Market Power, Governance and Innovation: OECD Evidence

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Abstract

The aim of this paper is to investigate the relationship between market power, governance and patenting activity in a sample of 25 OECD countries from 1988-2007. Controlling for a wide range of innovation predictors, we report that governance quality is related positively with patenting activity in the full sample and in samples of countries with higher-than-average per-capita GDP, governance scores and economic openness. Secondly, the relationship between market power and innovation has a *U-shape* in the full sample, but *inverted-U* shape in split samples. Third, when interacted with governance, market power tends to have an offsetting effect that weakens the positive relationship between governance and innovation. These findings are robust to a range of control variables such as per-capita GDP, income inequality, depth of equity markets, labour share in national income, economic globalization and military expenditures. Our findings indicate that governance is a significant factor that explain innovation and that blanket statements about the relationship between competition and innovation as well as the kind of reforms necessary to foster innovation can be misleading.

Keywords: Economic governance, innovation, patenting, market power

JEL classification: E02, B52, O3

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INTRODUCTION

Since Joseph Schumpeter's seminal contribution, the relationship between market structure and innovation has been a highly-debated issue in economics. This issue, however, tends to be treated as non-problematic in policy statements. For example, OECD (2007) has highlighted the significance of innovation for competitiveness and called for the regulatory and institutional framework to be reformed with a view to foster innovative activities. Similar statements have been made by the Commission of the European Union (EU) in the context of the Lisbon Agenda. The Commission declared the ambitious target of making the EU 'the most dynamic and competitive knowledge-based economy in the world' by 2010. This goal would be achieved through increased competition in goods and services markets, and increased policy coordination between member states (EU Commission, 2005).

This view was echoed in OECD (2006, 57-80), which argues that innovation performance is driven by a wide range of factors that include competitive product markets, macroeconomic stability, availability of internal and external finance, and economic openness. Yet, the extensive literature on the relationship between product-market competition and innovation provides conflicting findings, some of which indicate a positive relationship while some of which report a negative or non-linear relationship. Hence, there is an evident need to verify if product-market competition is conducive to innovation or whether innovation entails a deadweight losses associated with imperfect competition as a driver of innovation.

In addition, both academic and policy debate has paid little attention to the relationship between governance quality and innovation – particularly to interactions between governance quality and market structure and to the partial as well as combined effects of both factors. As Dixit (2009) has indicated, governance institutions may affect innovation because good governance is necessary for securing three essential prerequisites for market economies: (i) security of property rights; (ii) enforcement of contracts; and (iii) resolution of collective action problems. Institutions that secure property rights foster innovation by enabling investors in innovative activities to benefit from post-innovation profits, which may or may not be excessive depending on the market structure. Institutions that secure contract enforceability reduces transaction costs and foster innovation by enabling firms to choose advanced technologies that are usually encountered in contracted-dependent sectors (see also, Acemoglu et al., 2007). Finally, institutions that minimize or resolve collective action problems can also foster innovation because such institutions facilitate internalization of the externalities associated with innovation and enable countries to avoid prisoners' dilemmas in the management of common pool resources such as knowledge.

A number of empirical studies have investigated the determinants of innovation at the macro level. These include Clarke (2001), Griffith et al (2006a, 2006b), Guan and Chen (2012), and Tebaldi and Elmslie (2013). However, none of these studies examine the interactions between market structure and governance institutions as potential determinants of innovation. For example, Clarke (2001) examines the effects of macroeconomic variables and institutional factors on innovation, but without controlling for the level of market power. Similarly, Tebaldi and Elmslie (2013) examine the effects of governance institutions on patenting activity but without controlling for market structure and only with a small number of control variables that include R&D expenditures, geographical factors and demographic characteristics. Griffith et al (2006a, 2006b) do examine the relationship between market power and innovation, but neither the effects of macroeconomic variables nor the interactions between market structure and governance quality. Of other work, Tselios (2011), Weinhold and Nair-Reichert (2009) and Foellmi and Zweimuller (2000) investigate the relationship between income inequality and innovation; Guloglu et al 92012) Baldwin and Gu 92004) examine the effects of trade liberalization on innovation; and Altman (2009) and Zhou et al (2011) examine the relationship between labour costs and innovation. However, in all of this work, governance institutions are usually absent and so is the interaction between governance and market structure.

As such, the findings reported in the existing work may be subject to model specification bias. In this paper, we aim to contribute to existing work in three ways. First, we control for both market structure and governance institutions, taking into account the interactions between the two. Our measure of market structure consists of excess profits over and above the total costs of capital and labour. The governance measure, on the other hand, consists of a composite index composed of five governance dimensions: bureaucracy quality, control of corruption, investment profile, law and order, and government stability. Secondly, we control for a wide range of potential determinants of patenting activity, including income distribution, depth of equity markets, economic openness, labour's share in national income, the level of military expenditures, research and development (R&D) expenditures. Third: in line with Aghion and his co-authors' work on innovation at the firm level (Aghion et al., 2002, 2005), we control for non-linear relationship between market power and innovation. As a result, we will be able to provide evidence on whether governance and market structure have *complementary* or *offsetting* effects on innovation and whether the relationship between market structure and innovation is *U-shaped* or whether it has an *inverted-U* shape.

Our sample consists of 25 OECD countries for which data is collected from various sources for the period 1981 – 2008. The panel dataset is unbalanced, but it allows for estimation over 24 countries and 20 years for all relevant variables (see data and methodology section below). The dataset also enables us to check whether the relationship between innovation and its potential determinants differ between the full sample and the set of countries that have higher than sample average levels of per-capita GDP, economic openness and governance scores in each year. We report that the relationship between innovation and its potential determinants have the same signs across samples with the exception of profit mark-ups. We discuss the significance and policy implications of these findings below.

