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Dissemination of Two Faces of Knowledge: Do Liberal-Democracy and Income-Level Matter?*

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Abstract

Many researchers have examined the functional relationship between the level of realized total factor productivity (TFP) and innovation, and the positive effect new ideas have on productivity. However, it remains unclear how diverse ideas drive productivity? And whether the home country's levels of income, civil liberties and political rights influence the spillover effects of innovation? I answer these questions by using a new dataset on scientific publication. I separate innovations into technical and managerial, and then explore their effects on the economy, using pooled mean group estimations in a dynamic heterogeneous panel setting of 60 countries for the period 1996 to 2014. The findings show that, for high-income countries, domestic innovations in management are a significant source of change in productivity. In contrast, the results do not support the role of the domestic development of management innovation in middle-income countries. However, in the long run, international spillovers of management ideas positively affect the productivity of these latter countries. Regardless of which metric is utilized in the analysis, national spillovers of management ideas increase the productivity of countries with the most-liberal democratic regimes. In democratic countries where the regime is only partially liberal, domestic management innovations have a depressing effect on productivity. This last result differs over the long run, as international spillovers of management ideas contribute to higher productivity in less-democratic countries. The results show that, the elasticity of TFP with respect to management innovation is almost twice as large as it is for technical ideas in high-income countries. The results also indicate that increasing the number of researchers does not enhance the development of management innovation.

JEL classification: O30, O40, O50

Key words: Knowledge Dissemination, Managerial Ideas, Technical Ideas, Semi-endogenous Growth Model

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1 Introduction

In analysing productivity, researchers have been using scientific publications to measure the stock of knowledge, for almost three decades. Adams (1990) was the first to use this proxy to show the significant contribution technical knowledge makes to growth in total factor productivity (TFP), in US manufacturing industries, over the period 1953 to 1980. Chen and Dahlman (2004) used the annual number of scientific and technical journal articles published by the residents of specific countries to show the significant effect of the scientific and technical knowledge imparted by these papers on the growth rates of these specific countries' total output. Over the years, researchers have used different indicators to measure the stock of knowledge and to investigate the effectiveness of innovation or new-technical-knowledge generation on productivity growth. These indicators include the number of registered patents, expenditures on research and development, the number of scientists engaged in research and development, and the number of new titles in technology-related publications (manuals, handbooks, and the like).[1] For various reasons, however, all of these measures are flawed.

R&D expenditures allow countries to hire researchers to work on and generate new ideas, but it is innovation that spurs productivity growth. It takes more than two years for a new idea (innovation) to move from a concept to an invention and, ultimately, to a patent application. Although acquiring a patent is one step beyond publication, the use of patent data to measure the level of innovative activity (idea generation) is not without its problems. The most obvious limitation is that not all inventions are patented, which means patents do not capture all innovations. For instance, managerial ideas (such as, team structure, quality-control initiatives, managerial leadership, etc.) that have an impact on productivity do not appear in the form of a patent (Alexopoulos and Tombe (2012)). Another reason for an innovation not being patented is that not all inventions meet the criteria set out by the United States Patent and Trademark Office (USPTO). The other reason inventions are not patented is simply because the inventor did not apply for a patent, and, instead, may have decided to rely on secrecy to prevent duplication of the invention by competitors (like many tech army innovations) (Chen and Dahlman (2004)). For these reasons, patents are not a

[1] For example, see Griffith et al. (2004), Guellec and de la Potterie (2004), Lach (1995), Pessoa (2005), Porter and Stern (2000), and Abdih and Joutz (2006).

precise measure of innovative activity. Furthermore, even after an idea is registered as a patent, in the short run it would not be available and usable by other economies.

To solve the problem of measuring ideas, Alexopoulos and Cohen (2009) used catalogue of the Library of Congress on the number of new technology titles (manuals, handbooks, and the like) that are published in the US. The most obvious limitation of this indicator is that not all books are published in the US. Hence, this measure would not be applicable in the case of cross-country studies. In reality, there is a long process involved in developing an idea and then publishing it in the format of a manual or book. Researchers disseminate their ideas by presenting them at conferences and publishing them in conference papers and journals, which I consider a prior step to publishing a book. Scientific papers that are published in journals do not face the limitations of patents or books. Rather, they are immediately available for use by entities in any other economy around the world, which is the main assumption of the semi-endogenous growth model used in this study.

Due to their ease of availability, I expect scientific publications to have higher international spillover effects, compared to patents and books. This premise leads to the following questions. Does a change in the stock of knowledge in one country affect other countries? Do spillovers of new ideas have effects on the income level of the destination country? Do both the level of civil liberties and the extent of political rights in the destination country influence the absorptive capacity of international ideas?

The main objective of the present paper is to contribute to the empirical understanding of economic growth by estimating and analysing the effect of intra-national and international spillovers of new ideas on productivity. To evaluate the drivers of countries' productivity, I separate the stock of domestic knowledge from the pool of world knowledge. I evaluate the relative importance of intranational versus international knowledge spillovers in fostering TFP. I do so by separately considering the multiple sources of knowledge for each country's ideas production function.

