Chapter 9

Intellectual property reform and productivity enhancement

by
Ricardo H. Cavazos Cepeda and Douglas C. Lippoldt[1]

For a broad sample of OECD countries, this chapter considers empirically the relationship between change in the protection of intellectual property rights (IPR) between 1990 and 2000 and the evolution of technological achievement, as well as the relationship of such achievement to change in labour productivity. The core assessment proceeds via regression analysis using a two stage approach and national level data. The results point to a positive and statistically significant relationship between indicators for protection of patent and trademark rights and technological achievement. The relationship between such technological achievement and labour productivity was positive and significant in certain specifications.

For a broad sample of OECD countries, this chapter considers empirically the relationship between change in the protection of intellectual property rights (IPR) between 1990 and 2000 and the evolution of technological achievement, as well as the relationship of such achievement to change in labour productivity. The motivation for this assessment draws on economic literature pointing to the potential influence of IPRs on the ability of innovators (and subsequent rights holders) to appropriate benefits from their innovations. This may affect economic incentives for the application of improved technologies in the economy (e.g. from domestic innovation and technology transfer from abroad, including via trade and foreign direct investment), with potential implications for productivity and, ultimately, comparative advantage. The core assessment proceeds via regression analysis using a two stage approach and national level data. The results point to a positive and statistically significant relationship between indicators for protection of patent and trademark rights and technological achievement (the coefficient for copyrights was not statistically significant). The relationship between such technological achievement and labour productivity was positive and significant in certain specifications.

This chapter is structured as follows. It begins with a statement on motivation and a brief review of the literature, followed by an overview of the analytical approach and data employed. The results are then presented. A short conclusion highlights implications of the findings and provides an indication of potentially fertile areas for further research.

Motivation

An appropriate degree of protection for IPRs can contribute to economic development and growth by helping to clarify ownership rights and by providing rights holders with a means to obtain benefits from their innovations; in turn, this establishes an incentive for innovation and diffusion of innovation (Maskus, 2000). Changes in IPR protection have been shown to be associated with change in indicators for innovation, technology transfer, trade and foreign direct investment (e.g. Park and Lippoldt, 2008; Cavazos *et al.*, 2010; Branstetter *et al*., 2006). Such developments can facilitate the gradual accumulation of knowledge capital in firms, sectors and economies.[2] Thus, reform of inadequate IPR protection may be cited as one part of a general strategy for promoting economic development, in combination with other reforms (Park and Lippoldt, 2005).

The economic growth rates of open economies tend to be greater than those of closed economies (e.g. OECD, 2006). Market openness contributes to the realization of comparative advantage in a variety of ways such as through access to necessary technologies from abroad, availability of complementary intermediate inputs, and opportunities for specialisation and integration in international value chains. Internationally, these flow via international trade, foreign direct investment, licensing, and movement of personnel, among other channels. The degree of IPR protection available in a market can influence these international flows by providing rights holders with a means to appropriate the benefits of their innovations and to defend against abuse of their property (Maskus, 2000). The lack of adequate IPR protection in a country may in effect constitute a trade barrier in the sense that rights holders may be impeded in their ability to freely access the market to invest or trade their goods and services.

The international community has undertaken significant steps in the establishment of effective global minimum standards for protection of IPRs, particularly since the entry into force of the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 1995.[3] Nonetheless, IPR protection continues to vary significantly

across countries, both due to flexibility permitted under the emerging IPR framework and shortfalls in the implementation of the system. Using the Patent Rights Index, Figure 9.A1 provides an illustration of the international strengthening of IPR protection and the remaining diversity in such protection (Park, 2008; Park and Lippoldt, 2008).[4] As can be seen, there has been a positive long-term evolution of the average index scores for developed and developing countries, as well as a persistent gap between the levels of protection for patent rights in these two groups of countries. Similar patterns can be observed for copyright and trademark protection (Park and Lippoldt, 2008).

The incentives related to IPR protection could have important effects on technological development, which in turn could influence productivity. As can be seen from growth theory, economic expansion depends on labour and capital inputs and the technologies employed to combine them into desired outputs (e.g. Solow, 1956). If the recent strengthening of IPR protection in fact provides better incentives for increased innovation and diffusion of innovation, this may promote increased accumulation and upgrading of technology. In turn, this may influence the productivity of labour by enabling more efficient processing of inputs in generation of desired outputs. Consequently, this chapter aims to examine the association of changes in the strength of IPR protection during the period from 1990 to 2000 with changes in technological achievement and the association of technological achievement with change in productivity. The objective is to consider the responsiveness of these dimensions of the economy to the improved incentives from strengthened IPR protection.

Literature review

This literature review briefly explores some of the key dimensions of a possible relationship of IPR protection to technology accumulation and productivity. The intention is to establish a foundation for the subsequent interpretation of the empirical analysis in the next section.

While Solow treated technology as an exogenous factor in his growth model, Romer (1986, 1990) developed a model with endogenous technological change, providing an early contribution to the literature directly exploring the role of technology in growth. Romer noted the non-rivalrous nature of technology, which means that technology may be used repeatedly and simultaneously without excluding others from additional use, providing a basis for increasing returns on investment. In such an environment, market incentives may fuel technological change, and diffusion and accumulation of technology.

Where an adequate degree of IPR protection is available, the incentives for innovation may be heightened compared to an environment where such protection is weak. IPR protection has an important economic function in helping to ensure clarity of ownership and enabling innovators and subsequent rights-holders to appropriate benefits from innovation (Demsetz, 1967). Once an appropriate degree of IPR protection is in place, there are several mechanisms through which protection of IPRs may influence the availability of technology from domestic and international sources.

IPR protection may stimulate domestic innovators to produce and diffuse innovation. For example, in a study covering developing countries during the period 1990 to 2005, Park and Lippoldt (2008) highlight the domestic innovative response that arose in association with strengthening of patent rights. In another example, Dutt and Sharma (2008) use panel data from 1989 to 2005 to determine whether enhanced IPR was a

positive motivator for increased innovation by firms in India. They find strong evidence that Indian firms in innovation-intensive industries increased R&D spending after the TRIPS agreement in 1994. Indeed, the estimated increase in R&D spending by firms is 20% higher in industries that are one standard deviation above the mean in innovative intensity.

Internationally, IPR protection may contribute to an environment conducive to economically important technology transfer from abroad. Keller (2009) finds that in a majority of countries, foreign sources of technology are estimated to account for up to 90% of domestic productivity growth. Technical change on a global scale is therefore largely determined by international technology diffusion, which affects the distribution and growth of world incomes. Developing a better understanding of what causes technology diffusion can help to shed light on how economically lagging countries can catch-up.