The paper is organized in five sections. In the following section, we provide a brief review of the related literature. We take stock of the existing evidence and identify the scope for adopting a more comprehensive approach to modeling the relationship between innovation and its potential determinants at the national level. In section 3, we introduce the data and elaborate on estimation methodology. The data is collected from a number of sources, including the OECD's *Main Science and Technology Indicators (MSTI)* database, the World Bank's *World Development Indicators (WDI)* database, the *International Country Risk Guide (ICRG)* database, the *Standardized World Income Inequality* database (Solt, 2009), and the UNDP study on factor shares in national income (Rodriguez and Jayadev, 2010). For estimation, we use generalized least-squares (GLS) estimation with panel-corrected standard errors (PCEs). This method allows for estimation in the presence of panel heteroskedastacity, panel autocorrelation, and contemporaneous correlation (HPAC). In section 4, we provide evidence on the relationship between innovation and potential determinants. We use two measures of innovation: number of patents granted by the US Patent and Trademark Office (USPTO) and the number of triadic patent families registered with USPTO, the European Patent Office (EPO) and Japan Patent Office (JPO). Finally, in section 5 we summarize the main findings and elaborate on their implications for policy and further research.

RELATED LITERATURE

Studies of innovation at the national level tend to adopt a national innovation system (NIS) approach based on pioneering work by Freeman (1987), Dosi et al. (1988) and Lundvall (1992). In this approach, the NIS has two dimensions: the knowledge innovation process (KIP) and the innovation environment (IE) that consists of institutional factors, macroeconomic conditions and government policy (Faber and Hesen, 2004; Guan and Chen, 2012). This paper focuses on the environmental factors that influence the KIP and its outcomes. Specifically, we focus on the factors that may affect the number of USPTO-granted and triadic patents.

One of the most-frequently researched environmental factors has been market structure and the level of competition it depicts. The debate on the innovation-competition relationship dates back to Schumpeter (1934, 1942), who posited that firms' innovation effort is likely to be higher when markets are concentrated and/or firm size is large. This is because market power enables firms to generate excess profits that can be used to hire highly qualified personnel and respond to competition quickly by utilising internal finance instead of relying on costly external finance. In addition, market power enables firms to enjoy the benefits of innovation by erecting new barriers against future entry.

Arrow (1962) takes issue with the Schumpeterian hypothesis and demonstrates that a monopoly shielded against competition has less incentive to innovate because it can earn positive profits with or without innovation. However, a firm in a perfectly competitive market does not earn positive unless it innovates and its innovation is protected through exclusive rights. However, Arrow (1962) compares a pure monopolist with a perfectly-competitive firm. When the market as a whole is modelled as imperfectly competitive, Gilbert and Newbery (1982) demonstrate that an incumbent firm with significant market power can be expected to invest more in innovation compared to a new-comer with less market power.

The result obtained by Gilbert and Newbery (1982) depends on the assumption that the patent is obtained by the highest bidder – i.e., by the firms that invests more in R&D. This assumption is challenged by Reinganum (1983, 1985) who argue that innovation expenditures increase the probability of obtaining the patent but does not guarantee success. Given this uncertainty, the incumbent monopolist will decide to invest in innovation depending on the nature of innovation (drastic versus incremental innovation) and on the probability of innovation by the new-comer. Reinganum (1983, 1985) show that, the expected profits for the monopolist that invests in drastic innovation are less than the expected profits for a competitor; and this result holds even if innovation becomes less drastic on a drastic/non-drastic scale.

As demonstrated in Gilbert's (2006) extensive review, conflicting findings tend to be the norm in both theoretical and empirical work. Peneder (2012) argues that the conflicting results may be due to assuming a linear relationship between market power and innovation. Yet, such assumption overlooks the possibility that the relationship may depend on the degree of initial market power assumed. Schumpeter (1934, 1942) assumes that the initial degree of market power is low and this is evident from his argument that endogenous innovation under perfect competition is impossible. In Arrow (1962), on the other hand, the initial level of market power is assumed to be high: the comparison is between a legally protected monopoly and duopoly. Therefore the incentives analysed by Schumpeter and Arrow unfold exactly at the opposite ends of the market-power spectrum.

The *inverted-U* relationship between competition and innovation is central to the theoretical and empirical work by Aghion et al (2002, 2005). In this work, incumbent firms tend to operate with similar technologies and innovation consists of neck-and-neck rather than drastic innovation when the level of competition is low. When this is the case, an increase in competition induces incumbent firms to innovate as a means of escaping competition. Hence, at low levels of initial competition, the relationship between competition and innovation is positive. In contrast, when the initial level of competition is high, innovation is more likely to be drastic and will be undertaken by new comers who would have lower profits. Given that further increase in competition would reduce firm profits, less and less newcomers will be able to invest in innovation. Hence, at high levels of initial competition, the relationship between competition and innovation is negative. The dynamic that drives the non-linear relationship between competition and innovation is the type of innovation (neck-and-neck *versus* drastic innovation) and the type of innovators (incumbents *versus* new-comers) is determined endogenously by the level of competition. Phrased in terms of market power, the findings by Aghion et al (2002, 2005) imply that the relationship between *market power* and innovation would have a *U-shape*: innovation would fall when market power increases from a low initial level and would increase when market power increases from a high initial level.

Following the work by Aghion and his co-authors, we can detect a degree of convergence towards the affirmation of a non-linear relationship between competition and innovation. This tendency is confirmed in recent work published in a special issue of the *Journal of Industry, Competition and Trade*. In an introductory article to the special issue, Peneder (2012) states that the non-linear model is technically sophisticated and has intuitive appeal - not the least because it can reconcile the Schumpeterian and Arrow-like arguments. Three empirical papers in the special issue test explicitly for non-linear relationship between competition and innovation. While Berubé et al (2012) and Polder and Veldhuizen (2012) confirm the existence of an inverted-U relationship in Canadian and Dutch micro-data respectively, Peroni and Gomes Ferreira (2012) report a U-shaped relationship in Luxembourg firm-level data.

Nevertheless, the work reviewed above examines the relationship between market power and innovation at the firm level. To our knowledge, Griffith et al (2006a, 2006b) is the only work that investigates the relationship between market power and innovation at the national level. Using the ratio of business R&D expenditures to GDP as measure of innovation and average profitability as measure of market power, Griffith et al (2006a: 30-31) report a positive relationship between average market power and R&D intensity for 13 OECD countries from 1986-2000. However, when three Scandinavian countries (Finland, Sweden and Denmark) are excluded, the relationship is found to be negative. To address the sensitivity to sample size, the authors also use sector-level average profitability and log R&D (instead of R&D intensity). The results indicate a negative relationship between market power and log R&D for all sectors taken together and for individual sectors classified on the basis of their exposure to competition through the Single Market reforms in the EU (Griffith et al, 2006a: 32-34; Griffith et al, 2006b: 28). The measure of profitability (market power) used is the ratio of value added to total cost of capital and labour at sector or macro level.

