*]**.**

Dependent variable: growth of log real gdp per worker.

Period: 1960-1990

Econometric technique:
(b) fixed time and continental effects.

lprgap	-.013 (.007)	-.009 (.007)	-.013 (.007)	-.012 (.007)	-.016 (.007)	-.018 (.007)	-.012 (.007)
invs	.062 (.048)		.062 (.051)		.060 (.048)	.071 (.051)	.7E-03 (.5E-03)
h	.101 (.062)	.099 (.062)	.094 (.062)	.101 (.062)	.101 (.062)	.145 (.067)	.092 (.064)
lab	.23 (.23)	.30 (.23)	.23 (.23)	.27 (.23)	.21 (.23)	.34 (.23)	.113 (.23)
assiml	.329 (.099)	.338 (.099)	.332 (.094)		.325 (.094)		
imeq			-.005 (.046)	.023 (.058)			
ineq				.021 (.037)			
open					.002 (.007)		
secer						.2E-04 (.2E-03)	
assml (alt)							.394 (.184)
R^2 AR^2	.52 .43	.51 .44	.51 .42	.52 .44	.52 .43	.54 .45	48 40

* standard errors in parenthesis

Definitions and sources in Appendix A.

Table 3[*]

Dependent variable: growth of log real gdp per worker.

Period: 1960-1990

Estimation technique:
(c) fixed time effects and autocorrelation in the time structure for errors (GLS).

lprgap	-.023 (.005)	-.041 (.005)	-.023 (.005)	-.023 (.005)	-.023 (.005)	-.027 (.005)	-.023 (.005)
invs	.136 (.039)		.136 (.046)		.136 (.044)	.120 (.039)	.177 (.039)
h	.094 (.058)	.083 (.062)	.094 (.058)	.099 (.060)	.094 (.058)	.157 (.062)	.076 (.060)
lab	-.005 (.161)	-.9E-03 (.189)	-.009 (.092)	.101 (.205)	-.002 (.182)	.203 (.189)	-.071 (.187)
assiml	.262 (.099)	.440 (.081)	.262 (.090)	.327 (.090)			
open					-.2E-03 (.007)		
imeq			.002 (.044)	.108 (.044)			
ineq				.071 (.035)			
secer						.2E-03 (.2E-03)	
assml (alt)							.230 (.205)
R^2 AR^2	.63 .58	.57 .52	.63 .57	.61 .55	.63 .57	.66 .61	.60 .54

* standard errors in parenthesis

Definitions and sources in Appendix A.

The estimated set of coefficients of the index of assimilation, though presenting high variance, do not appear to present substantial differences between each other.

Empirical evidence supports the view that learning and efficient technological adoption, as represented by the assimilation index, bear a considerable impact on the growth. The size of the impact of learning on overall growth appears to be quite higher than that estimated for other indexes of technological transfer such as imports of equipment and openness.

However, in a small sample, the effects of a single country's experiences can be a determining factor in driving the results of the estimations. For this reason a series of regressions were run successively deleting countries from the set of observations.

Table 4[*]. Outlier Analysis.

Dependent variable: growth log real gdp per worker.

Period: 1960-1990.

Econometric technique:
(a) fixed time and country effects.

*	no kor	no jap	no sing	no spain
lprgap	-.055 (.021)	-.050 (.021)	-.041 (.021)	-.046 (.021)
assiml	.262 (.115)	.327 (.134)	.251 (.129)	.276 (.071)
h	.138 (.069)	.140 (.069)	.150 (.069)	.124 (.071)
invs	.064 (.060)	.085 (.060)	.044 (.071)	.090 (.060)
R^2 AR^2	.64 .50	.61 .46	.63 .49	.61 .47

* standard errors in parenthesis.

Definitions and sources in Appendix A.

According to these results, the evidence of a positive impact of learning on overall growth rates does not depend on specific countries' experience but is rather stable within the set.

It is common to model the effects of learning, or the effects of technological diffusion, using logistic type functions that have been inherited from epidemic models (Gomulka 1990, King and Robson 1989, 1993). If the effects of the assimilation index on productivity were to be represented by a logistic function, this would imply an assumption of some kind of threshold effect. If the assimilation index were below a given level, then its effects on productivity would be negligible. Above the threshold the process of knowledge acquisition would speed up and therefore its impact on productivity would rise. The logistic function also presents an upper bound. This can occur if, when the level of acquired knowledge has reached a certain level, the rate of further assimilation drops and likewise its effects on productivity.