The availability of technology is a key contributor to productivity, and differences in productivity are especially important in that they explain the large variation in incomes across countries (Hall and Jones, 1999; Keller, 2009). This matters in particular for the pace of economic development. For example, Comin and Hobijn (2010) argue that countries that performed well in the post-WWII period did so because they were able to adopt new technology quickly. In a further study, Comin and Mestieri (2010) found that 70% of differences in cross-country income per capita can be explained by differences in the speed of technology adoption.

Maskus (2004) points to five main market mediated channels for such technology transfer including trade, FDI (foreign direct investment), licensing, joint ventures and cross border movement of personnel. Park and Lippoldt (2005, 2008) have considered the first four of these channels and found a significant association of strengthened patent rights to these flows into developing countries. The association is particularly strong for FDI. With respect to other types of intellectual property, Park and Lippoldt also find significant but more modest relationships in certain cases with respect to copyright and trademark strengthening in developing countries.[5] Such technology transfer can facilitate the acquisition of technology directly by the parties concerned, while also helping to improve the absorptive capacity for new technologies more broadly (e.g. through human capital development[6]).

Measuring the impact of technology on economic growth, Eaton and Kortum (1995) isolate patterns of invention and technology diffusion from patent data and apply a model to explain productivity differences among OECD countries. They find that every OECD country except the United States derives more than half of its productivity growth from ideas from abroad. Finally, they conclude that a country's productivity level is largely determined by its ability to adopt new technology, regardless of whether that technology was developed at home or abroad. Schneider (2005) notes that high-technology imports are central to domestic innovation in both developed and developing countries, and foreign technology has a stronger impact on per capita GDP growth than domestic technology. One explanation is that imports provide innovations that do not exist in the local economy, and domestic researchers gain insights from these innovations. Based on this, by gaining access to foreign innovations, trade can be seen as facilitating technological diffusion and economic growth.

Openness and the ability to access technology appear to play an important economic role at the firm level. Firms now rely in part on external technology to enhance efficiency and productivity in order to adapt to new developments and stay competitive in the highly

integrated global economy. This may be due to the heightened pace of innovation, the spread of production networks, and the need for interactive functionality of products, among other possible causes. For example, in a study of German manufacturing firms, Gantumur and Stephan (2010) find that those that acquired external technology experienced more productivity growth than non acquiring firms. The study also highlights evidence of complementarity between internal and external R&D (research and development) in innovation and production, and stresses that in the case of German manufacturing, firm size has been an important determinant of innovative efficiency and productivity of external technology acquirers.

Some early references on the role of IPR in development focus on the technological differences between the North (developed countries) and the South (developing countries) and the impact of enhanced IPR protection on welfare in the North and South. Chin and Grossman (1988), for example, consider a recurring tension between the North and the South over IPR, whereby the North bears the costs of innovation, and the South adopts low levels of IPR protection in order to benefit from the innovation of the North. However, Diwan and Rodrik (1991) provide a contrasting view. They highlight the importance of different preferences for new technologies between North and South. For example, the North may prefer to focus pharmaceutical R&D on cancer treatments, while the South may prefer to focus efforts in this area on tropical diseases. However, global R&D resources are scarce and this provides a motive for countries in the South to pursue adequate IPR protection in order to compete for these scarce R&D resources.

More recently, Yang and Maskus (2008) consider North-South relations in terms of market entry strategies and IPRs. Northern firms have a choice between exports or licensing as a market strategy for supplying the South. This decision is based on the level of IPR in the developing country that the Northern firm wishes to enter. Their findings show that enhanced IPR protection leads to technology transfer through licensing and reduces the South's marginal production cost, thereby increasing its exports. Here, absorptive capacity plays an important role in the outcomes, including with respect to welfare.[7]

Summary

This brief review of the literature highlights the importance of technology for economic growth. IPRs appear to play a role in enhancing the incentives for new innovation and diffusion of existing innovation. In turn, the accumulation of technology in the economy that results from this process may influence productivity. From the evidence presented above, it appears that this process may operate in a broad range of developed and developing countries, with implications for growth and comparative advantage.

In this context, it is notable that the levels and evolution in protection for IPRs around the world since 1990 have not been uniform. The next section will consider the variation in IPR protection across countries and the association of change in IPR protection with changes in technological achievement and productivity.

Analytical approach and data

The analytical approach employed is empirical, based on a two equation system implemented using a two step approach.[8] The objective is to examine the relationship of change in IPR protection to change in technological achievement and the relationship of technological achievement to change in labour productivity.

The relationship of IPR protection to technological achievement is estimated in equation (1). The equation was estimated three times, drawing in turn on each of three indices of IPR protection, concerning respectively patent rights, copyrights and trademark rights. Control variables included GDP per capita and FDI inflows, with country fixed effects. All variables were introduced as natural logarithms. The equation considers the relationship using national-level (aggregate) balanced panel data for the years 1990 and 2000. The hypothesis underlying this part of the analysis is that in view of initial weaknesses in IPR protection (relative to current standards) for the countries concerned as of 1990, the strengthening of IPR protection during the subsequent decade would be associated with stronger incentives to innovate and diffuse innovation, and consequently stronger technological achievement.

Equation (2) considered the relationship of technological achievement to labour productivity using balanced panel data for the years 1990 and 2000, controlling for GDP per capita, with country fixed effects. Here as well all variables were introduced as natural logarithms. In order to control for endogeneity of technological achievement, the variable is instrumented using the exogenous variables in the system; for each country three estimates of ^T were developed using equation (1) results for patent rights, copyright and trademark rights. The hypothesis underlying this part of the analysis is that on average relatively higher levels of technological achievement during the period will be associated with relatively greater productivity; this is because greater technological achievement (as measured by the TAI) implies greater capacity to accumulate and diffuse technology across the economy, which can result in greater output per hour worked.

Equations (1) and (2) constitute the core analysis for this chapter. Equation (3) was included as a secondary means of confirming the results of the analysis using equation (2). It is structured in a manner somewhat similar to equation (2), but considers the change in labour productivity over the period as the dependent variable. It employs sector-level data, by country, for the value added per hour and gross output per hour series. The independent variables refer to the initial period. Sector fixed effects are employed. Data limitations required use of a restricted sample for the implementation of equation (3); it could not be estimated using predicted values for technology achievement (see below) based on trademark rights data, and one country dropped out of the sample.