Another factor that may affect innovation at the national level is the quality of governance institutions. According to North (1990, 1994), a country's institutional environment constrain actor’s choice sets and behaviour, and as such hinder or support economic performance in general and innovation in particular. Governance institutions can be considered as the ‘rules of the game’ and consist of both formal and informal institutions. Formal institutions include written rules, regulations, laws and contracts; whereas informal institutions consist of values and belief systems that a society has developed and internalized over time.

Keefer and Knack (1997: 591) is the first attempt at relating innovation to a country’s institutional quality. In their approach, returns on innovation investment are spread over long time periods and are essentially uncertain. Hence, firms tend to make less investment in new technologies or continue with obsolete ones if rule of law is weak and the risk of ‘expropriation’ is high. Lundvall et al. (2002) takes the debate further by providing a systematic analysis of how governance institutions affect a society's interactive learning and innovation capabilities. The authors demonstrate that arbitration institutions, labour market regulation, and property rights institutions affect the level of innovation by shaping actors' ability to trust, learn and share knowledge.

Acemoglu and his co-authors provide theoretical justification for examining the relationship between governance institutions and innovation. For example, Acemoglu (2006) develops a model of economic and political institutions that lead to poor economic performance, including low levels of investment in long-term innovation projects. In the model, groups with political power choose policies to increase their income by revenue extraction, factor price manipulation and political consolidation. These choices lead to inefficient economic institutions, under which equilibrium taxes and regulations are worse than what the elite would like them to be from an *ex ante* point of view. *Ipso facto*, economic institutions that provide additional security of property rights to other groups can have a positive effect on long-term investment and growth. Acemoglu et al., (2007) focus on the quality of contracting institutions and demonstrate that the latter tends to explain productivity differences between countries as well as the choice between contract-dependent and vertically-integrated firm structures.

Empirical work on the relationship between governance institutions and innovation is few and far in between. Clarke (2001) is the first attempt at investigating the relationship between rule of law and innovation in a panel of developed and developing countries. The study reports that R&D expenditures tend to be lower in countries where the risk of expropriation is higher and the rule of law is weaker. Giménez and Sanaú (2007) provide a model where rule of law has a positive effect on technological development and economic growth. Using evidence for 64 countries averaged over 1985-1997, the authors report that the model's prediction is confirmed by the data. A similar result is established by Dakhli and de Clercq (2004), who report that a reliable legal system and effective patent registration is conducive to higher levels of innovation. More recently, Tebaldi and Elmslie (2013) also propose a model where institutional quality affects innovation by helping in the process of registering new patents, diffusion of ideas across researchers, enforcement of property rights and reducing the uncertainty of new projects. Using data averaged over 1970-2003 for 110 countries, the authors report a positive and significant relationship between USPTO-granted patents and individual institutional indicators, which consist of control of corruption, market-friendly policies, protection of property rights and a more effective judiciary system. The results remain robust when initial level of knowledge stock (proxied by country shares in book production) is controlled for with a sample of 76 countries.

The control variables included in our analysis are also based on the existing literature. One such factor is income distribution, which may affect innovation from the demand or supply side. Zweimuller (2000) and Foellmi and Zweimuller (2006) propose a demand-induced innovation model where income inequality and concentration has a positive effect on innovation. Their model is based on hierarchical preferences for new products and higher willingness of the rich to pay higher prices for the new products. Firms that cater for the preferences of the rich are able to extract rents whereas others catering for the mass market with standardized products are not. Hence, income inequality and the persistence of inequality may be associated with higher levels of innovation. However, high concentration of wealth may also hinder innovation by preserving a poor majority, which restricts the market size.

Income inequality may affect innovation from the supply side too. If income is related to ability, economic agents may interpret income inequality as a signal of an economic system that rewards ability, an endowment that is distributed unequally. This expectation will encourage risk taking and innovation, the benefits of which are known to have a skewed distribution (Scherer et al, 2000). Hence, income inequality can be expected to increase the supply of innovation (Galor and Tsiddon, 1997; Hassler and Mora, 2000). However, income inequality may also induce resistance to innovation due to feelings of unfairness by lower income groups and wage earners – as indicated in Akerlof and Yellen (1990). In addition, income inequality may be associated with poor institutional quality, which reduces innovation.

The relationship between income inequality and innovation has been investigated by some empirical studies. For example, Weinhold and Nair-Reichert (2009) report that the number of patents registered by residents in a sample of 53 countries is related positively to size of the middle class over the period 1994-2000. However, Tselios (2011) report a positive relationship between income inequality and innovation, using data for 102 European regions over the period 1995—2000. Their findings indicate that, given the existing levels of income inequality in the European Union (EU), an increase in a region's inequality favours innovation.

Another factor that may affect innovation is labour cost. The question here is whether higher labour costs induce firms to innovate as a means of reducing unit costs and/or increasing productivity. Altman (2009) utilizes a behavioural-institutional model of induced technical change and reports that higher labour costs induce firms to innovate to remain competitive or to maintain current profit rates. Zhou et al (2011), however, provide mixed results. Using firm-level survey data for Dutch firms, the authors report that functional (as opposed to numerical) labour market flexibility is associated with higher levels of products that are new to the firm. The relationship, however, does not hold for numerical flexibility. This evidence suggests that human resource management practices aiming to dampen wage costs may not be conducive to firm-level innovation.

A larger volume of work exists on the relationship between union power and innovation. Menezes-Filho and Van Reenen (2005) provide an excellent review of this literature. Their overall conclusion is that the sign, size and statistical significance of the association between unions and innovation vary dramatically between studies. Nevertheless, some patterns could be identified. First, North American studies tend to report a negative relationship between unions and R&D expenditures; but the evidence from Europe (mainly the UK) is mixed. Secondly, the ability of the unions to extract rents and hinder innovation depends on whether the strategic game between unions and employers is a one-shot or repeated game. If the game is repeated, unions are less likely to hinder innovation by extracting rents. This is because employers can retaliate by setting employment at lower levels. However, repeated game is associated with multiple equilibria and it can boil down to a single-shot game – especially if the industry is in decline. Finally, the results also differ depending on whether unions bargain for wages only or for wages and employment at the same time. If the latter is the case, stronger unions may be conducive to higher innovation.

