Is the Export-led Growth Hypothesis Enough to Account for China’s Growth?

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Abstract
One of the missing pieces preventing us from understanding recent Chinese economic development is the role played by openness and capital accumulation in this process. The question is whether the sharp economic growth that the Chinese economy has experienced is another case of export-led growth due to the open-door policy or whether, on the contrary, this growth has been caused by high domestic savings and investment rates (and the consequent capital accumulation). To answer this question, we employed an empirical framework of the cointegrated vector autoregressive model. The empirical results show that both investment (in physical capital and R&D) and exports, as well as the exchange rate policy, are relevant factors in explaining China’s long-run economic growth over the past 4 decades.

Key words: investment, labor productivity, openness, output
JEL codes:F43, O40, O47, O53

I. Introduction

The Chinese economy has been undergoing a spectacular process of growth for almost 4 decades. China’s GDP grew by an average of approximately 8 percent over the period 1963–1978, despite the negative effects derived from the Great Leap Forward and the Cultural Revolution. This growth accelerated even further from the end of the 1970s until 2005, when the average annual growth rate exceeded 10 percent. As a result of this evolution, unparalleled by other economies in the world today, the percentage of China’s contribution to world GDP rose from less than 1 percent at the beginning of the 1960s to 5 percent by the
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middle of the 2000s.

Much of the published empirical literature has attributed this sharp economic growth to the opening of China’s economy and, in particular, to the expansion of exports. Indeed, it is well known that in 1978 China embarked upon an ambitious program of economic reforms. These reforms (which include the progressive adoption of market-oriented and open-door strategies for development that culminated in 2001 with China’s adhesion to the WTO) have led to an impressive export performance, with China’s participation in the world export markets increasing from negligible values to more than 7 percent in 2005. However, this explanation cannot account for the significant growth this country underwent before 1978. Like other planned economies, its growth in this period probably relied on high investment rates. However, since 1978, instead of decreasing, the investment-to-GDP ratio has, in fact, continued to increase. In the 1960s, the average investment rate was 20 percent. It has been increasing steadily ever since, reaching values of over 30 percent in the 1990s and over 40 percent in 2004. The concurrence of high investment rates and fast expansion of exports has sparked debate about their role in China’s economic growth. The core issue is probably a reappraisal of the controversy that appeared in the mid-1990s in relation to the sources of economic growth in high-performing Asian economies (Young, 1992; Pack and Page, 1994). According to Paul Krugman (1994, p.70), “Asian growth ... seems to be driven by extraordinary growth in inputs like work and capital rather than by gains in efficiency.” The experience of the “Asian tigers” showed a possible alternative scenario by which the mechanisms for growth differed from those previously considered (trade and especially export expansion). Rodrik (1995) even argues that the rapid growth of these economies was caused by investment booms, the expansion of trade being a consequence of this process.

The question would be of no great significance if it were not for the foreseeable differences in relation to the long-run sustainability of growth and its implications for economic policy. Has the promotion of domestic saving at the expense of consumption influenced economic growth? Has capital accumulation given rise to permanent increases in productivity; that is, has it improved workers’ efficiency? Is the adoption or the maintenance of almost mercantilist export programs really a suitable strategy for China? The role played by capital accumulation and exports in terms of economic growth thus continues to be one of the missing pieces preventing us from understanding China’s recent economic development. Doubt arises as to whether the sharp economic growth that the Chinese economy has experienced is another case of export-led growth due to the open-door policy or whether, on the contrary, this growth has been caused by high domestic saving and investment rates (and the consequent capital accumulation), referred to as the investment-led growth effect in the empirical literature. This proves to be an interesting question to be investigated in this work from both an academic and an economic policy
However, the investment or open-door policy in China cannot be understood without taking the exchange rate policy carried out by the Chinese Government into account in the analysis. In this regard, recent empirical evidence suggests that the real exchange rate plays an important role in influencing output in the long run (Levi-Yeyati and Sturzenegger, 2007; Gala, 2008; Rodrik, 2008). The case of China, along with the experiences of other developing countries that tend to maintain competitive exchange rates, has sparked a great deal of interest in the relationship between the real exchange rate and output, as a result of the fact that an additional tool has also been used to enhance growth. This is the mechanism through which the increase in domestic savings and investment rates operates (Levi-Yeyati and Sturzenegger, 2007) rather than through export expansion, as suggested by Rodrik (2008). However, despite these arguments, little work has been carried out on the case of China. Therefore, in the present paper, we are going to look for the three features that were stressed in China between 1964 and 2004. Moreover, unlike other studies such as Yu (1998) and Kwan et al. (1999), we consider factors such as R&D expenditure as determinants of economic growth in China, and significantly improve the empirical specification. Yu (1998) employs the Engle and Granger two-step estimator over the period 1980–1990, and finds that exports and investment explain output growth. Using a time-series approach and data from 1952 to 1993, Kwan et al. (1999) find empirical evidence of the contribution of investment and exports to growth, exports being consistent with large increases in investment. However, neither of these papers takes the endogeneity problem into account in the analysis, as a joint estimation of the variables in growth empirics is very demanding.