The model as estimated is presented below:

$$\ln T_{it} = \alpha_1 + \beta_1 \ln X_{it} + \eta_1 \ln V_{it} + \eta_2 \ln W_{it} + \Theta_i + \varepsilon_{it} \quad (1)$$

$$\ln Y_{it} = \alpha_2 + \beta_2 \ln \hat{T}_i + \eta_3 \ln V_{i,t} + \mu_i + e_{it} \quad (2)$$

$$\ln \Delta Z_{is} = \alpha_3 + \beta_3 \ln \hat{T}_i + \eta_4 \ln V_i + m_s + e_i \quad (3)$$

Where

T = *Technology Achievement Index* (NB, this variable would be endogenous in equation (2); to circumvent this situation, we instrument for it using the exogenous variables in equation 1 to obtain predicted values. The predicted values are indicated by

the following notation: ^T. Separate estimates of ^T were calculated for patent rights, copyright and trademark rights. In equation (3), the predicted values refer to 1990.)

Y = level of value added per hour or gross output per hour worked, national level data, for the periods 1990 and 2000.

ΔZ= change in the value added per hour or gross output per hour worked, sector-level data, by country, for the period from 1990 to 2000.

i = country

s = sector

t = *year* (1990 or 2000)

α_1, α_2 and α_3 are *constants*

β_1, β_2 and β_3 are coefficients for the independent variables of prime interest in the present analysis, namely those concerning protection of intellectual property rights (equation 1) and technological achievement (equations 2 and 3), respectively.

X = a measure of the strength of *intellectual property rights* (Park *et al* indices for patent, copyright and trademark protection, each included in separate iterations of the model),

V = a *control variable*, namely GDP per capita (in equation 3, this refers to 1990 only)

W = a *control variable*, namely inward FDI

Θ = country fixed effects

μ = country fixed effects

m = sector fixed effects

ε and *e* = the *error terms*

ln denotes the natural logarithm.

The data for the analysis were drawn from several sources:

- The *Technology Achievement Index* (TAI) was presented in the World Bank's *Global Economic Prospects, 2008* (WB, 2008). It is based on a broad range of indicators concerning innovation, technological adaptive capacity, channels of technology diffusion, diffusion of recent technologies and penetration of old technologies.[9] All together, there are 34 separate variables underlying the TAI. Aggregation is accomplished using weights calculated by principle components analysis.
- The series on output and productivity were *drawn* from the EU-KLEMS data set, November 2009 release.[10]
- The protection of IPRs is represented by three indices developed by Walter G. Park, American University, and colleagues. The indices measure the strength of IPRs based on laws on the books assessed *using* objective criteria concerning such dimensions as membership in relevant international treaties, statutory laws and legislation, and case law (for details see Park and Lippoldt, 2008). The present analysis employs the Patent Rights Index, Copyright Index and Trademark Rights Index.

- Control variables for equation 1 were drawn from the dataset underlying Park and Lippoldt (2008).
- The combined dataset from these *sources* covered 14 OECD countries: Australia, Austria, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Sweden, the United Kingdom and the United States. Data by sector were not available for the United States due to different sector classification within the KLEMS dataset; hence, it was dropped from the sample in the implementation of equation (3).

Descriptive statistics for the key variables are presented in Annex Table 9.A1, by year and pooled across time periods. Panel A highlights the complete sample, with all countries covered. In reference to the implementation of equation (3), Panel B highlights these statistics for the sample excluding the United States. As presented in the table, one notable feature of the data concerns the decline in the dispersion of the three IPR indicators between 1990 and 2000. In part, this may be attributed to greater international co-ordination in setting of minimum standards of protection for IPRs, including via the TRIPS Agreement that came into effect in 1995. In comparison to developing countries, the advanced economies in the present sample were extended less flexibility under the TRIPS Agreement and hence one might expect relatively smaller variation in the present sample than one would find globally.

Figure 9.A2 presents histograms showing the distribution of scores across the sample for 1990 and 2000, for each of the IPR indices and for the Technology Achievement Index. The scores are displayed in natural logarithms. The figure highlights graphically the increased convergence in the situation of these advanced economies with respect to the subjects covered by these indices.

Results

The analysis found positive and significant relationships in several specifications of the two core equations (1 and 2) and the confirming assessment in equation (3). The results point to a positive and statistically significant relationship between two indicators of IPR protection and technological achievement (Annex Table 9.A2). The relationship between such achievement and value added per hour – a key indicator for labour productivity – was also positive and significant (Annex Table 9.A3).

As can be seen from Annex Table 9.A2, with respect to protection of patent rights and trademark rights as measured by the two corresponding indices, the coefficients were positive and statistically significant (at the 0.1 and 0.05 levels, respectively). The control variables were also positive and significant. On average, a change of 1% in the Patent Rights Index, for example, was associated with a change of 0.31% in the Technological Achievement Index. The comparable result for trademarks was 0.17%. On the other hand, the coefficient for copyright was not significant. While this type of analysis does not determine causality, from these results it appears there is a clear association between the generally strengthened IPR protection for patents and trademarks and technological achievement during the period 1990 to 2000.

A further result of interest for comparative advantage can be seen in the positive and significant results with respect to the control variable, namely FDI inflows. Our results appear consistent with the notion of FDI as one hypothesized path of technology transfer, as suggested by others in the literature (Keller, 2007; Maskus, 2004). The parameter estimates in Annex Table 9.A.2 relating to inward FDI suggest this dynamic since they

are all positive and statistically significant. For example, in column (1) a 1% increase in inward FDI is associated with a 0.18% increase in technology achievement for the case of patents. Similarly, in columns (2) and (3), a 1% increase in inward FDI is associated with increases in technology achievement of 0.20% and 0.16%, with respect to copyrights and trademarks, respectively. Taken as a set, these results complement the evidence from the IPR indicator and suggest that FDI may operate in parallel or joint with IPR protection in relation to technological achievement. Together, they may aid in the diffusion of technology in the countries concerned, facilitating movement towards the world technological frontier and contributing to productivity increases.

The results for labour productivity are also positive and significant in the case of value added per hour (Annex Table 9.A3). Drawing on predicted values for TAI developed in relation to the indices of IPR protection[11], the results from equation (2) show that stronger technological achievement during the decade tended to be associated with increased labour productivity as measured by this indicator. This was not the case for gross output per hour. For example, consider technological achievement as estimated with respect to patent protection. On average, a 1% greater score for technological achievement was associated with a 0.35% greater score in value added per hour during the period between 1990 and 2000. For copyright and trademark protection, the comparable results were 0.40% and 0.42%, and the statistical significance was stronger. Thus, the results are consistent with the hypothesis that stronger technological achievement would be associated with change in labour productivity, at least as measured by value added per hour.[12] Arguably, this is a better indicator of labour productivity than gross output per hour, which does not take into account inputs.