The existing literature tends to report a positive effect from innovation into income growth. This is in line with both exogenous and endogenous growth theories, where technology is a source of total factor productivity and income growth. However, innovation may also depend on the level of per-capita income. As Clarke (2001) has indicated, wealthier countries tend to have higher levels of human capital and this may have a positive effect on economic agents' willingness to invest in innovation. Secondly, higher levels of income may lead to demand-induced innovation as higher average incomes increases the demand for novel products. Third, Taskin and Zaim (1997) report that countries with low initial per-capita GDP levels catch up at a faster rate while countries with relatively high income depend more on technological progress for their productivity increases. Hence, higher per-capita income may be associated with higher levels of investment in innovation. Finally, and from an empirical perspective, per-capita GDP might capture other sources of innovation and as such it can help control for omitted variables.

Access to capital might also affect firms' ability to finance innovation. The moral hazard and adverse selection problems associated with debt finance in general and debt-financing of innovation in particular are well known (Stiglitz and Weiss, 1981). In addition, debt financing may be costly for another reason: the collateral value of intangible assets such as patents is low and innovative firms may have to provide extra collateral. Hence, equity issue emerges as an alternative method of financing innovation. Indeed, Brown et al (2009) report that equity finance has become a significant source of financing R&D investments in the 1990s by young firms. In this paper, we will investigate whether stock market turnover (i.e., the value of traded stocks) as a percentage of GDP is related to innovation.

Military expenditures may have a positive effect on innovation for two reasons. On the one hand, there may be spill-over effects from government-financed innovation expenditures in the defence sector into R&D expenditures or patenting activity of private firms. On the other hand, there may be geographical spill-over effects, whereby the level of military expenditures may be associated with local/regional or international investment in innovation (Clarke, 2001). However, military expenditure may divert resources from innovation investment into the production of non-productive goods, leading to lower levels of innovation in non-defence sectors (Kentor and Kick, 2008).

Finally, economic openness (i.e., openness to trade, foreign direct investment and portfolio investment) may also be related to innovation. For example, Baldwin and Gu (2004) report that Canadian firms that moved into export markets increased investments in R&D and in capacity building aimed at absorbing foreign technologies. Similar finding is reported by Pla-Barber and Alegre (2007), who investigate 121 French biotechnology firms. The authors find that that firm size is not a determinant for innovation but export intensity is. At country level, however, the evidence is mixed. For example, Guloglu et al (2012) examines the relationship between technological change and a series of macroeconomic variables in G7 countries. The authors find no significant relationship between technological change and trade openness. Furthermore, when other indicators of openness are taken into account, economic openness tends to be negatively related to innovation. For example, Clarke (2001) reports a negative relationship between FDI and R&D expenditures and the negative correlation is robust to different model specifications. One possible reason is that FDI may be a substitute for investment in R&D. This is in contrast to frequent statements made by international organizations or national policy makers, who tend to emphasize the positive effects of globalization on innovation.[1]

The review above indicates that the work on the relationship between innovation and potential determinants has a long history, with majority of the work being focused on the relationship between market structure and innovation. A relatively smaller number of studies investigate the relationship between innovation and governance quality, income distribution, labour costs, depth of equity markets and the extent of economic openness. Even then, the existing work does not take account of how these potential predictors interact with market power and with what consequences for innovation.

The aim of this paper is to contribute to the existing work in three ways. First, we will try to establish if the non-linear relationship between market power and innovation that is established at the firm level also holds at the national level. To our knowledge, this is the first exercise in this direction. Secondly, we aim to expand the limited evidence base by investigating whether governance quality and market power have complementary or offsetting effects on innovation. Finally, we address the risk of model specification bias by controlling for a wide range of potential determinants, which include per-capita GDP, income distribution, labour costs, economic openness, military expenditures, and R&D expenditures as inputs into patenting activity. Extension of the research effort in these directions can support evidence-based policy debate by: (a) correcting for potential bias; (b) identifying the extent of complementary and offsetting effects from governance and market power; and (c) identifying the extent to which competition tends to drive or hinder innovation.[2]

METHODOLOGY AND DATA

We have collected data for 25 OECD countries from 1981-2008. The dataset is an unbalanced panel that allows estimation for 24 countries over 20 years from 1988-2007. For estimation, we use a Prais-Winsten estimator that takes into account panel heteroskedastacity,

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[1] For example, OECD (2007: 3) makes the following observation: "In addition to the rapid advances in scientific discovery and in general-purpose technologies such as ICTs and biotechnology, the accelerating pace of innovation is being driven by globalisation."

[2] The policy statements suggest that innovation is both a necessary condition for and an outcome of competitiveness at the same time. The concept of competitiveness is also quite fuzzy, implying either an ability to maintain market shares (i.e., absence of competition) or the existence of product-market competition. In addition, the policy statements suggests a linear relationship between competition (or competitiveness) and innovation – as it can be seen in OECD and EU policy documents.

panel autocorrelation, and contemporaneous correlation (HPAC) (See, Beck and Katz, 1995). Formally, the model to be estimated can be stated as follows:

$$Y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k X_{kit} + u_{it}. \qquad (1)$$

We assume that the error terms (u_{it}) are heteroskedastic, contemporaneously correlated and autoregressive (i.e, serially correlated). These assumptions can be stated as follows:

$$E(u_{it}^2) = \sigma_{ii} \quad \text{(heteroskedasticity)} \qquad (1.1)$$

$$E(u_{it}\, u_{jt}) = \sigma_{ij} \quad \text{(contemporaneous correlation)} \qquad (1.2); \text{ and}$$

$$u_{it} = \rho_i u_{i,t-1} + \varepsilon_{it} \quad \text{(country-specific serial correlation)} \qquad (1.3)$$

The model is estimated with a generalized least squares (GLS), using the Prais-Winsten estimator. The estimator is suitable for cross-sectional time-series data and allows for estimating coefficients with panel-corrected standard errors (PCSE). It also allows for error structures that are heteroskedastic and contemporaneously correlated across panels (Beck and Katz, 1995; Egger, 2002). The estimator is found to be efficient when the number of time period is close to the number of cases (countries) (Chen et al, 2009). Our dataset satisfies this condition with 24 countries and 20 years. In the estimation, we correct for first-order autocorrelation (AR(1)) that is specific to each panel (1.3). This specification is in line with methods typically used to estimate autocorrelation in time-series analysis.