In the present paper we use the cointegrated vector autoregressive (VAR) model as our empirical framework. This methodology enables us to perform a joint modeling within a context in which our variables are closely related to each other and there may be problems of endogeneity. Furthermore, in order to consider the existence of structural changes in our relations and to guarantee the stability of the parameters, we allow structural breaks in the estimated models. Moreover, we also allow for multiple long-run relationships and we explicitly test the long-run weak exogeneity to clarify the direction of the causality between the variables of interest, both in the short run and in the long run.

The present paper is arranged as follows. In the next section we review the published literature to determine how exports and capital accumulation encourage output and productivity. In Section III, we define the variables and present the econometric methodology. An empirical analysis is provided in Section IV. Finally, some concluding comments are provided in Section V.
II. Literature Review

The conventional Solow–Saw textbook growth model and endogenous growth models highlight the importance of capital accumulation in the process of growth. However, there is little agreement on the long-run effect of investment on growth. The first of these models suggests that capital accumulation plays a minor role in long-run economic growth. Of course, these models show that countries that invest more also tend to grow more. However, this effect seems to be transitory and could disappear in the absence of other factors that stimulate steady-state growth. From this perspective, investment could not be considered a source of sustained economic growth. This belief is also supported by R&D-based endogenous growth models (Romer, 1986; Grossman and Helpman, 1991). However, De Long and Summers (1992) argue that investment in equipment is associated with higher growth, due to the embodied technological progress, and that the government has played a positive role by investing in infrastructure to improve economic activity and productivity (Aschauer, 1989). These findings are more consistent with the main implications of other types of endogenous growth models, such as the AK or Schumpeterian models (Rebelo, 1991; Howitt, 2000). Furthermore, in these other kinds of models, “capital and knowledge are two state variables determining the level of output at any point of time” and “capital accumulation and innovation should be complementary processes, both playing a critical role” (Howitt and Aghion, 1998, p. 112). Therefore, both investment in equipment and R&D expenditure can interact to reinforce this relationship.

From a theoretical and empirical point of view, capital accumulation is not free of a certain amount of ambiguity as regards its relationship with the GDP or labor productivity. For example, Jones (1995) concludes that AK growth models do not provide a good description of growth in 15 selected OECD countries, while Blomstrom et al. (1996) find that causality runs from economic growth to investment. Nevertheless, the opposite view can also be found in the empirical literature. For example, Bond et al. (2004) find evidence that an increase in investment as a share of GDP results in a higher rate of growth in output per worker.

The published literature contains little empirical evidence of the investment-led growth effect in China. However, any evidence to this effect does seem to reveal that capital accumulation has played an important role in the process of economic growth (Kwan et al., 1999). For example, Chow (1993) emphasizes the role of capital accumulation as the main source of China’s economic growth from the 1950s until the end of the 1980s. Nevertheless,

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1 Kwan et al. (1999) found empirical evidence that investment had a positive influence on growth during the period 1953–1993.
there was no evidence of technological progress during this period. Yusuf (1994), however, argues that not only was capital accumulation an important determinant of economic growth, but that technological progress also played a significant role from 1978 to 1993. Furthermore, some authors, like Hu and Khan (1996) and Caruso (2002), argue that although the growth in productivity rose sharply during the early years of the reform, during the pre-reform period it was also positive, in contrast to Chow’s view. Finally, unlike previous studies, Qin et al. (2005) find some evidence that output drives investment in the Chinese economy.

However, openness, especially the expansion of exports, has also been considered to be one of the key factors in the promotion of economic growth in developed and developing countries (Lopez, 2005). Among the channels identified in the literature as potential generators of positive effects on output and productivity, the most immediate is the possibility that exposure to trade will induce a self-selection of firms (Melitz, 2003), the most productive being the ones that finally become exporters and, therefore, have a positive effect on the aggregate productivity. In addition, economies of scale, more efficient management and organization styles, and the existence of positive spillovers are found to be suitable channels through which exports influence economic growth (Feder, 1983; Helpman and Krugman, 1985). Finally, exporting activity allows foreign exchange constraints to be relaxed, thus permitting increased imports of capital and intermediate goods (Esfahani, 1991).