Annex Table 9.A4 presents the results of the supplementary assessment specified in equation (3), considering the change in labour productivity indicators during the decade in relation to the level of technological achievement as of 1990, controlling for GDP. This assessment drew on sectoral data to provide a confirming assessment to the foregoing national-level assessment.[13] While the data limitations required a narrowed focus (with predicted values for technological achievement taking into account either patents or copyright, but not trademarks and the loss of the United States from the sample), it nonetheless provided some encouragement. The coefficients for the relationship of technological achievement were positive across the board. However, they were only significant in the case of change in gross output per hour. Overall, a 1% variation in the initial level of technological achievement as of 1990 was associated with 0.12% and 0.16% change in gross output per hour (depending on whether indicators for protection of patent rights or copyright were used in developing the predicted TAI values). The difference in significance with the foregoing analysis appears to be influenced in part by the different coverage of the sample.

Conclusions

For a sample of advanced economies during the 1990s, this chapter has considered the relationship of changes in IPR protection to technological achievement, and the relationship of technological achievement to labour productivity. With respect to the indicators employed in the analysis, the results point to a positive and significant relationship of patent and trademark protection to technological achievement and, in turn, technological achievement to labour productivity. Taken as a whole, the results indicate that an appropriate degree of IPR protection may constitute one policy complement to be considered in relation to trade and investment policies designed to facilitate realisation of

improved economic performance in line with a country's potential comparative advantage.

From the available evidence, it is not clear what is driving the lack of significant relationship of copyright protection to technological achievement. For example, it may be that while copyright protection provides incentives for commercial diffusion of technical knowledge, it may also lead to market power effects that could potentially slow diffusion, and the resulting balance is ambiguous. Hence, it would appear that this issue merits further exploration that goes beyond the scope of the present chapter.

The present empirical analysis was conducted for a particular set of countries, during a specific period of time, with IPR protection being strengthened over a particular range of stringency. Thus, any generalisation should be approached with caution.[14] Nonetheless, on the basis of the statistical evidence presented above, it would appear that technological achievement is one factor correlated with change in labour productivity and that, for policy makers concerned with these matters, IPR protection is one policy dimension that merits consideration.

Notes

1. Ricardo H. Cavazos Cepeda, Director General, Estudios Económicas Comisión Federal para la Protección Contra Riesgos Sanitarios Mexico, and Douglas C. Lippoldt, Senior Trade Policy analyst, Agriculture and Trade Directorate, OECD. The authors wish to thank Michael Hennon, University of Denver, for his capable research assistance. The kind assistance of Andrew Burns, World Bank, is gratefully acknowledged in providing access to the Technology Achievement Index, as is the assistance of Walter G. Park, American University, in providing access to the intellectual property rights indices employed here. The views expressed are those of the authors alone and are not meant to represent the views of the OECD or any of its members.

2. For a detailed explanation about knowledge capital, see Romer (1986) and Grossman and Helpman (1990a, 1990b).

3. Although the TRIPS Agreement was a major factor in strengthening IPR rights around the world during the 1990s, it was not the only one. Others include, for example, increased numbers of ratifications of agreements administered by the World Intellectual Property Organisation, increased numbers of regional trade agreements incorporating IPR provisions, and unilateral (domestic) IPR policy reform.

4. Based on objective criteria for scoring the relevant laws on the books, the Patent Rights Index provides an indication from 0 (low) to 5 (high) for the strength of patent rights in each country (Park, 2008).

5. There are a number of studies that consider the relationship of IPR protection to international economic relationships, generally finding a positive association. These include Fink and Primo Braga (1999); Awokuse and Yin, 2010; Branstetter *et al.*, 2006; Ivus, 2008; Yang and Kuo, 2008; and Javorcik (2004). With respect to FDI and IPR protection, Lai (1998, 2003) and Lai and Qui (2003) note the positive role of IPR in the process of technology transfer and related welfare implications.

6. Lucas (1993) explores the disparate growth rates between Asian countries and argues that the primary driver of economic growth is human capital (knowledge), and that this is therefore the main source of differences between living standards. Hall and Jones (1999) also examine the large differences in worker output between countries, noting that human capital is critical to worker output, high levels of productivity, and long run growth. They argue success in these areas is determined by social infrastructure. That is the institutions and government policies allow individuals and firms to make investments, create and transfer ideas, and produce goods and services.

7. A recent World Bank study explores how developmental and regulatory impediments may constrain the ability of developing countries to adopt new technologies. Such barriers can deter the process of resource allocation and firm creation and destruction, slowing technological adoption and resulting in a failure to catch-up (Bergoeing *et al.*, 2010).

8. The regression analysis was implemented using the STATA statistical package.

9. The data from the WB-TAI for the present analysis cover two time periods, 1990 and 2000.

10. Further information on the EU-KLEMS data set can be found at *www.euklems.net/* .

11. This refers to the predicted values for TAI included in the equation as ^TAI. There were three iterations, each using the different results from the three iterations of equation (1) as calculated for patent rights, copyright and trademark rights.

12. As stated in the foregoing exercise, such evidence of a positive and significant relationship does not demonstrate causality.

13. In preparing this confirming assessment with equation 3, the equations 1 and 2 were rerun excluding the United States from the sample. The results are not presented here due to space limitations, but were very similar in scale, sign and significance to those presented in Tables 9.A2 and 9.A3.

14. For example, one cannot extrapolate from these results to assume that strengthening of IPR protection beyond the range considered here would yield further positive results of similar magnitudes.

References

Awokuse, T. and H. Yin (2010), "Does Stronger Intellectual Property Rights Protection Induce "More Bilateral Trade? Evidence from China's Imports," *World Development*, Vol. 38, No. 8, pp. 1094-1104.

Bergoeing, J. and L. Norman, and F. Piguillem (2010), "Why are developing countries so slow in adopting new technologies?" *Policy Research Working Paper*, The World Bank.

Branstetter, L., Fisman, R. and C. Fritz Foley (2006), "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence From U.S. Firm-Level Panel Data", *The Quarterly Journal of Economics,* February.

Chin, J. and G. Grossman (1988), "Intellectual Property Rights and North-South Trade", *NBER Working Paper* No. 2769, National Bureau of Economic Research.