This paper draws on an extensive body of work that uses the number of scientific publications as a measure of innovative output. It then compares this to the number of patents as a measure of innovation. I also distinguish between technical and managerial knowledge to investigate how different types of knowledge contribute to the growth rate of total factor productivity. In contrast to previous studies, which applied neoclassical growth theory to examine the drivers of total factor productivity, I use the semi-endogenous growth model originally introduced by Jones (2002). This model allows me to include the impact of human capital in estimations of total factor productivity. I also control for differences in the number of hours worked in each country. Another contribution of this paper is an adjustment for the share of capital of less developed countries. This provides more precise estimations of total factor productivity for the outlier countries.

In this paper, I adopt pooled mean group (PMG) estimator introduced by Pesaran et al. (1999). This estimator enabled me to examine both the long- and short-run effects of knowledge dissemination on growth in TFP. Using this model allows me to take into account country-specific heterogeneity. I consider 60 countries whose classifications are based on their income level and level of democracy. Although there is a large body of literature that investigates the link between knowledge dissemination and TFP growth, there is hardly any research that focuses on less-developed countries, or countries with less liberal-democratic regimes. This research will contribute to an understanding of how economic and political differences affect intra-national and international spillovers of technical and managerial knowledge.

Regardless of which metric is utilized in the analysis, national spillovers of the stock of ideas increase the TFP of high-income countries. The results show that managerial advances have almost three times the impact on the productivity of high-income countries than that of technical ideas. For middle-income countries, however, I find that domestic spillovers of managerial ideas do not contribute to TFP. However, international spillovers of all of the metrics used in this study show a positive impact on the TFP of middle-income countries. For the countries that are the most-liberal-democratic, the impact of managerial innovations on TFP is still positive. However, this effect was reduced, over the period under review, compared to the results of the estimations for high-income countries. Here, it is possible because not all countries with the highest level of liberal-democracy are among the high-income countries. The impact of intra-national and international managerial knowledge on the TFP of partially liberal-democratic countries is the reverse. In these countries, national innovations in management show a negative impact on TFP in the long run, while international innovations show a positive effect. From an estimation of the new-ideas-production function, I find that the research production of both technical and managerial ideas increases as the total stock of these ideas increases. Yet, the expansion in the number of researchers has no effect on the flow of managerial ideas.

The remainder of this paper is structured as follows. Section 2 presents the theoretical framework for productivity analysis. Section 3 presents and discusses the metric, which is the number of ideas found in scientific publications. Section 4 describes the econometrics specifications. Section 5 provides an empirical analysis including data description and the results based on the different classifications for the countries in the study. Section 6 analyses the effect of the stock of ideas on innovation. Section 7 concludes.

2 Framework for total factor productivity

The theoretical framework of the analysis of TFP, for the purposes of this investigation, uses the semi- endogenous growth model introduced by Jones (1995) and Jones (2002). Although Penn World Table (PWT) 9.0 provides TFP data for many countries, several developing countries emerge as outliers with TFP measurements that are high relative to that of the US. This does not look reasonable. For example, the TFPs of Turkey and Gabon are very similar to that of the US. Also, İmrohoroğlu and Üngör (2016) criticize the reliability of the TFP levels reported in PWT 9.0. They believe the problem arises from considering that the capital share is the same ($\alpha_i = 1/3$) for all countries. To produce more reasonable estimates of the TFP levels, they suggest a simple modification that uses a constant capital share of one third for developed countries and one half for developing countries. Since the TFP levels provided in PWT 9.0 are not accurate for developing countries, I use the semi-endogenous growth model introduced by Jones (1995) and Jones (2002) and I modify the capital share for developing countries so as to estimate the TFP per hour worked. Using the semi-endogenous growth model, I consider the differences in the quality of human capital, which most previous studies ignore.

Assume a world that consists of I economies, where each has the same production possibility but different endowments and allocations. Ideas are the only link between these economies. This means that any new ideas that are created, at any point in time, in any part of the world, will be immediately available for use by other economies. This is a reasonable assumption, since I consider scientific publications as a measure of the new ideas that are available for all economies, after they are published. Output is produced by using the production function

$$Y_{it} = A_{it}^{\sigma_i} K_{it}^{\alpha_i} H_{Yit}^{1-\alpha_i}, \quad \sigma_i > 0, \ \alpha_i = \frac{1}{3}, \frac{1}{2}, \ i = 1, ..., I \tag{1}$$

where Y_{it} is output of country i, at time t, A_t is common stock of ideas, K_{it} is the capital stock, and H_{Yit} is the quantity of human capital.

The first element in the production function is new capital, which is produced via the capital-accumulation process, given by

$$\dot{K}_{it} = s_{Kit} Y_{it} - d_i K_{it}, \qquad K_{i0} > 0 \tag{2}$$

where s_{Kit} is investment rate and $0 < d_i < 1$ is the depreciation rate.