Nevertheless, despite these arguments, there is some skepticism about the ability of openness to explain success in foreign markets and productivity gains, and about exporting firms’ being more productive than non-exporters (Rodriguez and Rodrik, 2001). We even found evidence for the existence of a growth-driven exports hypothesis, according to which countries with higher incomes engage in more trade (Helpman, 1988). In fact, the endogeneity problem has been a recurrent topic in the empirical literature on openness and growth, with no conclusive results (Frankel and Romer, 1999; Noguer and Siscart, 2005).

The evidence found in relation to the Chinese economy is in agreement with the rest of the empirical literature. On the one hand, Shan and Sun (1998) detail a wide selection of empirical studies on the export-led growth hypothesis, with all papers seeming to support the hypothesis. However, their results indicate that bidirectional causality exists between exports and output in China. A positive effect of exports on output is also found in Liu et al. (1997), Lin (1999), Liu Xiaohui et al. (2002), Jin (2004) and Yao (2006), but with different specifications. Notice that in many cases these results are found because exports are assumed to be an endogenous variable without testing their weak exogeneity. In the present paper, suitable tests will be used to provide evidence that, for the case of China, exports

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2 See also Rodrik (2006) for evidence on the structure of Chinese exports as a key role in China’s growth.
become a weakly exogenous variable in the long run. This implies that exports might influence output, but it is not possible to find the reverse causation in the long run. On the other hand, and contrary to the general perception, Hsiao and Hsiao (2006) find that exports are not the cause of China’s GDP. Thus, the findings in the current empirical literature on the role that exports play in China’s economic development seem inconclusive.

Regardless of the controversial aspect of the direction in which causality runs between investment and output, investment-led growth in China should be reconciled with the spectacular growth of Chinese exports. This possibility was underlined by Rodrik (1995) when explaining the economic growth of Korea and Taiwan in the 1960s. According to Rodrik, the outward orientation of these economies was more the result of the investment boom than the consequence of an export-led growth effect. The increase in exports was the result of export-oriented policies that enabled the increase in demand for imported capital goods (a consequence of the investment boom) to be met. However, as Baldwin and Seghezza (1996) argue, the opposite point of view is also feasible. According to Baldwin and Seghezza, trade-induced investment-led growth could have taken place and, in line with our results, there is evidence that both exports and investment boost output growth (Yu, 1998; Kwan et al., 1999).

Related to this debate is the fact that the success or failure of export-led growth strategies depends on many factors and domestic economic policies. One of these factors is the real exchange rate. Recent empirical evidence indicates that the real exchange rate has been used as a tool to promote output in the long run, especially in developing countries (Gala, 2008; Rodrik, 2008). Whereas Levi-Yeyati and Sturzenegger (2007) argue that the long-run effect of the real exchange rate works through greater investment and savings, Rodrik (2008) suggests the size of the tradable sector as the main channel in which to find this effect. This issue is important for the Chinese economy, because the government has been interested in maintaining a competitive exchange rate for a long time and this policy has been carried out simultaneously with aggressive promotion of exports and investment that has presumably helped to achieve rapid economic growth. However, little effort has been made to examine all these factors in a unified framework. In this paper, unlike other studies that consider exports to be the main engine of growth, we provide an alternative perspective of the drivers of China’s growth by considering growth factors other than exports.

III. Econometric Methodology and Data

Assuming a Cobb-Douglas production function, where output is a constant returns function
of capital and labor, that is, \( Y = AK^\alpha L^{1-\alpha} \). Using the standard Solow–Swan model of growth it is found that a permanent increase in investment or in the level of exogenous technological progress (\( A \)) predicts a higher level of output per worker, and this is our theoretical point of departure. However, we can assume that within a context of more recent versions of endogenous growth models, there are a variety of factors that could account for the improvement of technological progress, understood in a broad sense. In fact, in the literature review presented by Grossman and Helpman (1991), at least 10 potential determinants of long-run growth are identified, including investment, openness, R&D expenditure and property rights. In the present paper, because of the characteristics of the Chinese economy as well as the data that is currently available, we focus first on the effects of exports and investment on GDP and labor productivity. Second, we analyze additional factors of growth like R&D expenditure and improved competitiveness, as recently emphasized by several authors, including Rodrik (2008) and Gala (2008).