The Prais-Winsten estimator with panel-corrected standard errors (PCSEs) yields standard errors that are robust to two types of violation of the standard OLS assumptions. First, the standard errors are robust to each country having a different variance of disturbances. Secondly, they are robust to each country's observations being correlated with those of other countries over time. The control for within-panel serial correlation is an additional feature that allows for assuming two types autocorrelation coefficients: a single coefficient that is common to all countries; and different autocorrelation coefficients that are specific to each country. This additional feature enables us to avoid the inefficient estimate problem that arises when the data follows an autoregressive process.

Model (1) can be populated with the relevant variables as follows:

$$Innov_{it} = \beta_0 + rent_{it-1} + rent\_sq_{it-1} + gov\_score_{it-1} + gov\_score\_rent_{it-1} + gini\_gross_{it-1} + lab\_share_{it-1} + pc\_gdp_{it-1} + milit\_\exp\_gdp_{it-1} + traded\_stocks\_gdp_{it-1} + ec\_global_{it-1} + TRIPS\_dummy_{it} + berd\_va_{it-1} + berd\_va_{it-2} + u_{it}$$

We use two measures of innovation as dependent variables: number of patents granted by USPTO (*patents_uspto*) and number of patents in triadic patent families (*triadic_patents*) registered with EPO, JPO and USPTO. We have chosen patents as measures of innovation because patents indicate the extent to which patent holders consider the innovation as 'new to the market' (OECD, 2005). Being new to the market does not provide a reliable indication of quality though. However, patent registration is a costly exercise and patent holders will be willing to incur the cost only if they expect benefits from patenting the innovation – i.e., if patents protect a process or a product that provides a competitive advantage in the market place. Because we cannot observe the extent to which this is the case, empirical studies at the firm-level tend to use citations-weighted patents as a measure of quality (see, for example, Aghion et al, 2002, 2005).

As citations data was not available to us, we have decided to use two measures of registered patents. *Patents_uspto* is the number of patents that innovators register with the USPTO. Compared to patents registered with national patent offices, *patents_uspto* provides slightly better information about patent quality. This is because of extra cost associated with multiple registrations. However, *patents-uspto* may be affected by home bias so far as the registration of US patents is concerned (on home bias, see OECD, 2006). To check whether this may affect the results and to enhance the information content of the measure with respect to quality, we also use *triadic_patents*. This measure reflects the number of patents registered within patent families at three major patenting offices – EPO, JPO and USPTO. Compared to patent filings with a single office, triadic patent families cover a homogeneous set of inventions. These are considered as the most important inventions, and the resultant indicator is less influenced by patent offices' rules, regulations, and patenting strategies. Consequently, 'counting triadic patent families provide indicators of an improved quality and international comparability for measuring innovation' (Dernis and Khan, 2004). The patent count data is obtained from OECD's MSTI database. From the same source, we have also obtained data for business R&D expenditures as percentage of value added (*berd_va*), which is used as input into the innovation process. *Berd_va* is financed mainly by industry, but it also includes government subsidies.

The *rent* variable is calculated as the ratio of value-added to the total cost of capital and labour, in accordance with (3) below.

$$rent_{it} = VA_{it}/(CK_{it} + CL_{it}) \qquad (3)$$

VA = Gross value added at current prices, excluding the output of indirectly-measured financial intermediation services. As indicated in paragraph 8.14 of ESA (1995), financial intermediation services indirectly measured (FISIM) are not allocated to user sectors. Hence the value of the output of FISIM is treated as intermediate consumption of a nominal sector with zero output and negative value added equal in size but opposite in sign to intermediate consumption.'

CK = Cost of capital. The cost of capital is not provided in national accounts. We have calculated it by multiplying the net capital stock by US interest rates adjusted for country risk (see below).

CL = Cost of labour. This is the compensation of employees item in national accounts. Compensation of employees consists of wages and salaries and employers' social contributions.

Thus defined, the *rent* variable measures the average rate of profits retained by owners of capital (or employers). It is used as such by Griffith et al (2006a, 2006b). The measure is similar to the price-cost margin (or Lerner Index) calculated at the firm or industry level. As a measure of market power, it is better than country-level concentration indices such as a macro-level Herfindahl-Hirschman index (HHI). Macro-level HHI provides inadequate information about market power because the definition of the market over which the concentration index is calculated is imperfect (see, Aghion et al, 2002, 2005).

However, the market power index also has some shortcomings. First, it is based on the assumption of constant returns to scale (or the unobservable marginal cost is proxied by average costs). Therefore, it will underestimate (overestimate) the level of profit mark-up if there is increasing (decreasing) returns to scale (Griffith et al, 2006a, 2006b). Secondly, the cost of capital is not directly observable and has to be calculated by making assumptions about the appropriate interest rates. Griffith et al (2006a, 2006b) use long-term US interest rates as a proxy, assuming full capital mobility and a single world interest rate. They also conduct sensitivity check by using national interest rates and found that the results are not sensitive to different ways of constructing the cost of capital.

In this paper, we use long-term US interest for lending to the private sector and adjust them for other countries by taking into account each country's composite risk rating (CRR) compiled by ICRG. The higher the value of the CRR, the more risky the country is. Subtracting the US CRR from each country's CRR, we have obtained relative CRR (*CRR_relative*) for each country/year. Using *CRR_relative*, we have adjusted the interest rate for each country/year upward if the country's CRR in that year is higher than the US CRR. We also carry out sensitivity check to see if results differ when US interest rates are used as world interest rates for calculating the cost of capital. The adjustment is carried out in accordance with the following procedure:

- If *CRR_relative* = 0 or MINUS, use US interest rates
- If *CRR_relative* = 0.1 to 2.0, use US interest rates + 1 percentage point. For example if US interest rates is 10%, use 11%
- If *CRR_relative* = 2.1 to 4.0, use US interest rates + 2 percentage points.
- If *CRR_relative* = 4.1 to 6.0, use US interest rates + 3 percentage points.
- If *CRR_relative* = 6.1 to 8.0, use US interest rates + 4 percentage points.
- If *CRR_relative* = 8.1 or more, use US interest rates + 5 percentage points.

