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# *Ideas Production in Emerging Economies*

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# Ideas Production in Emerging Economies

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**Abstract**

We model 'new ideas' production in a panel of 17 emerging countries. Our results reveal: (i) ideas production is duplicative, (ii) externality associated with domestic knowledge stocks is of above unit factor proportionality, (iii) OECD countries raise the innovation-bar for emerging countries, (iv) there is no significant knowledge diffusion across emerging countries, and (v) growth in emerging countries appear far from a balanced growth path.

JEL Classification: C2; O3; O4.

Key Words: Ideas Production; Knowledge Diffusion; Panel Co-integration.

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**Ideas Production in Emerging Economies**

## 1. Introduction

Innovations drive productivity and growth in R&D based new growth models (Romer,1990; Grossman and Helpman,1991; Aghion and Howitt, 1998). However, the 'scale effects' embedded in these models do not conform to the growth experiences of major industrialized countries (Jones, 1995). The second-generation models (e.g., Aghion and Howitt, 1998; Howitt, 2000) argue that the 'scale effects' get diluted in an expanding economy yet growth can be sustained if R&D is kept at a fixed proportion of the proliferating production sectors.

Voluminous empirical literature reports evidence consistent to these models: (i) domestic knowledge stocks and knowledge diffusions significantly explain domestic productivity and growth, and (ii) research intensity, accumulated knowledge stocks, and knowledge diffusion are important for the discovery of 'new ideas'. [1] However, most extant studies analyze OECD countries because of the concentration of R&D activities and the data limitations.

In recent decades, low and middle-income countries (emerging economies) have increased their R&D activities. [2] However, knowledge production across these countries is hardly scrutinized. We bridge this gap by

[1] See, among others, Porter and Stern (2000); Keller (2004); Luintel and Khan (2009 and 2011); Coe et al. (2009).

[2] Their share of world R&D expenditure went up from 10% (1992) to 20% (2008). Emerging countries such as China (1.05%), India (0.71%), and the Russian Federation (1.03%) [Table 1] have R&D intensities equivalent to some OECD countries - Spain (0.71%), Ireland (1.0%) and Italy (1.1%) [Luintel and Khan, 2009].

modeling ideas production in a panel of 17 emerging countries and characterize their growth path.

## 2. Model

Output ($Y$) is modelled in a standard neo-classical (Cobb-Douglas) tradition with labour augmenting technology ($A$), and constant returns to physical capital stock ($K$) and labour ($L$):

$$Y = K^{\alpha}[A(1-a_l)L)]^{1-\alpha} \tag{2.1}$$

Time subscripts are suppressed. There are goods and knowledge producing sectors; $a_l$ is the fraction of $L$ used in the R&D sector. A simple capital accumulation process is: $\dot{K} = s\cdot Y$; $s$ is a constant saving ratio. [3] The domestic flow of 'new knowledge' ($\dot{A}_d$) is:

$$\dot{A}_d = \overline{\delta} L_A \tag{2.2}$$

$\overline{\delta}$ is the average research productivity. Jones (1995) sets $\overline{\delta} = \delta A_w^{\phi} L_A^{\lambda-1}$; $0 \le \lambda \le 1$. Romer (1990) assumes $\phi = 1$ and $\lambda = 1$. $A_w$ is global knowledge stock. We modify $\overline{\delta}$ as:

$$\overline{\delta} = \delta L_A^{\lambda-1} A_d^{\phi} A_{fe}^{\theta} A_{fo}^{\beta} \tag{2.3}$$

In (2.3), $\overline{\delta}$ depends on the number of R&D researchers ($L_A = a_l L$), domestic knowledge stocks ($A_d$), and foreign knowledge stocks originating from OECD ($A_{fo}$) and emerging countries ($A_{fe}$); $\lambda$, $\phi$, $\theta$ and $\beta$ are parameters. The level of sophistication of ideas may differ between OECD and emerging countries implying potentially different diffusions hence the distinction. Substituting (2.3) into (2.2) yields:

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[3] A constant $s$ is a pretty standard formulation in these models.

$$\frac{\dot{A}_d}{A_d} = g_{A,d} = \delta L_A^{\lambda} A_d^{\phi-1} A_{fe}^{\theta} A_{fo}^{\beta} \tag{2.4}$$

Taking logs of (2.4), differentiating with respect to time and rearranging:

$$\frac{\dot{g}_{A,d}}{g_{A,d}} = \lambda n + (\phi - 1) g_{A,d} + \theta g_{A,fe} + \beta g_{A,fo} \tag{2.5}$$

Where, $g_x$ denotes growth rate of $x$ and $n = \frac{\dot{L}}{L}$. Setting $\dot{g}_{A,d} / g_{A,d}$ = 0 and solving for growth ($g^*_{A,d}$) along a balanced growth path (BGP):

$$g^*_{A,d} = \frac{\lambda}{1-\phi} n + \frac{\theta}{(1-\phi)} g_{A,fe} + \frac{\beta}{(1-\phi)} g_{A,fo} \tag{2.6}$$

This BGP is defines if $\phi < 1$, which is in the spirit of Jones (1995) semi-endogenous growth model with one key difference - $g^*_{A,d}$ not only depends on $n$ but also on the externalities associated with $g_{A,fe}$ and $g_{A,fo}$. Theoretically, these externalities may take any value: positive, negative or zero (see below). If $\phi > 1$, from (2.5):

$$\dot{g}_{A,d} = \lambda n (g_{A,d}) + (\phi - 1) g^2_{A,d} + \theta g_{A,ef} * g_{A,d} + \beta g_{A,of} * g_{A,d} \tag{2.7}$$

$\dot{A}_d$ increases more than proportionally with $A_d$. Successive differentiation of (2.7) yields:

$$\frac{\partial^2 \dot{g}_{A,d}}{\partial g^2_{A,d}} = 2(\phi - 1) \tag{2.8}$$

If $\phi > 1$ then $\dot{g}_{A,d}$ is strictly convex in $g_{A,d}$ provided that $g_{A,d}$ (0)>0 and $\lambda n + (\theta g_{A,ef} + \beta g_{A,of}) > 0$. If $\phi = 1$, then $g_{A,d}$ is ever increasing if

$\lambda n + (\theta g_{A,ef} + \beta g_{A,of}) > 0$ and vice versa. There are no steady state solutions if $\phi \geq 1$.

Whether steady state exists is an empirical issue. If it does then it can readily be shown that, at the steady state, output and output per labour grow respectively at the rate of ($g_{A,d} + n$) and $g_{A,d}$. Given that $g_{A,fe}$, $g_{A,fo}$ and $n$ are exogenous, the dynamics of $g_{A,d}$ and the economy's growth path depend on the value of $\phi$.

### 3. Empirical Specification

The analytical model outlined above implies the following empirical specification for the flow of 'new ideas':

$$\log \dot{A}_{d,i,t} = \alpha_i + \gamma_t + \lambda \log L_{A,i,t} + \phi \log A_{d,i,t} + \theta \log A_{fe,i,t} + \beta \log A_{fo,i,t} + e_{i,t} \qquad (3.1)$$

(i= 1,…,N; and t=1,…,T).

Specification (3.1) is a fixed effect panel model. The subscripts "i" and "t" denote the cross-sectional and time series dimensions; $\alpha_i$ captures the country-specific fixed effects and $\gamma_t$ captures the time effects. In the literature, a significant $0 < \lambda < 1$ implies duplication in innovations. A positive and significant $\phi$ implies standing-on-the-shoulder effect (positive externality); a negative and significant $\phi$ is the fishing-out effect (negative externality). A zero $\phi$ implies $\dot{A}_{d,i,t}$ is independent of $A_{d,i,t}$. Likewise, a positive and statistically significant $\beta$ implies positive externality from $A_{fo,i,t}$ whereas a negative $\beta$ implies raising-the-bar effect. The interpretation of $\theta$ is similar.