Our empirical analysis basically uses annual data for China provided by the National Bureau of Statistics of China for the period 1964–2004. Our dataset consists of GDP (\( \text{lgdp} \)), labor productivity (output per worker) (\( \text{lprod} \)), investment (\( \text{linv} \)), exports in FOB terms (\( \text{lexp} \)), R&D expenditure (\( \text{lrd} \)) of the Chinese economy, the real exchange rate (\( \text{lrer} \)) and US GDP (\( \text{lgdpusa} \)).

The empirical strategy begins with an analysis of the stationary properties of our variables, which can be seen in Table 1. It is evident from the unit root test (Phillips Perron and Augmented Dickey–Fuller) that all the variables that we consider are I(1) in levels, and we reject the possibility of them being I(2).

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The methodology that we use is the cointegrated VAR model proposed by Johansen.

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3 See the China Compendium of Statistics 1949–2004, published by the National Bureau of Statistics of China (NBS). Base year 1952 = 100. We have used the original base year derived from the NBS. Moreover, although Chinese National Accounts started in 1952, we moved the beginning of the effective sample to 1964. This change was due to the difficulty involved in performing a sufficiently homogenous treatment over such a turbulent period as the one between 1958 and 1962, with the Great Leap Forward and the consequent economic collapse that produced abnormally low values of macroeconomic aggregates for the period 1961–1963 (Chow, 1993).

4 This variable was introduced into the model as a control variable. The justification for including this kind of control variable in a similar context to this paper can be seen in Marin (1992). Moreover, US GDP is usually employed as a reference country representing world activity. Data from the USA were taken from the Bureau of Labor Statistics and the Bureau of Economic Analysis.

5 All variables are in logs and real terms, and have been deflated by the GDP deflator. The real exchange rate was calculated using the nominal exchange rate between the Chinese currency and the US dollar (renminbi/$) and consumer price indices.
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We start the analysis with a broad general specification in which certain restrictions will be imposed until the most irreducible form is reached.

More specifically, we start with an unrestricted VAR model, with a restricted linear trend in the cointegration space and with an unrestricted constant ($\mu$) of dimension $r \times 1$:

$$\Delta X_t = \alpha \beta \Delta X_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta X_{t-i} + \sum_{i=1}^{q} \phi_i \Delta Z_{t-i} + \theta \Delta D_t + \sum_{i=1}^{l} \psi_i \Delta \Delta D_{t-i} + \mu + \varepsilon_t,$$

where $\alpha \beta$ are the coefficients of the long-run matrix, $\alpha$ gives the direction and speed of

Table 1. Unit Root Tests

| Variable | Model 1 (trend and constant) | Model 2 (constant) | Model 3 (none) |
|----------|------------------------------|-------------------|----------------|
|           | Phillips–Perron | Phillips–Perron | Phillips–Perron |
| lgdp      | Levels | Difference | Levels | Difference | Levels | Difference |
| lprod     | -1.72  | -5.04*    | 0.75   | -4.77*    | 22.38 | -2.61** |
| lexp      | -2.34  | -5.64*    | 1.34   | -5.41*    | 6.83  | -2.91** |
| lrer      | -1.63  | -5.43*    | -1.01  | -5.47*    | 1.95  | -4.94* |
| lgdpusa   | -4.13**| -4.89*    | -1.76  | -4.81*    | 10.50 | -1.91*** |
| lrd       | -2.39  | -6.40*    | -0.19  | -5.59*    | 5.25  | -4.12* |
| linv      | -3.14  | -5.90*    | -0.52  | -5.82*    | 10.30 | -3.46* |

Note: *, ** and *** represent rejection of the null hypothesis at the 1, 5 and 10-percent level, respectively.

(1995) and Johansen and Juselius (1994). We start the analysis with a broad general specification in which certain restrictions will be imposed until the most irreducible form is reached. More specifically, we start with an unrestricted VAR model, with a restricted linear trend in the cointegration space and with an unrestricted constant ($\mu$) of dimension $r \times 1$:

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This methodology is based on the principle of “general to specific” discussed in Hendry and Mizon (1993). Applications of cointegration techniques for the case of China can be found in Chen et al. (2009), among others.
adjustment toward equilibrium and $\tilde{\beta}$, are the coefficients of the cointegrated vectors; $X$ is the matrix of endogenous variables in the model, $Z$ is the matrix of weakly exogenous variables, $i$ is the linear trend restricted to the cointegration space and $D_{st}$ is the matrix of the level-shift dummy; $\Gamma_i$ is the unrestricted matrix of the coefficients in the short run and of dimension $p \times p$, while $\omega_i$ and $\theta_i$ are the coefficients of the variables that have been considered prior to analyzing the weakly exogenous variables ($Z$) and the level-shift dummy ($D_{st}$), respectively. Finally, the term ($D_{st}$) contains a vector of unrestricted dummy variables and their corresponding coefficients. In addition, we assume that the error term, $\varepsilon_t$, is an i.i.d. Gaussian sequence $N(0, \Omega)$ and that the initial values, $X_{-k+1}, \ldots, X_0$, are fixed.

**IV. Empirical Analysis**

1. Productivity Model

Initially, the endogenous variables considered in the model presented in this section are labor productivity, investment, exports, real exchange rate and R&D expenditure. The US activity level is included to capture foreign influence on the Chinese economy, and is considered a weakly exogenous variable. Starting from this five-equation system, the exogeneity test suggests that exports could be managed as an exogenous variable with a $p$-value of 0.90. Under this new specification with four endogenous variables (productivity, investment, real exchange rate and R&D expenditure) and two exogenous variables (exports and US activity), the exogeneity test is applied to show that R&D expenditure can also be considered to be an exogenous variable with a $p$-value of 0.73. Finally, the determination of the number of lags, according to the criterion of Hannan and Quinn, indicates that two lags are enough to capture the dynamic effects of the model and to avoid autocorrelation problems.

In short, the definitive specification that we have considered is a VAR(2) model with three endogenous variables (productivity, investment, and real exchange rate) and three exogenous variables (exports, R&D expenditure and US activity), with their

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8 We have included two level-shift dummies restricted to the cointegration spaces in 1978 ($D_{s78}$) and in 1994 ($D_{s94}$) in accordance with the set of stability tests.

9 The dummy $D_{89p}$ attempts to capture the political instabilities and economic restrictions in 1989 (restrictive fiscal and monetary policies were introduced by the Chinese Government at the end of 1988 to stem sharply rising inflation, the contractive effects of which coincided with the events that took place in Tiananmen Square).

10 The criterion to include a dummy was $|\hat{\epsilon}_{t+1} | > 3.3\hat{\sigma}_e$. For further details of the impact of deterministic components in the VAR model, see Juselius (2007).

11 In this model, productivity was corrected by applying the methodology suggested by Nielsen (2004).

12 These tests are available upon request from the authors.
corresponding deterministic components. We applied the misspecification tests for the residuals of the model, where neither autocorrelation nor normality problems existed.

Based on the statistical model, we can obtain the number of long-run relationships ($r$), and the number of common trends ($p - r$) by using the likelihood ration (LR) test. Table 2 shows the trace test, where everything seems to indicate that two long-run relationships ($r = 2$) exist in our model, as well as a common trend. In addition, the inverse root of the characteristic polynomial for this rank is 0.80 (less than unity), which shows that our model is stationary.

The following cointegration vectors can be found in the selected model. They are expressed as error correction mechanisms ($t$-values in brackets):

\[
ecm_1 = lprod - 0.16linv - 0.29lexp - 0.17Drd_{ret} \\
[-4.47] [-11.77] [-5.97] 
\]

\[
ecm_2 = linv - 0.31lr + 0.20Drd_{ret} - 0.08t \\
[-5.73] [-6.99] [-24.73] 
\]

The first relationship (Equation 2) describes how exports and investment both account for the level of productivity in the long run. In contrast, the second relationship (Equation 3) shows that R&D expenditure favors an increase in investment. The coefficients associated with the two relationships are statistically significant and show the expected signs. The restrictions imposed on both cointegration relationships were accepted with a $p$-value of 0.175. The coefficients of adjustment toward equilibrium are statistically significant and negative, and take a value of $-0.36$ with a $t$-statistic of $-5.55$ for the first cointegrated vector and $-0.64$ with a $t$-statistic of $-5.86$ for the second. Although complete parameter constancy is difficult to guarantee in a period of such important economic changes, the reduced-form model is stable in the forward and backward analysis. In this sense, our estimates should be considered as average effects throughout the period analyzed.

| $p - r$ | $r$ | Eigenvalue | Trace | Trace* | 95% | $p$-value | $p$-value* |
|--------|-----|------------|-------|--------|-----|-----------|-----------|
| 3      | 0   | 0.77       | 117.85| 100.96 | 77.10| 0.000     | 0.000     |
| 2      | 1   | 0.59       | 56.11 | 49.36  | 49.6 | 0.011     | 0.052     |
| 1      | 2   | 0.37       | 19.09 | 16.55  | 25.86| 0.254     | 0.415     |

Table 2. Determination of the Rank Test in the Productivity model

Note: 1Corresponds to the trace test with Bartlett’s correction. The asymptotic distributions have been simulated for the current deterministic specifications.