The second element is aggregate human capital, which is described as

$$H_{Yit} = h_{it} L_{Yit} \tag{3}$$

$$h_{it} = e^{\psi_i \ell_{hit}}, \quad \psi_i > 0 \tag{4}$$

where h_{it} is human capital per person, L_{Yit} the total amount of labour employed in producing the output, and ℓ_{hit} is the amount of time an individual spends in accumulating human capital. There is also a resource constraint on labour in each economy. After excluding the time spent in school, the endowed time of each individual is divided between producing goods and producing ideas. So, the resource constraint is as follows:

$$L_{Ait} + L_{Yit} = L_{it} = (1 - \ell_{hit}) N_t, \tag{5}$$

$$N_t = N_0 e^{nt}, \qquad N_0 > 0, \ n > 0, \tag{6}$$

where L_{it} denotes employment, N_t denotes the number of agents in each economy at time t, which grows at constant exogenous rate $n > 0$.

Now, I can rewrite the production function expressed in (1) in terms of output per worker as follows:

$$y_{it} = \left(\frac{K_{it}}{Y_{it}} \right)^{\frac{\alpha_i}{1-\alpha_i}} \ell_{Yit} h_{it} A_t^{\frac{\sigma_i}{1-\alpha_i}}, \quad \ell_{Yit} \equiv L_{Yit} / L_{it} \tag{7}$$

where $y_{it} \equiv Y_{it}/L_{it}$, output per person, K_{it}/Y_{it}, is the capital-output ratio, and ℓ_{Yit} is the fraction of the labour force that produces the output. Taking the natural logarithm of (7) gives the following:

$$ln\,TFP_{it} = \frac{\alpha_i}{1-\alpha_i} ln\left(\frac{K_{it}}{Y_{it}}\right) - ln(\ell_{Yit}) - \frac{\sigma_i}{1-\alpha_i} ln(h_{it}) = \frac{\sigma_i}{1-\alpha_i} A_t, \tag{8}$$

where $\frac{\sigma_i}{1-\alpha_i} A_t$ captures total factor productivity (TFP_{it}), which varies across countries and over time.[2] I include the number of hours worked per year as a measure of labour input, which controls for the differences in the number of hours worked in each country.

3 Measuring stock of knowledge: technical versus managerial ideas

In this paper, the measure of new ideas is obtained from The SCImago Journal and Country Rank which includes both the journals and the country scientific indicators developed from the information contained in the Scopus® database (Elsevier B.V.). The journals are grouped by subject and country. I extract the number of citable documents published for the selected year, by country of publication, in each subject area (only articles, reviews, and conference papers are considered). This data includes 27 subject areas. Using this information, I construct two measures of new ideas, namely the technical and managerial flow of new ideas. Technical ideas cover 21 subject areas, including multidisciplinary, agricultural and biological sciences, biochemistry, genetics and molecular biology, chemical engineering, chemistry, computer science, earth and planetary sciences, energy, engineering, environmental science, immunology and microbiology, materials science, mathematics, medicine, neuroscience, nursing, pharmacology, toxicology and pharmaceutics, physics and astronomy, veterinary, dentistry, and the health professions. Managerial ideas are categorized into three main subject areas: business-management-accounting, economics-econometrics-finance, and decision sciences.

To construct the measure of the stock of technical and managerial ideas for each country, I use a standard perpetual inventory method. The stock of ideas (${S^j}_{it}$) in country i, in year t, is as

[2] See Hasanzadeh and Khan (2017).

follows:

$$S^j{}_{i,t} = S^j{}_{i,t-1}(1-\delta) + f^j{}_{i,t} \ \ , \ t = 1997, ..., 2014, \tag{9}$$
$$S^j{}_{i,1996} = f^j{}_{i,1996}/(\delta + g_f{}^j),$$

where the superscript j represents the technical, managerial, and patent variables; $f^j{}_{i,t}$ is the number of new citable documents, and $g_f{}^j$ is the average growth rate of new citable documents between 1996 and 2014, in country i. The depreciation rate, δ, is set to 0.15, which is similar to that in the patent literature.

4 Model specification

The general framework for analysing the dynamic panel, in this paper, is a model that is based on the pooled mean group estimator (PMG) developed by Pesaran et al. (1999). The PMG presents the autoregressive distributed lag (ARDL) model in error-correction form. Despite the possible existence of endogeneity, this model provides consistent coefficients because it includes the lags of both the dependent and independent variables. One of the main features of the ARDL model is that it can be used even with variables with different orders of integration. In other words, the ARDL model allows us to incorporate I(0) and I(1) variables in the same estimation.[3]

Among the three different estimators in the dynamic panel framework, I use the pooled mean group (PMG) estimator, which provides a useful intermediate alternative between estimating the separate country regressions (the MG case) and the fixed-effects estimator, which imposes homogeneity on all of the slope coefficients and error variances across countries. The PMG allows for short-run heterogeneous dynamics, but it also imposes a long-run homogeneous relationship for the countries in the sample. Given that the categorized countries have access to common technologies, it is reasonable to believe in the existence of common long-run coefficients across each group of countries. Since I categorize the countries in the study according to similarities in their measures of income level and level of liberal-democracy, I expect the long-run equilibrium relationship between the variables to be similar across the countries in each category. The short -run adjustment

[3] I test for the presence of unit roots to ensure that no series exceeds I(1) order of integration. I use the tests of Im et al. (2003), Breitung (2000), Levin et al. (2002) and Hadri (2000). The results of these tests are available upon request.

is allowed to be country-specific because the spillover of ideas has widely different impacts, depending on the country. The PMG allows the speed of adjustment to differ across countries. The assumption of the same speed of convergence across countries is consistent with the neoclassical model only if both the rates of technological and population growth are the same across countries (Bassanini and Scarpetta (2002)).