Comin, D. and B. Hobijn (2010), "Technology diffusion and post-war growth", *NBER working paper* No. 16378, National Bureau of Economic Research.

Comin, D. and M. Mestieri (2010), "An intensive exploration of technology diffusion", *NBER Working Paper No. 16479*, National Bureau of Economic Research.

Demsetz, Harold (1967), "Toward a Theory of Property Rights", *The American Economic Review*, Vol. 57, No. 2, *Papers and Proceedings of the Seventy-ninth Annual Meeting of the American Economic Association*, May, pp. 347-359.

Diwan, I. and D. Rodrik (1991), "Patents, appropriate technology, and North-South trade", *Journal of International Economics*, No. 30, pp. 27-47.

Dutt, A. and S. Sharma (2008), *Intellectual Property Rights and Innovation in Developing Countries: Evidence from India*, International Finance Corporation, World Bank Group.

Eaton, J. and S. Kortum (1995), "Trade in Ideas: Patenting and Productivity in the OECD", *NBER Working Paper No. 5049*, National Bureau of Economic Research.

Fink, C. and C.A. Primo Braga (1999), "How Stronger Protection of Intellectual Property Rights Affects International Trade Flows", *Policy Research Working Paper Series 2051*, The World Bank.

Gantumur, T. and A. Stephan (2010), "Do external technology acquisitions matter for innovative efficiency and productivity?" German Institute for Economic Research.

Grossman, G.N. and E. Helpman (1990a), "Comparative advantage and long-run growth" *American Economic Review*, Vol. 80, No. 4, pp. 796-815.

Grossman, G.N. and E. Helpman (1990b), "Trade, Knowledge Spillovers, and Growth," *NBER Working Paper* 3485, October.

Hall, R. and C. Jones (1999), "Why do some countries produce so much more output per worker than others?" *The Quarterly Journal of Economics,* Vol. 114, pp. 83-116.

Ivus, O. (2008), "Do Stronger Intellectual Property Rights Raise High-Tech Exports to the Developing World?" Working paper of Department of Economics, University of Calgary, October.

Javorcik, B. (2004), "The composition of foreign direct investment and protection of intellectual property rights: Evidence from transition economies", *European Economic Review*, No. 49, pp. 39-62.

Keller, W. (2007), "Transfer of Technology", *The New Palgrave Dictionary of Economics*, (Second edition) L. Blume and S. Durlauf, Macmillan, 2008.

Keller, W. (2009), "International Trade, Foreign Direct Investment, and Technology Spillovers", *NBER Working Paper* 15442, National Bureau of Economic Research, Inc.

Lai, L.-C. (1996), "International intellectual property rights protection and the rate of product innovation," *Journal of Development Economics*, Vol. 55, pp. 133-153.

Lai, L.-C. (2003), "The North's intellectual property rights standard for the South?" *Journal of International Economics*, No. 59, pp. 183-209.

Lin, C. and P. Lin (2010), "Property rights protection and corporate R&D: Evidence from China," *Journal of Development Economics*, No. 93, pp. 49-62.

Lippoldt, D. (2008), "The Multilateral Trading System and the Strengthening of Intellectual Property Rights in Developing Countries: Trade and Investment Impacts", in *Global Challenges of Intellectual Property Rights* (eds. Robert Bird and Subhash Jain, University of Connecticut), E. Elgar Publishing.

Lucas, R. (1993), "Making a Miracle", *Econometrica*, Vol. 61, No. 2, March, pp. 251-272.

Maskus, K.E. (2000), "Intellectual Property Rights in the Global Economy", *Institute for International Economics*, Washington DC, August.

Maskus, Keith (2004), "Encouraging International Technology Transfer," United Nations Conference on Trade and Development and International Centre for Trade and Sustainable Development, Issue Paper No.7.

OECD (2006), *Trading up: economic perspectives on development issues in the multilateral trading system*, OECD, Paris.

Park, W.G. (2008), "International Patent Protection: 1960-2005", *Research Policy*, No. 37, pp. 761-766.

Park, W.G. and D.C. Lippoldt (2005), "International licensing and the strengthening of intellectual property rights in developing countries during the 1990s", *OECD Economic Studies,* Vol. 40.

Park, W.G. and D.C. Lippoldt (2008), "Technology Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries," *OECD Trade Policy Working Paper* No. 62*,* January 25.

Romer, P.M. (1986), "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, Vol. 94, No. 5, October.

Romer, P.M. (1990), "Endogenous Technological Change", *The Journal of Political Economy*, Vol 98(5), from *Part 2: The Problem of Development: A Conference of the Institute for the Study of Free Enterprise Systems* (October 1990), pp. S71- S102, The University of Chicago Press, available at: *www.jstor.org/stable/2937632*.

Schneider, P. (2005), "International trade, economic growth and intellectual property rights: A panel data study of developed and developing countries," *Journal of Development Economics,* Vol. 78, pp. 529-547.

Solow, R.M. (1956), "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, Vol. 70, pp. 65-94, February.

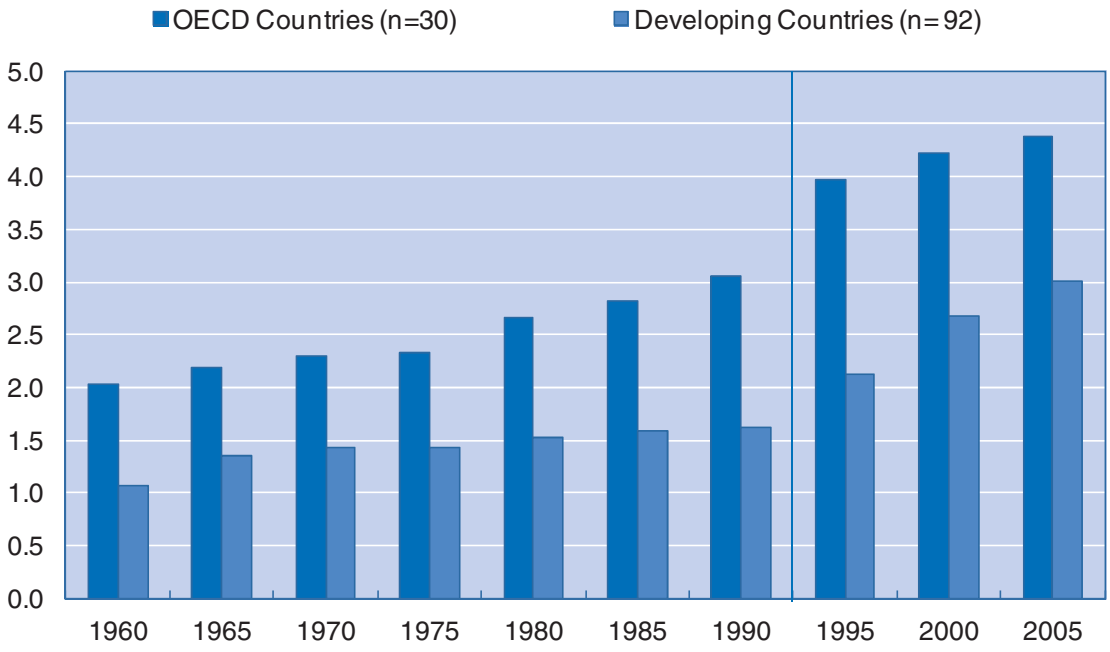
World Bank (2008), *Global Economic Prospects*, available at: *siteresources.worldbank.org/INTGEP2008/Resources/complete-report.pdf*.