We model the relationship between innovation and profit mark-ups (*rent*) as non-linear. Hence model (3) includes the square of the *rent* variable. This is in line with the firm-level work reviewed above.

The governance indicators are obtained from ICRG and they include the following: bureaucracy quality, control of corruption, investment profile, law and order, and government stability. The indicators range from 0 to 4 for bureaucratic quality; from 0 to 6 for control of corruption, democratic accountability and law and order; and form 0 to 12 for government stability and investment profile. The higher the value of the indicator the better is the governance quality.

These indicators measure perceptions of the respondents to ICRG surveys. As such, their use as a measure of governance (or institutional) quality is debated extensively in the literature (see Kurtz and Schrank, 2007; Kaufmann et al, 2007). The debate revolves around the issue of endogeneity and reverse causality. Because respondent's perceptions of governance are likely to be influenced by economic performance (e.g., growth rate or level of unemployment) of the country, governance scores may be measuring economic performance rather than governance quality *per se*. Hence, their use as predictors of economic performance creates endogeneity problems that lead to spurious results. This issue is addressed by using instrumental variable (IV) techniques or by using lagged values. In this paper, we examine the relationship between governance and patenting activity. Unlike growth or unemployment, the effect of patenting activities on perceptions is likely to be weak and hence the reverse causality problem is less severe in our case. To address the risk of any residual endogeneity, we use one-year lagged values of the governance indicators – and indeed all other covariates in equation (3).

Using the ICRG indicators, we have conducted principal component analysis (PCA) and constructed an aggregate governance score (*gov_score*). The *gov_score* is constructed by excluding components with eigenvalues of less than 1 – as recommended in the literature (see, for example, Jolliffe, 2002). In our estimation, we control for the partial effect of *gov_score* and for the effect of its interaction with the level of profit mark-ups through the interactive term *gov_score*rent*. The inclusion of an interaction term in models with quadratic terms (such as *rent_squared* here) is reported to provide more reliable estimates of the coefficients. Using both simulation data and a genuine dataset on parents' education and children's educational performance, Ganzach (1997) concludes as follows: if appropriate interaction terms are not included, then the estimated quadratic model may indicate concave relationship between the independent variables and the dependent variable, whereas the true relationship is, in fact, convex. Conversely, when quadratic terms are omitted despite being justified by theory or by the data structure, the omission causes the interaction terms to have complementary effects whereas the true effect is offsetting.

The income inequality measure (*gini_gross*) is obtained from the Standardized World Income Inequality Database (SWIID). *Gini_gross* is standardized using the United Nations University's World Income Inequality Database. Standardization is carried out by minimizing reliance on problematic assumptions in existing income inequality data and by using as much information as possible from proximate years within the same country (for details, see Solt, 2009). The SWIID data has been used in recent empirical research (see, Bergh and Nilsson, 2010; Mahutga et al, 2011). We control for *gini_gross* because it has been demonstrated that income inequality can influence innovation, but the direction of its effect can be either negative or positive (see literature review above).

Another factor we control for is the share of labour in national income (*lab_share*). We have obtained the labour share data from Rodriguez and Jayadev (2010). The authors report that both economy-wide and manufacturing industry labour shares have declined from 1980s in most countries. Their findings are robust to adjustments for self-employment and adjustments for unbalanced panel structure. They also report that declines in labour shares are driven by declines in intra-sector labour shares rather than movements in activity towards sectors with lower labour shares. We have used their data to establish if innovation is driven by considerations related to reducing labour costs. The aim here is to contribute to existing evidence, which tends to use union power as a proxy for labour costs.

OECD (2007) claims that globalization is a major driver of innovation. The logic in such arguments rests on a positive relationship between increased competition (i.e., reduced rents) and innovation. Although trade liberalization is usually found to have a positive effect on innovation, the evidence on the relationship between economic openness (including openness to trade, FDI and portfolio investment) is inconclusive. Hence, we use a measure of economic globalization constructed by Dreher (2006). The Economic Globalization Index is based on 'hard evidence' in the sense that it synthesizes data on actual economic flows (trade, FDI and portfolio investment flows) and data on restrictions. In our data set, the economic globalization index (*econ_global*) ranges from 34 to 98, with higher values indicating higher levels of economic openness.

Other factors we control for include per-capita GDP (*pc_gdp*), military expenditures as percentage of GDP (*milit_exp_gdp*), traded stock as percentage of GDP (*traded_stocks_gdp*) and lagged values of business R&D expenditures as percentage of value added (*berd_va*). The rationale for including per-capita GDP, value of traded stocks and military expenditures is discussed briefly in the literature review above. Further elaboration on the relevance of these predictors can be found in Clarke (2001). We will use the remainder of this section to say a few words about inclusion of the dummy variable (*trips_dummy*) and the business R&D expenditures as percentage of value added (*berd_va*).

The *trips_dummy* captures two important developments in 1994 that are likely to affect patenting activity: (a) the conclusion of the Paris Convention for Protection of Industrial Property and Patent Cooperation; and (b) the conclusion of Trade-Related Intellectual Property Rights (TRIPs) within the World Trade Organization (WTO). The inclusion of *trips_dummy* is justified for two reasons. First, the conclusion of the Paris convention has led to convergence in the criteria used for granting patents. Secondly, the TRIPs agreement has strengthened intellectual property rights and may have had a positive effect on registration of patents.

Pakes and Grillisches (1984) and Hall et al (1986) are first to study the lag structure in the relationship between R&D expenditures and patenting at the firm level. They control for contemporaneous R&D and its three lags and report that the relationship between R&D expenditures and patenting has a U-shape – with closest and furthest lags having large effects and intermediate lags with small effects. The empirical work that has followed tends to control for R&D expenditures not only as an input measure of innovation but also as predictor of innovation productivity. Therefore, we include lagged values of R&D in model (3), but we restrict the number of lags to two in order to reduce the risk of multicollinearity.