Pesaran et al. (1999) demonstrate that the PMG's allowance for short-run parameter heterogeneity yields more reliable estimates of the long-run responses, and can also affect the estimated speeds of convergence toward long-run equilibrium. Taking the maximum lag as being equal to one, the ARDL (1,1,0) equation is given by the following:

$$\begin{aligned} \Delta\ lnTFP_{i,t} &= \varphi_i(lnTFP_{i,t-1} - \beta_1 lnS^j{}_{i,t-1} - \beta_2 lnS^j{}_{-i,t-1} - \beta_3 ER_{i,t}) \\ &\quad + \gamma_1\Delta\ lnS^j{}_{i,t} + \gamma_2\Delta\ lnS^j{}_{-i,t} + \gamma_3\Delta ER_{i,t} + u_{it}, \end{aligned} \tag{10}$$

where $lnTFP_{i,t}$ is the natural log of total factor productivity calculated using (8), $S^j_{i,t-1}$ is the stock of knowledge at the beginning of time t, at country i, and $S^j_{-i,t-1}$ is the stock of knowledge in the rest of the world. The control variable $ER_{i,t}$ captures the business-cycle effect and is equal to one minus the unemployment rate. γ represent the short-run coefficient of the lagged independent variables, β represents the long-run coefficients, and φ is the coefficient of the speed of adjustment to long-run equilibrium.

5 Empirical analysis

5.1 Data description

This study adopts a panel-data approach and covers 60 countries for the period 1996 to 2014. The countries are classified based on two different measures. The first measure is obtained from the World Bank's classification of economies, which is based on the level of gross national income and includes low-, lower-middle-, upper-middle- and high-income countries. Table 1 provides a list of the countries in the sample and includes 39 high-, 13 upper-, and 8 lower-middle-income countries. In the estimations that are based on the countries' levels of income, I consider upper- and lower-middle-income countries together as the middle-income group of countries. The second classification is based on political and civil rights and is taken from the annual report of Freedom House, which tracks the degree of liberal-democracy in countries around the world. Table 2 shows 44, 12, and 4 countries that are the most-liberal, partially liberal, and least-liberal countries, respectively. The combined Gastil index of liberal-democracy (Freedom House) adds together the Gastil indexes of civil liberties and political rights. Each component gives a score of 1 for the most-liberal-democratic regimes, to 7 for the least, so that 2 is the best score and 14 is the worst. This method of classification is based on an average of the combined index for each country over the period 1996 to 2014.

Two groups of data are used. The first group is related to the calculation of TFP. Here, the data are drawn from PWT 9.0, and includes real GDP at constant national prices (in mil, 2011 US$); the capital stock at constant national prices (in millions of 2011 US$); the index of human capital per person, based on the number of years of schooling and returns to education; the number of persons actively engaged in the labour force (in millions) and the population in millions; and the average annual number of hours worked by persons engaged in the labour force. The number of researchers working in the R&D sector was obtained from the World Bank publication, World Development Indicators. For countries with missing data on the number of researchers, I use average growth rate for filling missing values.

The second group of data is related to the calculation of the stock of ideas. Two proxies are used to measure the level of innovative activity in each economy: patents and scientific publications. The annual number of U.S. patents filed by residents of a country is one of the most basic measures of the level of innovative activity that bears commercial value and that is taking place within an economy. Since different patenting agencies have different criteria for the novelty of an original innovation, I consider only patents granted by the UPSTO. By using only U.S. patent data, I have a consistent set of minimum standards for an innovation (Chen and Dahlman (2004)). The second proxy is defined, using scientific publications collected from SCImago. (2007). As is explained in section 3, I divide the number of citable documents published in each country into two groups: technical ideas and managerial ideas. The employment rate is included, in the model, as a control variable to account for the impact of the business cycle.

5.2 Results

In this part, I provide the examination results of knowledge spillovers on TFP based on two different country classification applied in this study. The first classification follows the World Bank's classification of economies, according to the country's level of gross national income, which includes low-, lower-middle-, upper-middle-, and high-income countries. The second classification is for the level of liberal-democracy, a classification that uses the Gastil index.