To estimate this hypothesis about learning effects on the sample under consideration, various cut-off points on the assimilation index were introduced. The sample was restricted to countries for which the learning index was above a lower threshold and below an upper threshold, and in the middle interval coefficients were expected to be higher. The regressions were run as follows: in the first place two cut-off points were fixed (0.010-0.15); then small changes of one were introduced. The estimation was then repeated beginning with a small change in the initial cut-off point. The interval that provided the best fit was selected.

If a logistic function were to fit the estimated effect, as the cut-off interval enlarges, the estimated coefficients would fall and so would do the "goodness of fit".

In this case, the equation estimated included levels of initial human capital as an explanatory variable.

In the series of estimation performed, there was no evidence for an upper bound in the effects of the assimilation index, i.e. the coefficients estimated on the interval (0.015-0.10) (reported in Table 5) were very similar to those obtained for the intervals (0.015-0.15) and (0.015-0.020). For these last two cases the coefficients hardly varied at all. This could be the an effect of the limited sample or that learning had not exhausted its effects in the countries under analysis.

Strong evidence was found for a threshold effect on the lower side of the assimilation index. The estimated coefficients increase substantially if the equation is estimated with a cut-off level of 0.03, and then tend to decrease as the threshold is moved down. This appears to support the view for which there must be at least some amount of accumulated ability in the economy to be able to fully enjoy the benefits of technology.

Table 5*. Truncated Sample.

Dependent variable: growth log real gdp per worker.

Period: 1960-1990

Econometric technique:
(a) time dummies.
(b) time and continental dummies.

cut-off level	0.03 (a) obs:19	0.015 (a) obs:25	0.002 (b) obs:37
lgap	-.013 (.018)	-.016 (.018)	-.023 (.013)
assiml	.723 (.163)	.424 (.145)	.352 (.180)
h	.96 (.71)	.32 (.40)	.11 (.17)
invs			.032 (.046)
secer	.2E-02 (.2E-03)	.2E-03 (.5E-03)	
R^2	.70	.62	.42
AR^2	.46	.47	.45

* standard errors in parenthesis.

Definitions and sources in Appendix A.

The coefficients estimated for the ability index increase considerably once low levels of the assimilation index are cut off, however, variance also increases as a result of the reduced size of the sample. After a certain level of exports is reached, a further increase appears to be associated with positive effects on growth rates. These effects are estimated to be quite strong though dispersion is also high.

However, the development of the abilities represented by the technological index is a relatively recent phenomenum. With such a short time period it is difficult to evaluate whether a) the effects of the assimilation index could present a learning function structure, in which case they will tend to level off in the long run since the productivity effects of learning will tend to decrease as a certain amount of knowledge is reached in the economy; or b) these are long term effects accruing to the economy from the introduction of technology and from the development of sectors regarded as the "engines of growth".

To conclude the analysis of the association of ability acquisition with growth performance, it is interesting to check whether the effects of it are in some way explained by alternative variables in the economy. It becomes important to know to what extent the assimilation index is correlated with other omitted variables that might in part in explain the high impact of such variable on growth.

The most used alternative index of "openness to technological transfer" is the trade dependency ratio (Edwards, 1989, 1992, 1993; Helliwell 1992) which was also included in previous regressions. As reported in column 5 of Tables 1, 2, 3 when the two variables are estimated simultaneously, the coefficient on the learning index does not change considerable, while the "openness" effect does not have statistically significant coefficient. The correlation coefficient between the assimilation index and openness is .56, significant at the 5% level.

It is interesting, at this point, to examine the table of cross-correlations of the learning index with a set of indicators of resource endowments.

Table 6. Correlation coefficients[4].

	assimilation index
labour	0.312*
human cap.	0.630*
land	-0.017

* significant at 5% level.

This table shows that labour has a statistically significant level of correlation with the learning index. Secondary school enrollment rates show a strong correlation with the learning index, which suggests that schooling is a more important element for the development of these abilities than some particular resource endowment.

Section 3. Conclusions.

This analysis found a significant positive association of an index of learning and competitively producing technological goods on the growth rates of a set of developing countries' . There was evidence for a lower threshold on the effects of this variable, which suggests that only above a minimum level the does the index produce significant positive effects on economic performance. Finally, the index was found to bear a strong correlation with the level of human

4 In this table, labour is represented by population per square kilometer, human capital by secondary school enrollment rates and natural resource endowment by amount of land per person.

capital in the country. This study argues that developing countries experienced strong beneficial effects deriving from learning and competitively producing foreign developed technology, and that education appears to be a necessary pre-condition for this process.

Although the results are encouraging, there is still a series of problems which remain open.