## 4. Sample and Data

Macro panel dataset are typically non-stationary requiring the use of non-stationary panel data econometrics. We therefore include countries with at least 17 annual data points. Seventeen countries with an unbalanced panel of 347 observations satisfy this criterion hence our sample. [4]

$\dot{A}_{d,i,t}$ is proxied by the resident patent applications. $A_{d,i,t}$ is calculated from $\dot{A}_{d,i,t}$ following the perpetual inventory method at 15% and 20% depreciation rates and the average annual sample growth rate of $\dot{A}_{d,i,t}$.

Three alternative measures of $A_{fo,i,t}$ weighted by the ratios of bilateral (i) total import ($A^{Tm}_{fo,i,t}$), (ii) machinery import ($A^{mm}_{fo,i,t}$), and (iii) inward foreign direct investment ($A^{fdi}_{fo,i,t}$) are calculated. [5] Due to data constraints, only two measures of $A_{fe,i,t}$ based on bilateral total import ratio ($A^{Tm}_{fe,i,t}$) and machinery import ratio ($A^{mm}_{fe,i,t}$) are computed. Data on researchers (full-time equivalent) and R&D expenditure are from UNESCO and various national sources; patent applications are from WIPO; bilateral trade flows are from UN COMTRADE

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[4] Sample countries are: Argentina (24), Chile (18), China (24), Colombia (24), Croatia (17), Hungary (24), India (24), Latvia (17), Lithuania (18), Malaysia (18), Mexico (24), Pakistan (19), Poland (18), Romania (18), the Russian Federation (18), Tunisia (18), and Turkey (24); where (.) indicates annual data points. The longest sample (24) covers 1985-2008 and the shortest (17) is 1992-2008.

[5] The calculation of foreign knowledge stocks employing such weights is standard in the literature (see Luintel and Khan, 2011; Coe et al. 2009). Measures of $A_{fo,i,t}$ for the i[th] sample country is computed incorporating 21 OECD countries while those of $A_{fe,i,t}$ includes 16 countries of the sample.

database; GDP and exchange rates are from the World Bank; and bilateral FDI from OECD.

Table 1 about here

Table 1 reports some descriptive statistics. Emerging countries rank well below the US and Japan yet their R&D activities are not trivial. Time series plots (available on request) show sharp increases in their R&D activities in recent decades.

**5. Empirical Results**

Panel unit root tests proposed by Im, Pesaran and Shin (2003) and Fisher-ADF (Maddala and Wu, 1999) and Pedroni (1999) confirm that the dataset is a non-stationary panel. [6]

We apply Pedroni's (1999) Group Philip-Perron ($G-t_{pp}$) and Group ADF ($G-t_{adf}$) t-statistics for panel co-integration test. They allow for heterogeneous co-integrating vectors across panel units under the null of a non-cointegrated panel. The $G-t_{adf}$ test is shown to have better power properties amongst a range of tests (Pedroni, 2004). The co-integrating parameters are estimated by the Fully Modified OLS (FMOLS).

In estimations, we account for different alternative measures of foreign knowledge stocks. Table 2 reports the results. The first three columns include measures of OECD originated foreign knowledge stocks in turn. Columns (iv) and (v) do the same for emerging countries originated foreign knowledge stocks. The last two columns model them jointly.

[6] Results are available on request.

Panel A reports $G-t_{pp}$ and $G-t_{adf}$ tests. Both reject the null at very high level of precision across all specifications implying that they all are co-integrated.