5.2.1 Level of income classification

Table 3 shows the long- and short-run parameters for four PMG regressions in high-income countries. The first three columns show the estimation results, using citable documents as a measure of the stock of knowledge. The last column shows the estimation results, using the stock of patents. The long-run coefficient of the domestic stock of knowledge in all the PMG regressions appears to be positive and highly significant. The estimated results also indicate a negative and significant impact of the total domestic stock of ideas on TFP in the short run. In the long run, all of the regressions show that the international stock of knowledge suggests a negative and significant effect on the total factor productivity of high-income countries. In terms of their magnitude, managerial ideas and patents have the most and least effect, respectively, on long-run growth in TFP in high-income countries. Furthermore, the elasticity of TFP, with respect to the stock of managerial ideas, is around three times larger than it is for technical ideas. The speed of convergence toward long-run equilibrium is higher in the estimated model that uses patents as the metric. Next, I examine to what extent the above findings vary by income level, by re-estimating the models for the middle-income countries (including, lower-middle- and upper-middle- income countries). Table 4 shows the results of this estimation. This time, the long-run coefficient of the internal stock of ideas, using all ideas and technical ideas, appears to be positive and highly significant. However, in the long run, the internal stock of managerial ideas shows a negative and insignificant effect on the TFP of middle-income countries. The internal stock of patents denotes a negative and statistically significant effect on productivity, in the long run. With regards to all four regressions, the internal stock of ideas, in both forms (citable documents and patents) does not show any significant effects in the short run. In the long run, however, the elasticity of TFP, with respect to the rest of the world's stock of knowledge, is positive and highly significant in all four estimated models. However, in the short run, both the external stock of managerial ideas and patents do not show any significant effects on the middle-income countries' TFP.

To summarize, these results undermine the notion that the home country's level of income matters in knowledge dissemination. If the home country belongs to the middle-income group, then the domestic stock of managerial ideas does not have any significant effect on long-run growth in TFP. However, if the home country is categorized as a high-income country, then the stock of all forms of ideas, even managerial ones, will contribute to a higher level of long-run growth in TFP. In terms of magnitude, the managerial stock of knowledge shows the greatest inter-temporal and international long-run spillovers in the TFP of high-income countries. In regressions that use all ideas and technical ideas, middle-income countries show a higher speed of convergence. However, in high-income countries, the speed at which the model returns to equilibrium after a shock is higher in regression models that use managerial ideas and patents.

5.2.2 Liberal-democracy classification

A country's level of liberal-democracy also has an effect on how knowledge spillovers impact TFP. Here, the Gastil index of liberal-democracy (Freedom House) classification is used as the metric. Tables 5 and 6 show the estimates obtained from the most liberal-democratic countries (Gastil index of liberal-democracy <5) and partially liberal-democratic countries (Gastil index of liberal-democracy of between $5 \leq$ and ≤ 10). Taking into account the whole set of regression results, it can be concluded that, in the long run, inter-temporal knowledge spillovers have always positively contributed to the TFP of the most liberal-democratic countries. However, the results for the countries with partially liberal-democratic regimes show that the internal stock of managerial knowledge has a depressing effect on TFP in the long run. In the long run, the domestic stock of patents implies a large magnitude of knowledge spillover in the most liberal-democratic countries. But, in countries with only partial democracy, the stock of all citable documents has the greatest effect on TFP in the long run. In contrast to countries with the most liberal -democratic regimes, the international stock of managerial knowledge stimulates the productivity of those countries with partially liberal-democratic regimes. In terms of the speed with which the long-run effect is realized, all of the estimated models on the partially liberal-democratic countries show higher speeds of convergence, compared to the ones of the most liberal-democratic countries. In my sample, all of the partially liberal-democratic countries are among the middle-income ones, except for Singapore.

Table 7 shows the results for the least liberal-democratic countries. Here, the only variable that has a stimulating effect on TFP, in the long run, is the international knowledge spillover of managerial ideas. However, the results can be biased, since only four countries are classified as being in the least-liberal-democratic group.

Comparing the estimations for the high-income countries with the most-liberal-democratic ones shows larger domestic managerial knowledge spillovers.[4] It is possible that this is because not all of the most-liberal-democratic countries are in the highest income level. Tables 1 and 2 show that all high-income countries are among the most-liberal-democratic regimes, except for Singapore. Regardless of whether a country is classified as high-income or the most-liberal-democratic regime, the domestic spillovers are quite the same for both technical ideas and all ideas. For high-income countries, however, the impact of domestic spillovers of managerial ideas is almost four times that of the high-liberal-democratic countries. This can be because, in my sample of countries, there are more countries classified as the most-liberal-democratic regimes that belong to the middle-income group (Brazil, Bulgaria, Costa Rica, Jamaica and Romania). A comparison among all of the estimated models, under different country classifications, shows that domestic spillovers of managerial innovations have the highest influence on the TFP of high-income countries. Yet, the impact of foreign (international) managerial knowledge spillovers on productivity is greatest among the partially liberal-democratic and middle-income countries. If we compare all of the estimated models with different country classifications (except for the least-democratic-countries classification), we notice that international managerial-knowledge spillovers have larger impact on TFP in the countries that are categorized as middle-income or partially liberal-democratic.