The greatest problem lies in the identification of the correct index for technological assimilation. In this case a special group of export shares where chosen to represent the ability to reproduce successfully and competitively foreign developed technology. This index might have a series of problems, which will be briefly reviewed:

a) simultaneity effects with overall growth rates, as for any export variable. This problem was tackled by using the five year lagged variables, but the index might still be accounting for more general effects than specifically technological development phenomena. Countries which export "light electrical and electronic" goods, may have experienced rapid growth because of worldwide expansion in demand for these products relative to other products.

b) exports are not the only measure of successful technology assimilation, since such transformation can occur only in the local markets without changing the composition of exports.

c) the definition of "transferable technology" can vary considerably across time. This can be observed in the definition of goods classified as research intensive by the OCDE studies (1976, 1981, 1986, 1990) along time. Although the assimilation index was designed to include the various definitions of "mobile Schumpeter industries" as discussed in the introduction, it might still leave out industries that went through substantial processes of quality upgrading (food and beverages, toys, cars) which might also provide a good index of the level of foreign technology assimilated within the country.

d) There might be factors other than the assimilation of technology behind countries' economic success in certain sectors. The most important factor to be taken under consideration in this case is factor endowment, particularly skilled labour. The activities identified as embodying "transferable technology" also appear to require a great deal of labour in assembly activities. An attempt to control for this was made through checking simple correlations of the index with natural resource endowment variables.

The really interesting comparison would have been on the level of wages in the countries under analysis with respect to the wage level of the US. This was only possible across low inflation Asian and European countries. Wage data for Latin American countries were difficult to convert in a common currency because of high inflation problems. Moreover, in all cases the variable of interest would have been wages of ratios skilled labour, which represented a further difficulty in data collection. Assuming that skilled workers' wage levels were significantly lower in countries that experienced "assimilation" success than in those where there was no "assimilating process", then, the learning index would be only picking up a comparative advantage of the skilled labour abundant countries in the production of a good. The fact that such production is also linked to growth performance could be more a question of international demand conditions than of the countries' acquired ability to compete in the international environment.

To conclude, the idea of linking technological assimilation to the catching-up process of developing countries is certainly a challenging issue. There are many problems to be accounted for in the empirical estimation of such process.

This paper has provided a possible interpretation of the analysis of such problems but much more empirical research is needed in order to get a clear view of the means and ways of technological diffusion.

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Appendix A:
Variable names and sources:

Dependent variable: Growth ln real gdp per worker; Source: SH PWT5. Calculated with yearly data for the periods: 1955-60, 1960-65, 1965-70, 1970-75, 1975-80, 1980-985, 1985-90.

Explanatory variables:
ACTPOP: Total Active Population; beginning of period values. Source: World Bank Indicators of Social Development and ILO Yearbook of Labour statistics.

ASSIML: Index of learning and reproducing efficiently and competitively foreign developed technology (SITC 1, 714, 7222, 723, 724, 725, 726, 729) over Total Exports; five years lagged values. Source Un Yearbook of International Trade Statistics.
-ASSIML (alt): Index of learning and reproducing efficiently and competitively foreign developed technology (SITC 1, 714, 7222, 723, 724, 725, 726, 729) over Total GDP; five years lagged values. Source Un Yearbook of International Trade Statistics.

IMEQ: Imports of machinery and transport equipment (SITC 7), over GDP; beginning of period values. Source: UN Yearbook of International trade and SH PWT5.

INEQ: Investment net of IMEQ over GDP; beginning of period values. Source: SH PWT5.

INVS: Investment share of GDP; beginning of period values.Source SH PWT5.

LPRGAP: Logarithm in base e of the per worker output gap with respect to the U.S, (GDP/W_c / GDP/W_{us}); beginning of period values. Source: SH PWT5.

H: Growth of secondary school enrollment rates; average lagged period (5 years) growth rate. Source: World Bank Indicators of Social Development and UNESCO yearbook.

LAB: Growth of active population; average lagged period (5 years) growth rate. source: World Bank Indicators of Social Development and ILO yearbook.

MACHIMP: Import of machinery (SITC 711, 712, 715, 717, 718) as a share of GDP; beginning of period values. Source: UN Yearbook of International trade and SH PWT5.

OPEN: (Total Imports + Total Exports) / RGDP; beginning of period values. Source: UN Yearbook of International trade and SH PWT5.

SECER: Secondary School Enrollment Rates; beginning of period values lagged 5 years .Source: World Bank Indicators of Social Development and UNESCO yearbook

Appendix B.

Countries in the Sample:

ARGENTINA
BRAZIL
CHILE
COLOMBIA
MEXICO
HONG KONG
JAPAN
KOREA
MALAYSIA
THAILAND
SINGAPORE
GREECE
IRELAND
SPAIN
TURKEY

Years in the Sample:

1955, 1960, 1965, 1970, 1975, 1980, 1985, 1990.

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