Yang, M. and E. Maskus (2009), "Intellectual property rights, technology transfer and exports in developing countries", *Journal of Development Economics*, No. 90, pp. 231-236.

Yang, C-H and N-F Kuo (2008), "Trade-Related Influences, Foreign Intellectual Property Rights and Outbound International Patenting," *Science Direct,* Research Policy Vol. 37, 31 January.

Annex 9.A.
Figures and tables

Figure 9.A1. Index of patent rights based on laws on the books
(0 = weak, 5 = Strong)

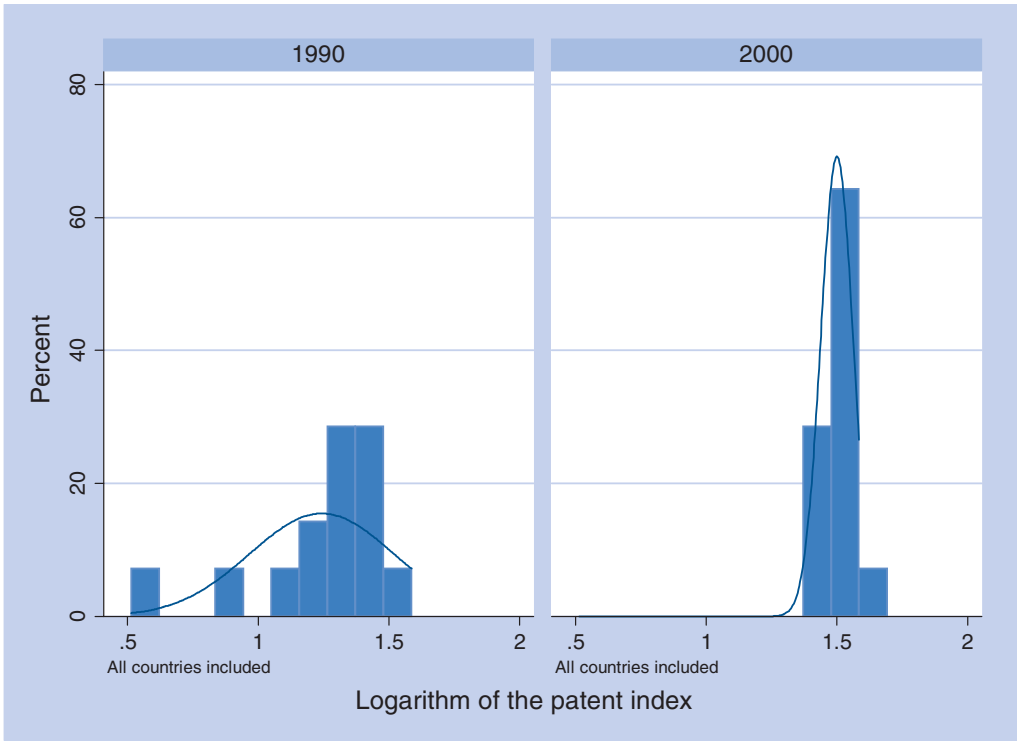


The chart presents the average score for the Patent Rights Index for OECD and developing countries. Using objective criteria, the Patent Rights Index scores the strength of patent rights based on laws on the books. Scores can range from 0 to 5. The thin vertical line represents the advent of the WTO TRIPS Agreement.

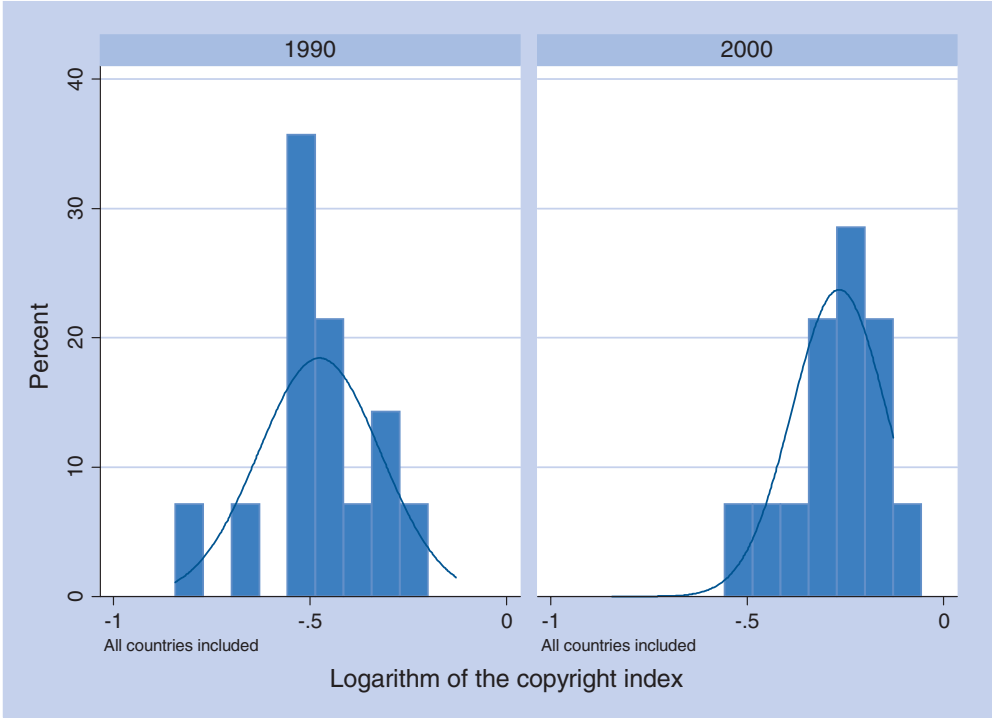
Source: Park and Lippoldt (2008).