Panel B reports the co-integrating parameters. All estimates of $\lambda$ (i.e., $\partial \dot{A}_d / \partial L_A$) are positive and significant but less than unity implying that scientists produce 'new ideas' but research is duplicative as well. The estimates of $\phi$ $(\partial \dot{A}_d / \partial A_d)$ are significantly greater than unity across all specifications except in column (v) where it is statistically unity. They imply a very strong standing-on-the-shoulder effect. All OECD originated foreign knowledge stocks appear with significantly negative parameters implying raising-the-bar effect. Interestingly, both measures of $A_{fe,i,t}$ appear insignificant. Reported results remain qualitatively robust to 20% depreciation rates as well as variations in the panel. [7]

The finding of duplicative research ($0 < \partial \dot{A}_d / \partial L_A < 1$) is consistent with the existing literature (Porter and Stern 2000; Luintel and Khan, 2009). However, the finding of $\partial \dot{A}_d / \partial A_d > 1$ is quite contrasting - it is often reported to be less than unity. That innovations in OECD countries raise the innovation-bar for emerging economies is an important finding, which contrasts the positive knowledge diffusion across OECD countries (Luintel and Khan, 2009). Another finding of interest is that there appear to be no significant knowledge diffusions across emerging economies.

[7] We re-estimated all specifications of Table 2 by dropping Argentina, Chile, China, Indian and the Russian Federation from the panel in turn. Results remain robust.

That all estimates of $\phi$ are statistically unity or greater imply that emerging economies are far from a balanced growth path at least from the perspectives of new growth models.

**6. Conclusion:**

This is probably the first study to examine ideas production in a panel of emerging countries and calculate growth implications. Analyzing 17 countries we find that the innovative activities are overlapping; OECD countries raise innovation-bars for the emerging countries; and knowledge diffusion across the emerging countries is insignificant. The estimated parameters of knowledge production function imply that emerging countries are not growing at a balanced growth path.

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**Table 1: Descriptive Statistics (Sample Mean)**

| | GDP Growth [1] | Patents [2] | Research Productivity [3] | R&D Expenditure [4] | R&D Intensity [5] | RSE [6] | Research Intensity [7] |
|---|---|---|---|---|---|---|---|
| Argentina | 3.3 | 413 | 1.84 | 1,521 | 0.44 | 22,420 | 0.15 |
| Chile | 5.3 | 267 | 3.17 | 898 | 0.56 | 8,414 | 0.14 |
| China | 9.9 | 38,010 | 5.45 | 31,602 | 1.05 | 697,535 | 0.10 |
| Colombia | 3.7 | 89 | 2.75 | 547 | 0.22 | 3,229 | 0.02 |
| Croatia | 3.4 | 337 | 5.64 | 454 | 0.80 | 5,972 | 0.29 |
| Hungary | 1.6 | 1,430 | 9.09 | 1,608 | 1.18 | 15,721 | 0.36 |
| India | 6.2 | 2,403 | 1.83 | 11,683 | 0.71 | 131,367 | 0.04 |
| Latvia | 5.1 | 135 | 3.97 | 101 | 0.45 | 3,410 | 0.27 |
| Lithuania | 1.8 | 104 | 1.34 | 235 | 0.61 | 7,748 | 0.44 |
| Malaysia | 6.0 | 323 | 5.49 | 1,087 | 0.46 | 5,882 | 0.07 |
| Mexico | 2.7 | 556 | 2.43 | 3,438 | 0.33 | 22,891 | 0.06 |
| Pakistan | 4.3 | 56 | 0.46 | 809 | 0.30 | 12,134 | 0.03 |
| Poland | 4.6 | 2,464 | 4.49 | 2,624 | 0.60 | 54,866 | 0.31 |
| Romania | 2.8 | 1,289 | 5.15 | 929 | 0.53 | 25,029 | 0.22 |
| Russian Federation | 1.0 | 22,430 | 4.25 | 15,055 | 1.03 | 527,974 | 0.71 |
| Tunisia | 4.8 | 44 | 0.46 | 322 | 0.62 | 9,455 | 0.32 |
| Turkey | 4.3 | 451 | 2.04 | 2,886 | 0.51 | 22,159 | 0.10 |
| Mean | 6.0 | 4,165 | 4.49 | 4,459 | 0.76 | 92,718 | 0.12 |
| | | | | | | | |
| US | 2.9 | 136,443 | 11.89 | 258,930 | 2.64 | 1,147,949 | 0.82 |
| Japan | 2.0 | 338,873 | 54.11 | 104,122 | 3.03 | 626,293 | 0.96 |