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13 See Juselius (2007) for a description of the specification process.
14 Details are available upon request for both models.
15 Details are available upon request for both models.
Our findings are consistent with an export-led productivity growth effect. The first long-run relation (Equation 2) shows a positive relationship between productivity and exports, where the causality runs unidirectionally from exports to productivity in the long run. Unlike other studies, we have not found a bidirectional causality relation, as exports became exogenous in our analysis. Additionally, not only exports but also investment has a positive effect on productivity. This result is interesting because it shows that both exports and capital accumulation play a central role in the long-run dynamics of productivity in China. Therefore, our results are also consistent with the existence of an investment-led productivity growth effect. The second long-run relationship shows that investment and R&D expenditure are cointegrated. An interesting result derived from this analysis is that R&D expenditure affects investment directly and positively, with a moderate coefficient, and that it has an indirect effect on productivity through investment.

Table 3 represents the dynamics of the short-run structure where the overidentifying restrictions based on the LR test are accepted with $\chi^2(23) = 31.669$ (0.1072). Productivity

| Table 3. Short-run Identification |
|-----------------------------------|
| **Model 1: Labor productivity model** | **Model 2: GDP model** |
| $\Delta lpro$ | $\Delta linv$ | $\Delta lexp$ | $\Delta lpro$ | $\Delta linv$ | $\Delta lexp$ |
| $\Delta lpro_{-1}$ | 0.34 | 1.14 | --- | 0.36 | --- | 0.64 |
| $\Delta gdp_{-1}$ | 4.79 | 7.26 | --- | 2.74 | --- | 3.83 |
| $\Delta lexp_{-1}$ | 0.50 | 1.05 | --- | 0.51 | --- | 0.48 |
| $\Delta lrd_{-1}$ | 3.66 | 2.99 | --- | 3.66 | 2.99 | --- |
| $\Delta lrd_{-1}$ | --- | 0.13 | --- | --- | --- | --- |
| $\Delta lrd_{-1}$ | --- | 0.09 | --- | --- | --- | --- |
| $\Delta lrd_{-1}$ | --- | 0.03 | --- | --- | --- | --- |
| $\Delta lrd_{-1}$ | 0.07 | --- | --- | 0.07 | --- | --- |
| $\Delta lrd_{-1}$ | 2.95 | --- | --- | 2.95 | --- | --- |
| $\Delta gdp_{-1}$ | 0.12 | 0.40 | --- | 0.12 | 0.40 | --- |
| $\Delta lpro_{-1}$ | 5.64 | 7.95 | --- | 5.64 | 7.95 | --- |
| $\Delta gdp_{-1}$ | 0.07 | --- | --- | 0.07 | --- | --- |
| $\Delta lpro_{-1}$ | 0.12 | 0.20 | --- | 0.12 | 0.20 | --- |
| $\Delta lpro_{-1}$ | 6.18 | 3.95 | --- | 6.18 | 3.95 | --- |
| $\Delta lpro_{-1}$ | 0.03 | 0.14 | --- | 0.03 | 0.14 | --- |
| $\Delta lpro_{-1}$ | 6.38 | 5.09 | --- | 6.38 | 5.09 | --- |
| $\Delta lpro_{-1}$ | 0.03 | 0.13 | --- | 0.03 | 0.13 | --- |
| $\Delta lpro_{-1}$ | 0.04 | 0.27 | --- | 0.04 | 0.27 | --- |
| $\Delta lpro_{-1}$ | 0.35 | 0.31 | --- | 0.35 | 0.31 | --- |
| $\Delta lpro_{-1}$ | 0.27 | 0.81 | --- | 0.27 | 0.81 | --- |

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adjusts toward equilibrium with the export-led and investment-led productivity relationship \((ecm_1)\) and the investment vector \((ecm_2)\). The alpha coefficients show the speed and direction toward equilibrium. In the labor productivity equation, it can be observed that the adjustment is relatively slow and productivity adjusts toward equilibrium approximately every 2 years, and is probably associated with the continuous transformations in the Chinese economy within the period considered. Additionally, in the dynamics of the model we observe that R&D expenditure has a positive effect on the productivity equation in the short run. This indicates that not only the transfer and absorption of foreign technology through the generation of spillovers from exports favor efficiency and productivity, but that efforts in innovation play a relevant role in improving productivity in the Chinese economy. Moreover, foreign demand, measured by the US activity level, shows a procyclical performance, which favors the growth of productivity. Finally, the productivity lag itself has a positive effect on the productivity equation.