Figure 9.A2. Histograms presenting the distribution of the index scores, all countries in the sample, 1990 and 2000

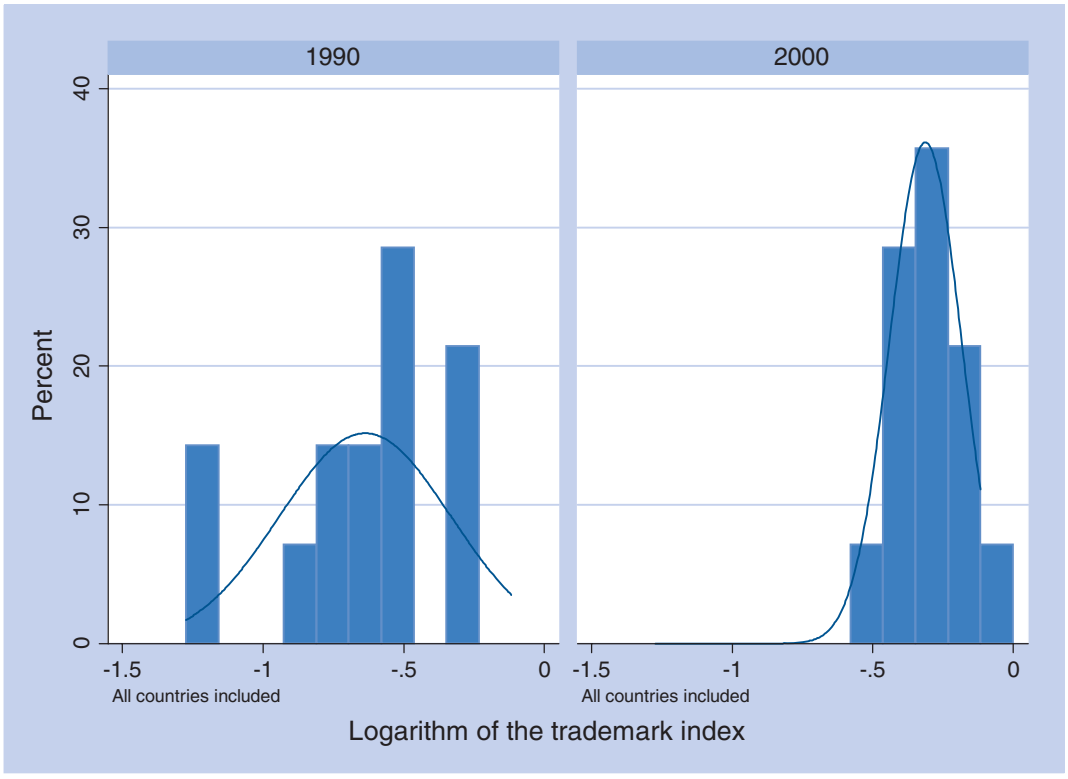
Panel A. Logarithm of the patent rights index scores



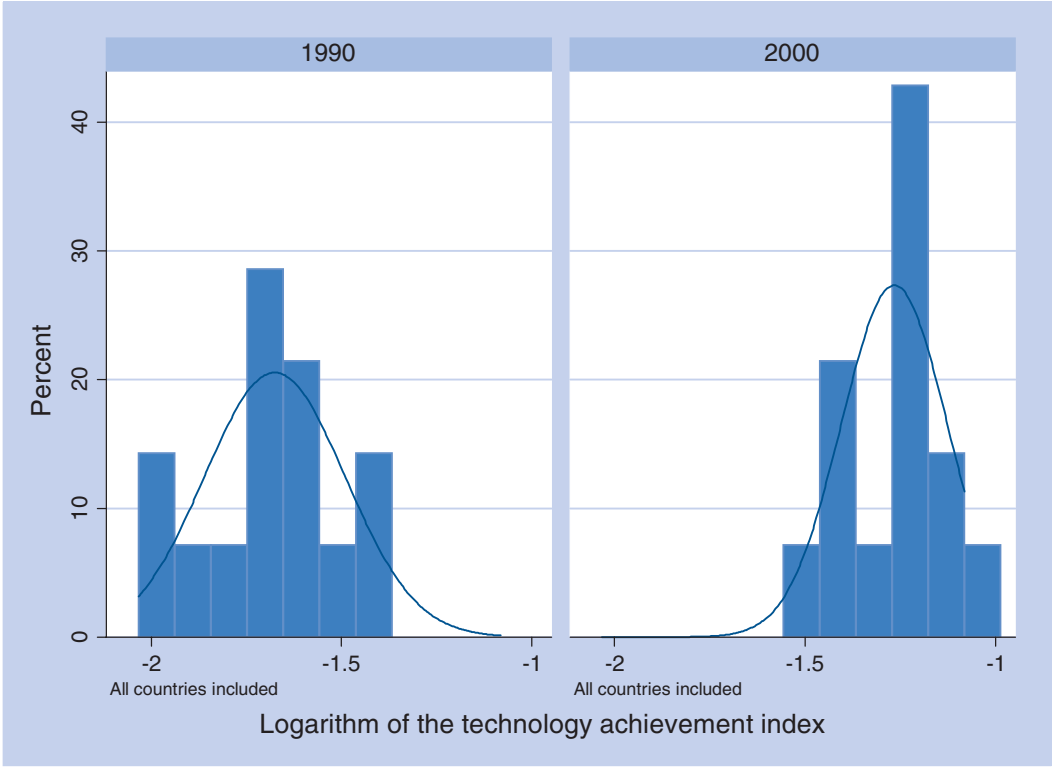
Panel B. Logarithm of the copyright index scores



Panel C. Logarithm of the trademark rights index scores



Panel D. Logarithm of the technology achievement index scores



Annex Table 9.A1. Descriptive statistics for the sample, 1990 and 2000

A. All countries covered

Variable	Observations	Mean	Standard deviation	Coefficient of variation	Minimum	Maximum
Full sample (pooled years)						
Technology achievement index	28	0.24	0.06	0.25	0.13	0.34
Patents index	28	4.03	0.76	0.19	1.67	4.88
Copyrights index	28	0.70	0.12	0.16	0.43	0.88
Trademarks index	28	0.64	0.15	0.24	0.28	0.89
GDP per capita	28	21196.31	7089.87	0.33	8563	36649
Inward FDI	28	158433.70	249445.30	1.57	6289	1256867
Year 1990						
Technology achievement index	14	0.19	0.03	0.18	0.13	0.24
Patents index	14	3.57	0.82	0.23	1.67	4.68
Copyrights index	14	0.63	0.09	0.15	0.43	0.79
Trademarks index	14	0.55	0.15	0.27	0.28	0.78
GDP per capita	14	19033.74	6566.82	0.35	8563	33280
Inward FDI	14	97212.54	130232.80	1.34	6289	483933
Year 2000						
Technology achievement index	14	0.28	0.04	0.14	0.22	0.34
Patents index	14	4.49	0.27	0.06	3.97	4.88
Copyrights index	14	0.77	0.09	0.12	0.59	0.88
Trademarks index	14	0.74	0.09	0.13	0.58	0.89
GDP per capita	14	23358.89	7155.63	0.31	10497	36649
Inward FDI	14	219654.80	322798.80	1.47	14113	1256867

Covers all countries in the sample, including the United States.