1. Average annual growth rate (%),
2. Resident patent applications,
3. Resident patent applications/researchers (%),
4. R&D expenditure in million (2005 PPP$),
5. R&D expenditure/GDP (%),
6. Researchers, Scientists and Engineers,
7. Researchers, Scientists, and Engineers/labor force (%).

## Table 2: Knowledge Production Function

$$\log \dot{A}_{d,i,t} = \alpha_i + \gamma_t + \lambda \log L_{A,i,t} + \phi \log A_{d,i,t} + \beta \log A_{of,i,t} + \theta \log A_{ef,i,t} + e_{i,t}$$

| Panel A: Panel Cointegration Tests | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (i) | (ii) | (iii) | (iv) | (v) | (vi) | (vii) |
| $G-t_{pp}$ | -3.845 $^{a}$ | -3.794 $^{a}$ | -2.894 $^{a}$ | -2.727 $^{a}$ | -3.465 $^{a}$ | -2.864 $^{a}$ | -3.696 $^{a}$ |
| $G-t_{adf}$ | -5.513 $^{a}$ | -4.910 $^{a}$ | -3.889 $^{a}$ | -4.062 $^{a}$ | -5.036 $^{a}$ | -5.129 $^{a}$ | -4.142 $^{a}$ |
| Panel B: FMOLS Results (Dependent variable: $\dot{A}_{di,t}$ ) | | | | | | | |
| $L_{A,i,t}$ | 0.298 $^{a}$ (3.520) | 0.279 $^{a}$ (4.133) | 0.451 $^{b}$ (2.308) | 0.331 $^{a}$ (3.410) | 0.189 $^{a}$ (3.697) | 0.786 $^{a}$ (4.202) | 0.361 $^{a}$ (4.218) |
| $A_{d,i,t}$ | 1.578 $^{a}$ (24.366) | 1.495 $^{a}$ (24.231) | 1.904 $^{a}$ (22.969) | 1.401 $^{a}$ (14.817) | 1.046 $^{a}$ (16.992) | 1.993 $^{a}$ (17.701) | 1.517 $^{a}$ (17.657) |
| $A_{fo,i,t}^{Tm}$ | -0.206 $^{a}$ (-3.220) | – | – | – | – | -0.134 $^{b}$ (2.525) | – |
| $A_{fo,i,t}^{mm}$ | – | -0.168 $^{b}$ (-2.485) | – | – | – | – | -0.121 $^{b}$ (-2.243) |
| $A_{fo,i,t}^{fdi}$ | – | – | -0.156 $^{a}$ (-7.189) | – | – | – | – |
| $A_{fe,i,t}^{Tm}$ | – | – | – | -0.095 (-0.970) | – | -0.171 (-1.511) | – |
| $A_{fe,i,t}^{mm}$ | – | – | – | – | -0.018 (-1.416) | – | 0.060 (1.233) |
| N | 17 | 17 | 13 | 17 | 17 | 17 | 17 |

All mnemonics are explained in the text. $G-t_{pp}$ and $G-t_{adf}$ are asymptotically standard normal left-sided tests. Results pertain to foreign knowledge stocks derived at 15% depreciation rate and are robust to 20% depreciation rate. Superscripts a, b and c respectively denote 1%, 5% and 10% significance levels. (.) are t-ratios. Results are computed by RATS procedures. Complete data on bilateral FDI flows are available only for 13 OECD countries with 276 observations; hence N=13 in column (iii).