[4]I exclude the least-democratic countries in this comparison due to the limited number of observations in this estimation.

6 Estimating ideas production function

In this section, I estimate the sensitivity of ideas production to the human capital resources that are devoted to the ideas-producing sector and the pre-existing stock of knowledge. Consider the national-ideas production function for country i,

$$f_{i,t} = \delta L^{\lambda}{}_{Ai,t} \; S^{\phi}{}_{w,t-1} \tag{11}$$

where $f_{i,t}$ is the flow of new ideas in country i, at time t. These new ideas are in the form of technical, managerial, or all ideas that are found in citable documents. $L_{Ai,t}$ shows the number of researchers in R&D sector, and $S_{w,t-1}$ is the world's stock of ideas at the beginning of the current period. Since this stock of ideas is in the form of citable documents that are immediately available to be used by all economies, I consider the effect of the whole stock of ideas on a certain country's discovering new ideas. In the case of measuring new ideas by patent, I apply the assumption of Porter and Stern (2000), which is that the ideas production in a given year will be reflected in the patents that are granted three years in the future. I define the national-ideas-production function for country i as follows:

$$PATS_{i,t} = \delta L^{\lambda}{}_{Ai,t-3} \; S^{\phi}{}_{i,t-3}, \tag{12}$$

where $PATS^{j}{}_{i,t}$ is the number of patents granted to country i. Table 8 presents the results of the regression of the flow of new ideas on the amount of labour employed in the ideas-producing sector, and the measure of the stock of knowledge and controls, for the time period under review.

The estimated sensitivity to an increase in the stock of all ideas ($\hat{\phi}$) is 1.449, while the return to the research effort ($\hat{\lambda}$) is 0.352. By separating the measurement of new ideas, I find a higher sensitivity to the stock of managerial innovations ($\hat{\phi}$=2.788), compared to the technical ones ($\hat{\phi}$=1.355). The results also show that increasing the number of researchers does not affect the research productivity that results from managerial ideas.

7 Conclusions

This paper uses a new data set on scientific publications, by different subject areas, to examine the effect of knowledge spillovers on productivity growth at the country level for the period 1996 to 2014. I apply the pooled mean group estimator to deal with heterogeneity problems. I consider both domestic and international knowledge spillovers to investigate the effects of each of these knowledge spillovers on the total factor productivity of the destination country. Comparing all the estimations highlights the important role domestic knowledge spillovers play in high-income and highly liberal-democratic countries. In contrast, the results show the significant role international spillovers play in fostering the productivity growth of middle-income countries and countries with partially liberal-democratic regimes. Regardless of which metric is utilized, international knowledge spillovers have always contributed to higher productivity in middle-income counties. Yet, in the long run, foreign spillovers have a negative impact on the productivity of high-income countries. By distinguishing between managerial and technical ideas, I find evidence that managerial ideas have the largest domestic spillovers in high-income countries and no effect in middle-income countries. However, international managerial knowledge spillovers have the greatest impact on the productivity of middle-income countries and countries with partially liberal-democratic regimes. The results show that managerial innovations do better in regimes where there is less democracy. Further research should shed more light on this, including the impact on high-income countries with less liberal-democratic regimes, such as China, to investigate whether authoritarianism works better in terms of influencing managerial innovations.

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Table 1: Income-level classification

High income	Upper middle income	Lower middle income
Australia	Argentina	Bangladesh
Austria	Brazil	Cambodia
Barbados	Bulgaria	India
Belgium	Colombia	Indonesia
Canada	Costa Rica	Pakistan
Chile	Ecuador	Philippines
Cyprus	Jamaica	Sri Lanka
Czech Republic	Malaysia	Vietnam
Denmark	Peru	
Estonia	Romania	
Finland	Russian Federation	
France	Thailand	
Germany	Turkey	
Greece		
Hungary		
Iceland		
Ireland		
Italy		
Japan		
Latvia		
Lithuania		
Luxembourg		
Malta		
Netherlands		
New Zealand		
Norway		
Poland		
Portugal		
Singapore		
Slovakia		
Slovenia		
South Korea		
Spain		
Sweden		
Switzerland		
Trinidad & Tobago		
United Kingdom		
United States		
Uruguay		

Table 2: Liberal-democracy classification

The most-liberal	Partial-liberal	The least-liberal
Argentina	Bangladesh	Vietnam
Australia	Colombia	Russian Federation
Austria	Ecuador	Cambodia
Barbados	India	Pakistan
Belgium	Indonesia	
Brazil	Malaysia	
Bulgaria	Peru	
Canada	Philippines	
Chile	**Singapore**	
Costa Rica	Sri Lanka	
Cyprus	Thailand	
Czech Republic	Turkey	
Denmark		
Estonia		
Finland		
France		
Germany		
Greece		
Hungary		
Iceland		
Ireland		
Italy		
Jamaica		
Japan		
Latvia		
Lithuania		
Luxembourg		
Malta		
Netherlands		
New Zealand		
Norway		
Poland		
Portugal		
Romania		
Slovakia		
Slovenia		
South Korea		
Spain		
Sweden		
Switzerland		
Trinidad and Tobago		
United Kingdom		
United States		
Uruguay		