Our examination of the summary statistics by year and by country suggests that heteroskedastacity and serial correlation are likely to confound the estimation results. The patent counts for some countries (US, Japan, Germany and the UK) are much larger than the rest of the sample. To a less extent, this is the case for per-capita GDP too. Such differences in the magnitude of the variables are likely to cause the variance of the error terms to be heteroskedastic. The data also reveals an upward trend over time. This is evident with respect to patent counts, per-capita GDP, stock market turnover, and income inequality; and indicates risk of serial correlation. Therefore, the choice of Prais-Winsten estimator seems appropriate as it corrects for heteroskedasticity, serial correlation and contemporaneous correlation across countries.

Table 1: Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Log(patents_uspto)	610	6.23	2.52	0.69	12.39
Log(triadic_patents)	610	4.80	2.48	0.00	9.68
Rent	487	1.44	0.40	0.80	3.21
Rent_squared	487	2.24	1.50	0.63	10.29
Gov_score	608	0.04	1.60	-5.57	2.02
Gov_score*rent	487	0.31	2.87	-12.89	3.17
Gini_gross	636	42.88	5.64	26.09	61.69
Traded_stocks_gdp	593	62.59	55.73	0.19	479.74
Lab_share	580	51.82	9.29	0.00	73.64
Log(pc_gdp)	634	9.62	0.73	7.92	10.94
Milit_exp_gdp	622	1.87	0.99	0.00	5.79
Econ_global	624	73.72	13.69	38.53	98.69
Berd_va	508	1.53	1.06	0.01	5.35
Trips_dummy	640	0.70	0.46	0.00	1.00

Summary statistics of the variables are given in Table 1 above. The variables are measured in four different scales. Patents (*patents_uspto* and *triadic_patents*) are count variables, which are known to have a Poisson distribution with positive integer values and mean equal to variance. Hence, Poisson-distributed data is not suitable for OLS estimation. Instead, Poisson regression is recommended. However, for ease of interpretation, we have decided to take the natural logarithm of the patent data. The log of patent data is approximately normal and as such can be used for estimating model (3). The other variable in log is per-capita GDP (*pc_gdp*). The *rent* variable is a ratio; whereas *gini_gross, lab_share*, *traded_stocks_gdp, milit_exp_gdp* and *berd_va* are percentages. Two variables (*gov_score* and *econ_global*) are indices. *Gov_score* is computed using principal component analysis methodology but *econ_global* is taken as given and ranges between 38.53 and 98.69 in the dataset.

RESULTS

The results in Table 2 are based on data for the full sample of 24 countries from 1988-2007. They indicate that the majority of the covariates have a significant relationship with the number of patents. Moreover, the sign and significance of the relationship are consistent across two types of patents: patents granted by USPTO and triadic patents. This is a significant finding because it suggests that the number of triadic patents that reflects higher innovation quality is proportional to the number of registered patents across countries and over time.

Table 2: Predictors of patenting activity: 24 OECD countries

Dependent variable	Ln_patents_uspto (1)	Ln_triadic_patents (2)
L1.rent	-1.959***	-1.367**
	(0.536)	(0.614)
L1.rent_sq	0.676***	0.450**
	(0.176)	(0.185)
L1.gov_score	0.301**	0.243*
	(0.118)	(0.126)
*L1.gov_score*rent*	-0.235***	-0.162*
	(0.084)	(0.083)
L1.gini_gross	-0.024***	-0.029***
	(0.008)	(0.010)
L1.lab_share	0.019	0.034***
	(0.012)	(0.011)
L1.ln_pcgdp	3.025***	2.381***
	(0.293)	(0.211)
L1.miltexp_gdp	0.284***	0.435***
	(0.086)	(0.055)
L1.traded_stocks_gdp	0.003***	0.002*
	(0.001)	(0.001)
L1.econ_global	-0.041***	-0.044***
	(0.005)	(0.006)
L1.trips_dummy	0.313***	0.241**
	(0.099)	(0.102)
L1.berd_va	0.315	0.540**
	(0.192)	(0.237)
L2.berd_va	0.180	0.249
	(0.234)	(0.272)
Constant	-20.107***	-16.568***
	(2.821)	(1.968)
Observations	333	331
Number of countries	24	24

Number of coefficients	14	14
R-squared	0.96	0.946
Chi^2	769.243	1408.934
Model degrees of freedom	13	13
$P>Chi^2$	0.000	0.000

Estimates are based on Prais-Winsten regression with heteroskedastic panels, panel-specific AR(1) autocorrelation and contemporaneously correlated panel disturbances.

The results also indicate that patenting activity has a *U-shaped* relationship with the level of profit mark-ups (*rent*). When the profit mark-up increases by one decimal point (for example from 1.4 to 1.5 as a proportion of total cost), the number of patents registered with USPTO decreases by 19.59 per cent. The decrease in the number of triadic patents is 13.67 per cent. However, the decrease is non-monotonic. The positive and significant coefficient of *rent_squared* indicates that the number of patents decreases at lower rates until *rent* reaches the turning point of the parabolic curve. From that level, the number of patents begins to increase at a non-monotonic rate. This result is in line with findings obtained with firm-level data (Aghion et al, 2002, 2005; Berubé et al, 2012; and Polder and Veldhuizen, 2012). The *U-shaped* relationship we find here is based on market power rather than competition and therefore it is the mirror image of the *inverted-U* relationship found in the firm-level literature that investigates the relationship between competition and innovation.