B. All countries covered, excluding the United States

Variable	Observations	Mean	Standard deviation	Coefficient of variation	Minimum	Maximum
Full sample (pooled years)						
Technology achievement index	26	0.23	0.06	0.25	0.13	0.34
Patents index	26	3.97	0.76	0.19	1.67	4.67
Copyrights index	26	0.69	0.11	0.16	0.43	0.87
Trademarks index	26	0.64	0.16	0.25	0.28	0.89
GDP per capita	26	20409.03	6667.82	0.33	8563	36649
Inward FDI	26	103667.00	107616.10	1.04	6289	438631
Year 1990						
Technology achievement index	13	0.19	0.03	0.17	0.13	0.24
Patents index	13	3.49	0.78	0.22	1.67	4.34
Copyrights index	13	0.62	0.09	0.14	0.43	0.79
Trademarks index	13	0.55	0.15	0.28	0.28	0.78
GDP per capita	13	18323.83	6250.85	0.34	8563	33280
Inward FDI	13	67464.85	70374.68	1.04	6289	249870
Year 2000						
Technology achievement index	13	0.28	0.04	0.13	0.22	0.34
Patents index	13	4.46	0.26	0.06	3.97	4.67
Copyrights index	13	0.76	0.09	0.11	0.59	0.87
Trademarks index	13	0.74	0.10	0.13	0.58	0.89
GDP per capita	13	22494.22	6643.09	0.30	10497	36649
Inward FDI	13	139869.20	127809.80	0.91	14113	438631

Covers all countries in the sample except the United States.

Table 9.A2. The relationship of intellectual property protection to technological achievement, 1990 to 2000

Variables	(1) Log of technology achievement index	(2) Log of technology achievement index	(3) Log of technology achievement index
	(IPR Index = Patent Rights Index)	(IPR Index = Copyright Index)	(IPR Index = Trademark Rights Index)
log per capita GDP	0.640*	0.996***	0.857***
	(0.351)	(0.312)	(0.236)
log IPR index (either patent, copyright or trademark)	**0.307***	**-0.0266**	**0.170****
	(0.161)	**(0.280)**	**(0.0667)**
log of inward FDI	0.176***	0.195**	0.158***
	(0.0474)	(0.0724)	(0.0359)
constant	-10.16***	-13.51***	-11.66***
	(2.998)	(2.841)	(2.080)
Observations	28	28	26
Number of countries	14	14	14
R-squared	0.932	0.918	0.942

1) The countries covered include Australia, Austria, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Sweden, the United Kingdom and the United States.

2) Country fixed effects are included in these regressions.

3) Robust standard errors are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' calculations.

Table 9.A3. The relationship of technological achievement to labour productivity, country basis

1990 to 2000

Variables	Value added per hour	Gross output per hour	Value added per hour	Gross output per hour	Value added per hour	Gross output per hour
	^T value inferred using Patent Rights Index		^T value inferred using Copyright Index		^T value inferred using Trademark Index	
log per capita GDP	0.0462	0.302	-0.0262	0.183	-0.0028	0.202
	(0.228)	(0.353)	(0.237)	(0.364)	(0.212)	(0.332)
Log Technology Achievement Index (predicted values, ^T)	**0.354***	**0.275**	**0.401****	**0.352**	**0.420****	**0.396**
	(0.166)	**(0.257)**	**(0.165)**	**(0.252)**	**(0.166)**	**(0.246)**
Constant	4.554*	2.609	5.339*	3.898	5.195**	3.818
	(2.498)	(3.862)	(2.581)	(3.966)	(2.348)	(3.651)
Observations	28	28	28	28	26	26
Country ID	14	14	14	14	14	14
R-squared	0.825	0.760	0.834	0.774	0.853	0.824

1) The countries covered include Australia, Austria, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Sweden, the United Kingdom and the United States.

2) Country fixed effects are included in these regressions.

3) Robust standard errors are shown in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations.

Table 9.A4. The relationship of technological achievement to change in labour productivity,

Sectoral basis, 1990 to 2000.

Variables	Change in value added per hour, from 1990 to 2000	Change in gross output per hour, from 1990 to 2000	Change in value added per hour, from 1990 to 2000	Change in gross output per hour, from 1990 to 2000
	(^T value inferred using Patent Rights Index)		(^T value inferred using Copyright Index)	
log per capita GDP (as of 1990)	-0.0405	-0.103	-0.101	-0.173**
	(0.0787)	(0.0715)	(0.0928)	(0.0857)
Log Technology Achievement Index (predicted values, ^T, as of 1990)	**0.0344**	**0.115***	**0.0821**	**0.155****
	(0.0758)	**(0.0663)**	**(0.0751)**	**(0.0675)**
Constant	0.327	1.137	1.012	1.888*
	(0.910)	(0.830)	(1.051)	(0.973)
Observations	180	180	180	180
Country ID	13	13	13	13
R-squared	0.109	0.263	0.115	0.274

1) Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

2) The countries covered include: Australia, Austria, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Sweden, and the United Kingdom. Due to lack of data the United States is not covered.

3) Due to a lack of sectoral data for several countries, no comparable regression could be produced for technology achievement inferred using the Trademark Index.

4) Sector fixed effects are included in these regressions. The sector fixed effects take into account 15 major sectors covering virtually all of the economy: agriculture, hunting and forestry; mining and quarrying; total manufacturing; electricity, gas and water supply; construction; wholesale and retail trade; hotels and restaurants; transport and storage and communication; financial intermediation; real estate, renting and business activities; public administration and defence; compulsory social security; education; health and social work; other community, social and personal services; and private households with employed persons. No data were available concerning the sector "extraterritorial organisations and bodies."