Investment also adjusts toward equilibrium with both vectors in the long run. The alpha coefficients in the investment equation show that, similarly to the previous equation, adjustment with the first vector is relatively slow. Adjustment toward equilibrium with the second cointegrated vector (investment vector), however, is reasonably fast. Moreover, in its own equation, investment shows a minor overreaction, given the negative coefficient in \((ecm_1)\). However, it is compensated by the higher negative value in \((ecm_2)\), and, as a consequence, this long-run relationship adjusts toward equilibrium. An interesting result in the short run is that investment accelerates as productivity increases, because a positive productivity shock probably attracts investment through the expectations of obtaining future returns. In addition, we observe that foreign demand and R&D expenditure both favor increased investment. Nevertheless, one unexpected finding is that exports have a transitory negative effect on the investment equation.

Finally, the third equation reveals that the real exchange rate is appreciated when investment is over the steady state \((ecm_3)\). This result can probably be explained by the fact that when investment is over its value in the long run, there is an inflationary effect owing to an increase in aggregate demand, and a consequent appreciation of the real exchange rate.

2. Output Model

Similarly to the previous model, our starting point is the output model which contains the following variables: Chinese activity level (GDP), exports, investment, real exchange rate, R&D expenditure and US activity level.

Once again, either the exogeneity or the endogeneity of the variables considered in the
simple model is analyzed under the assumption that the US activity level is weakly exogenous. Like the productivity model, the exogeneity test shows us that exports are exogenous, with a $p$-value of 0.27. Therefore, by following the same sequence as the previous model specification, we also find that R&D expenditure is exogenous, with a $p$-value of 0.09. Thus, at the end of this process, our model contains three endogenous variables (China’s GDP, investment and real exchange rate) and three exogenous variables (exports, R&D expenditure and the US activity level). Finally, determining the number of lags in accordance with the criterion of Hannan and Quinn shows that two lags are enough to capture the dynamic effects and to avoid autocorrelation problems. Indeed, we also applied the misspecification tests for the residuals of this model, where neither autocorrelation nor normality problems were found.

In Table 4 it can be seen that both the null hypotheses of the absence of cointegration and the existence of one cointegration vector are clearly rejected. In our model, therefore, we accept the null hypothesis of the existence of two long-run relationships ($r = 2$) and a common trend, where both $p$-values accept the null hypothesis, and the inverse root of the characteristic polynomial for $r = 2$ is 0.78; that is, less than unity. This shows that our relationships are stationary and adjust toward an equilibrium.

In the model we selected, the following cointegration vectors can be found to be expressed as error correction mechanisms ($t$-values in brackets):

$$
ecm_1 = \text{lg} \, dp - 0.39 \text{linv} - 0.88 \text{lrr} - 0.10 \exp - 0.25 D_{94} - 0.15 D_{78}
$$

$$
[-9.98] [-6.20] [-3.31] [-6.43] [-4.32]
$$

$$
ecm_2 = \text{linv} - 0.28 \text{lrd} + 0.23 D_{78} - 0.09 t
$$

$$
[-5.67] [-7.68] [-29.09]
$$

The coefficients associated with the variables in both relations are statistically significant and show the expected signs. The restrictions imposed in both cointegrating vectors are accepted with a $p$-value of 0.425. The coefficients of the adjustment toward equilibrium are also statistically significant and negative, and show a value of $-0.42$ ($-7.21$)

### Table 4. Determination of the Rank Test in the Output Model

| $p-r$ | $r$ | Eigenvalue | Trace | Trace$^*$ | 95% | $p$-value | $p$-value$^*$ |
|-------|-----|------------|-------|-----------|-----|-----------|-------------|
| 3     | 0   | 0.76       | 116.82| 99.43     | 76.16| 0.000     | 0.000       |
| 2     | 1   | 0.59       | 58.39 | 50.49     | 49.62| 0.006     | 0.041       |
| 1     | 2   | 0.40       | 20.95 | 17.02     | 25.60| 0.166     | 0.375       |

Note: $^a$Corresponds to the trace test with Bartlett’s correction. The asymptotic distributions have been simulated for the current deterministic specifications.