Table 3: High-income countries

	Dependent Variable: $log(A_t)$			
	All Ideas	Technical Ideas	Managerial Ideas	Patent
ln(Internal citable documents stock)$_{t-1}$	0.073ˆ***	0.074***	0.201***	
	(0.028)	(0.027)	(0.027)	
ln(Rest of world citable documents stock)$_{t-1}$	−0.223***	−0.232***	−0.298***	
	(0.043)	(0.043)	(0.036)	
ln(1+Internal patent stock)$_{t-1}$				0.067***
				(0.019)
ln(1+Rest of world patent stock)$_{t-1}$				−0.039*
				(0.023)
Employment rate$_t$	−2.325***	−2.483***	−0.214	0.039
	(0.393)	(0.389)	(0.221)	(0.170)
Error-correction coefficient	−0.190***	−0.187***	−0.191***	−0.211***
	(0.028)	(0.028)	(0.035)	(0.036)
Δln(Internal citable documents stock)	−0.465***	−0.462***	−0.027	
	(0.168)	(0.169)	(0.046)	
Δln(Rest of world citable documents stock)	1.312***	1.325***	0.278**	
	(0.294)	(0.295)	(0.124)	
Δln(Internal patent stock)				−0.050
				(0.052)
Δln(Rest of world patent stock)				−0.029
				(0.096)
ΔEmployment rate	1.288***	1.288***	1.167***	1.115***
	(0.196)	(0.195)	(0.220)	(0.191)
Intercept	1.267***	1.297***	0.808***	0.386***
	(0.191)	(0.197)	(0.154)	(0.067)
No. of Countries	39	39	39	39
No. of Observations	702	702	702	702

Notes: *, ** and *** indicate significance at 10%, 5% and 1%. All ideas include technical plus managerial ideas.

Table 4: Middle-income countries

	Dependent Variable: $log(A_t)$			
	All Ideas	Technical Ideas	Managerial Ideas	Patent
ln(Internal citable documents stock)$_{t-1}$	0.074***	0.074***	−0.006	
	(0.023)	(0.023)	(0.032)	
ln(Rest of world citable documents stock)$_{t-1}$	0.178***	0.174***	0.495***	
	(0.063)	(0.065)	(0.068)	
ln(1+Internal patent stock)$_{t-1}$				−0.302***
				(0.039)
ln(1+Rest of world patent stock)$_{t-1}$				1.246***
				(0.110)
Employment rate$_t$	3.518***	3.399***	−6.960**	0.271
	(0.063)	(0.625)	(2.750)	(0.811)
Error-correction coefficient	−0.246***	−0.247***	−0.113**	−0.161***
	(0.072)	(0.071)	(0.046)	(0.052)
Δln(Internal citable documents stock)	−0.102	−0.091	−0.002	
	(0.210)	(0.212)	(0.028)	
Δln(Rest of world citable documents stock)	2.085***	2.147***	0.261	
	(0.481)	(0.481)	(0.190)	
Δln(Internal patent stock)				−0.096
				(0.067)
Δln(Rest of world patent stock)				−0.270
				(0.188)
Δ Employment rate	1.466**	1.458**	3.176***	1.754***
	(0.653)	(0.644)	(1.150)	(0.459)
Intercept	−1.727***	−1.693***	0.019	−2.501***
	(0.511)	(0.495)	(0.023)	(0.832)
No. of Countries	21	21	21	20
No. of Observations	378	378	378	360

Notes: *, ** and *** indicate significance at 10%, 5% and 1%. All ideas include technical plus managerial ideas.

Table 5: Most-liberal democratic countries

	Dependent Variable: $log(A_t)$			
	All Ideas	Technical Ideas	Managerial Ideas	Patent
ln(Internal citable documents stock)$_{t-1}$	0.072**	0.077***	0.041***	
	(0.030)	(0.029)	(0.012)	
ln(Rest of world citable documents stock)$_{t-1}$	−0.224***	−0.241***	−0.113***	
	(0.046)	(0.046)	(0.024)	
ln(1+Internal patent stock)$_{t-1}$				0.098***
				(0.018)
ln(1+Rest of world patent stock)$_{t-1}$				−0.066***
				(0.022)
Employment rate$_t$	−2.368***	−2.627***	−0.168*	0.102
	(0.396)	(0.398)	(0.089)	(0.174)
Error-correction coefficient	−0.172***	−0.166***	−0.170***	−0.194***
	(0.020)	(0.020)	(0.027)	(0.032)
Δln(Internal citable documents stock)	−0.447***	−0.443***	−0.026	
	(0.154)	(0.154)	(0.035)	
Δln(Rest of world citable documents stock)	1.337***	1.361***	0.245**	
	(0.254)	(0.255)	(0.106)	
Δln(Internal patent stock)				−0.041
				(0.047)
Δln(Rest of world patent stock)				−0.055
				(0.097)
ΔEmployment rate	1.169***	1.170***	1.039***	0.984***
	(0.141)	(0.141)	(0.145)	(0.142)
Intercept	1.118***	1.158***	0.474***	0.350***
	(0.137)	(0.143)	(0.082)	(0.060)
No. of Countries	44	44	44	44
No. of Observations	792	792	790	792

Notes: *, ** and *** indicate significance at 10%, 5% and 1%. All ideas include technical plus managerial ideas.