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and \(-0.82 (-6.47)\) for the first and second relationship \((ecm_1\) and \(ecm_2)\), respectively. Finally, the reduced-form model is stable in the forward and backward analysis.

The long-run model for output is very similar to the model of productivity that we have seen. The first relationship corresponding to Equation (4) shows a positive relationship among China’s output, investment, real exchange rate and exports. Our findings are consistent with the export-led growth hypothesis, which predicts the existence of a positive relationship between the level of domestic activity and exports, where the direction of the causality runs unidirectionally from exports to GDP in the long run. Furthermore, the positive effect of investment on output in the long run emphasized by the literature also appears in this relationship. Therefore, our findings are consistent with Yusuf (1994), who finds that capital accumulation is one of the most important factors in the economic growth process in China.

As mentioned above, we include the real exchange rate as a proxy variable to take competitiveness into account in the analysis, given that a close relationship is maintained between the real exchange rate and trade, and even investment. On comparing it with the previous productivity model, however, it can be observed that the real exchange rate positively affects output in the long run. As stated earlier, this result is in line with the findings of Levi-Yeyati and Sturzenegger (2007), Gala (2008) and Rodrik (2008), among others.

The effects of R&D expenditure on investment can be observed in the second relationship (Equation 5). This result is interesting in the sense that investment is affected by the innovating effort of the Chinese economy in both the models analyzed, because it allows investment to increase and stimulates the accumulation of physical capital, which also favors economic growth.

Table 3 shows the dynamic structure of the output model, where the overidentifying restrictions based on the LR test are accepted and the test is distributed as \(\chi^2 (25) = 32.606 (0.1412)\).

The Chinese activity level adjusts toward equilibrium with the two cointegrated vectors \((ecm_1\) and \(ecm_2)\). In contrast to the previous model, the alpha coefficients in this model show a reasonably fast adjustment. Output level adjusts toward equilibrium with the first relation approximately every year and a half. In the dynamic model, the US activity level displays a procyclical performance, which is similar to that of the productivity model. Furthermore, R&D expenditure, investment and exports positively affect output in the short run. However, the real exchange rate shows a transitory negative effect.

As in the productivity model, investment adjusts toward equilibrium with the two vectors. From this equation, it is evident that both vectors show a relatively fast speed of adjustment. Investment is error-correcting with the second long-run relation and adjusts...
toward equilibrium approximately every year. Similarly to the productivity model, the investment equation overreacts with the first relation (productivity vector), but is also compensated by the negative coefficient in $ecm_1$. R&D expenditure has directly favored increased investment in China. The dynamics of this model show that investment, R&D expenditure and the US activity level have a positive effect on the investment equation. Once again, however, the real exchange rate has a transitory negative effect in the short run.

Finally, similar to the previous model, the real exchange rate adjusts toward equilibrium with the second cointegrated vector ($ecm_2$). When investment is over its value in the long run, an appreciation of the real exchange rate results, and the alpha coefficient shows a reasonable speed of adjustment toward equilibrium of approximately a year and a half.

V. Conclusions

In the present paper, we have analyzed whether the rapid process of economic growth in China since the 1960s, especially in labor productivity and output, can be mainly explained by an investment-led growth effect or, conversely, by an export-led growth effect. Moreover, we have investigated the empirical relationship between the real exchange rate and output, due to the fact that previous evidence suggests it has been used as an additional economic policy tool to stimulate growth. Unlike other studies, new relevant factors such as R&D expenditure, the real exchange rate and foreign output were also included in our analysis. Therefore, we emphasized the complementarities between capital accumulation and innovation, combined with openness, as the most important channels in which to stimulate economic activity.

Our empirical evidence shows that both an export-led growth effect and an investment-led growth effect are relevant in the Chinese economy. This result remains whether we analyze the long-term dynamics of output or productivity. In both models, a positive relationship is found among labor productivity or output, exports and investment in the long run. Additionally, our findings show that exports exogenously drive output and productivity in the long run. Furthermore, we found that R&D encourages investment, with a moderate coefficient in the long run. In contrast to the productivity model, we found that the real exchange rate played an important role in determining the output level. Moreover, bearing in mind the continuous process of reforms in China during the period under study, these findings can only be found if structural changes in 1978 and 1994 are considered. In accordance with the results found in this paper, everything seems to indicate that there are additional factors that account for China’s growth other than exports, the export-led growth hypothesis being only part of the explanation in this process.
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