Table 6: Partial-liberal democratic countries

	Dependent Variable: $log(A_t)$			
	All Ideas	Technical Ideas	Managerial Ideas	Patent
ln(Internal citable documents stock)$_{t-1}$	0.323^{***}	0.314^{***}	-0.106^{***}	
	(0.039)	(0.038)	(0.019)	
ln(Rest of world citable documents stock)$_{t-1}$	-0.691^{***}	-0.689^{***}	0.325^{***}	
	(0.092)	(0.091)	(0.049)	
ln(1+Internal patent stock)$_{t-1}$				0.056^{**}
				(0.022)
ln(1+Rest of world patent stock)$_{t-1}$				-0.110^{**}
				(0.043)
Employment rate$_t$	3.125^{***}	2.911^{***}	2.780^{***}	3.197^{***}
	(0.606)	(0.588)	(0.341)	(0.176)
Error-correction coefficient	-0.347^{***}	-0.348^{***}	-0.336^{**}	-0.329^{***}
	(0.133)	(0.132)	(0.108)	(0.115)
Δln(Internal citable documents stock)	0.232	0.243	0.237	
	(0.147)	(0.155)	(0.158)	
Δln(Rest of world citable documents stock)	2.936^{***}	2.979^{***}	0.712^{*}	
	(0.910)	(0.922)	(0.428)	(0.368)
Δln(Internal patent stock)				-0.066
				(0.055)
Δln(Rest of world patent stock)				-0.699^{*}
				()
ΔEmployment rate	1.433^{*}	1.443^{*}	2.025^{**}	2.087^{**}
	(0.857)	(0.841)	(0.880)	(0.836)
Intercept	1.903^{**}	2.001^{**}	-1.808^{***}	-0.192
	(0.768)	(0.798)	(0.561)	(0.117)
No. of Countries	12	12	12	12
No. of Observations	216	216	216	216

Notes: *, ** and *** indicate significance at 10%, 5% and 1%. All ideas include technical plus managerial ideas.

Table 7: Least-liberal democratic countries

	Dependent Variable: $log(A_t)$			
	All Ideas	Technical Ideas	Managerial Ideas	Patent
ln(Internal citable documents stock)$_{t-1}$	0.044	0.045	0.015	0.118
	(0.035)	(0.036)	(0.054)	
ln(Rest of world citable documents stock)$_{t-1}$	0.237	0.223	0.507***	
	(0.161)	(0.169)	(0.119)	
ln(1+Internal patent stock)$_{t-1}$				0.118
				(0.132)
ln(1+Rest of world patent stock)$_{t-1}$				−0.015
				(0.344)
Employment rate$_t$	7.352***	7.472***	−10.603*	0.160
	(1.289)	(1.326)	(5.974)	(1.612)
Error-correction coefficient	−0.330***	−0.326**	−0.247	−0.256***
	(0.131)	(0.130)	(0.184)	(0.182)
Δln(Internal citable documents stock)	−0.830*	−0.843*	0.043	
	(0.496)	(0.499)	(0.081)	
Δln(Rest of world citable documents stock)	2.207	2.228	0.029	
	(1.603)	(1.598)	(0.450)	
Δln(Internal patent stock)				−0.352
				(0.402)
Δln(Rest of world patent stock)				0.302
				(0.351)
ΔEmployment rate	2.142	2.105	8.171	1.470
	(2.564)	(2.504)	(6.182)	(1.394)
Intercept	−3.748**	−3.671**	0.856***	0.108
	(1.563)	(1.542)	(0.603)	(0.099)
No. of Countries	4	4	4	3
No. of Observations	72	72	68	54

Notes: *, ** and *** indicate significance at 10%, 5% and 1%. All ideas include technical plus managerial ideas.

Table 8: TFP and the Stock of Ideas

	Dependent Variable: $log(P_{i,t})$			
	All Ideas	Technical Ideas	Managerial Ideas	Patent
ln(Existing Stock of Ideas)	1.449***	1.355***	2.788***	0.455***
	(0.464)	(0.469)	(0.545)	(0.068)
ln(Number of Researchers)	0.352**	0.353**	0.248	0.251***
	(0.138)	(0.137)	(0.175)	(0.100)
Constant	Yes	Yes	Yes	Yes
Trend	Yes	Yes	Yes	Yes
No. of Countries	60	60	60	59
No. of Obs	1080	1080	1067	944

Notes: ** and *** indicate significance at 5% and 1%. All ideas include technical plus managerial ideas.