The turning point for rent can be calculated easily by taking the partial derivative of the models with respect to rent and setting equal to zero. The terms with rent are as follows:

$$ln\_patents\_uspto = -1.959rent + 0.676rent^2 - 0.235rent * gov\_score \quad (4a)$$
$$ln\_triadic\_patents = -1.367rent + 0.45rent^2 - 0.162rent * gov\_score \quad (4b)$$

Differentiating with respect to rent:

$$\partial(ln\_patents\_uspto)/\partial(rent) = -1.959 + 1.352rent - 0.235gov\_score = 0 \quad (4a')$$
$$\partial(ln\_triadic\_patents)/\partial(rent) = -1.367 + 0.90rent - 0.162gov\_score = 0 \quad (4b')$$

The turning point for rent depends on governance score. Taking the sample average of the governance score (which is 0.04), the turning points can be calculated as follows:

For USPTO-granted patents, *rent* = 1.97/1.352 = 1.46 (4a'')
For Triadic patents, *rent* = 1.373/0.9 = 1.53 (4b'')

These values are close to the average level of rent in the sample (1.44) and enable us to conclude that an increase in *rent* leads to a fall in patenting activity when the initial level of rent is approximately less than the sample average; however a unit increase in rent leads to an increase in patenting activity when the initial level of rent is higher than average.

The governance coefficient is positive and significant and can be interpreted in the same way: a one-decimal-point increase in governance score is associated with an increase of 3.01 per cent in the number of patents registered with USPTO and an increase of 2.43 per cent in the number of triadic patents. This finding is in line with earlier findings on the governance-innovation relationship reported by Clarke (2001), Giménez and Sanaú (2007), Dakhli and de Clercq (2004), and Tebaldi and Elmslie (2013). The difference form earlier findings is that our result is based on an aggregate score that captures six dimensions of governance quality: bureaucracy quality, control of corruption, democratic accountability, investment profile, law and order and political stability. As such, it does not indicate which dimension is the most influential but it does provide evidence that overall governance quality matters. To our knowledge, this is the first estimate of the relationship between overall governance quality and patenting activity.

More importantly, however, we also find a negative and significant relationship between the interaction term (*gov_score*rent*) and patenting activity. Given the positive coefficient on governance, this finding indicates that rent has an offsetting effect on the relationship between governance and patenting activity. This can be seen easily by calculating the marginal effects of governance, taking into account the interaction between rent and governance. The marginal effects of the governance score and the rent are given in panels A and B of Table 4 below.

Table 3: Marginal effects

Panel A: Marginal effect of governance	Rent: complementary or offsetting?
$\frac{\partial ln\_patents\_uspto}{\partial gov\_score} = 0.301 - 0.235 rent$	Offsetting
$\frac{\partial ln\_triadic\_patents}{\partial gov\_score} = 0.243 - 0.162 rent$	Offsetting

Panel B: Marginal effect of rent	Governance: complementary or offsetting?
$\frac{\partial ln\_patents\_uspto}{\partial rent} = -1.959 + 1.352 rent - 0.235 gov\_score$	Complementary until rent = 1.46; offsetting thereafter
$\frac{\partial ln\_triadic\_patents}{\partial rent} == -1.367 + 0.90 rent - 0.162 gov\_score$	Complementary until rent = 1.53; offsetting thereafter

From summary statistics, rent has an average of 1.44 and ranges from 0.80 to 3.21. In other words, rent is always positive. Hence, the marginal effect indicates that rent always has an *offsetting* effect on the relationship between governance and innovation (Panel A of Table 3). To our knowledge, this is the first finding that establishes not only a positive partial effect from governance to innovation but also an offsetting (substitution) effect from rent when the latter is interacted with governance quality. This finding indicates that the partial effect of governance usually reported in the existing literature can be misleading because the true *marginal effect of governance* on innovation depends on market power, which has an offsetting effect on the relationship between governance and innovation.

The *marginal effect of market power* on innovation depends both on the level of rent and the governance score (Panel B of Table 3). From (4a'') and (4b'') above, the relationship between rent and innovation is positive until the rent values that correspond to the turning points and negative thereafter. Hence, an increase in governance score tends to *complement* the negative effect of the rent on governance until the turning points; but it tends to *offset* it thereafter. Again, to our knowledge, this is the first finding that establishes not only a non-linear relationship between rent (i.e., market power) and innovation at the macro levels, but also both complementary and offsetting effects that augment or weaken the relationship between market power and innovation. This finding also indicates that the partial effect of market power on innovation reported in Griffith et al (2006a, 2006b) can be misleading because the true *marginal effect* of market power on innovation is non-monotonic.

The results in Table 2 indicates that relationship between income inequality and innovation is negative and significant: one percentage point increase in the *gini* index is associated with a decrease of 2.4 and 2.9 per cent in the number of patents registered with USPTO and the number of triadic patents, respectively. This is in contrast to empirical findings reported by Foellmi and Zweimuller (2006) and Tselios (2011); but in line with Weinhold and Nair-Reichert (2009). We think that our finding is driven by the characteristics of the sample. Recall that the sample consists of OECD countries with an average per-capita GDP of 21,703 US dollars. The high level of per-capita GDP indicates that firms engage in innovation to cater not only for the preferences of the high-income groups but also the average-income groups who have a substantial purchasing power. Hence, our finding lends support to Weinhold and Nair-Reichert (2009) who report that innovation is related positively to size of the middle class in a sample of 53 countries from 1994-2000. Furthermore, the negative relationship between income inequality and patenting activity is compatible with the finding of positive relationship between governance quality and patenting activity. Higher levels of income inequality may be reflecting relatively poorer governance quality.

As indicated in the literature review, the cost of labour is another factor that may affect innovation. The results in Table 2 indicate that labour share has a positive and significant relationship with innovation only in the case of triadic patents. This finding is in line with Altman (2009) whose behavioural-institutional model predicts that higher labour costs induce firms to innovate to remain competitive or to maintain current profit rates. However, the finding is in contrast to the US-based empirical results reviewed in Menezes-Filho and Van Reenen (2005), which tend to report a negative relationship between union power and innovation.

Due to space limitations, we are unable to elaborate on the findings concerning the effects of per-capita GDP, military expenditures and stock market turnover as percentage of GDP. Suffice it to say that the results are in line with the existing literature. A similar comment can be made about the effect of lagged business R&D expenditures: the coefficient on the first lag of berd_va is always positive, but significant only with respect to triadic patents. Hence, we are unable to verify the existence or absence of the lag structure identified by Pakes and Grillisches (1984) and Hall et al (1986). However, we can report that frequent claims about globalization as a driver of innovation (e.g., OECD, 2007) are not supported by the OECD data: the index of economic globalization is related negatively to the number of patents registered with USPTO and triadic patents.

We have conducted three sensitivity checks to verify the robustness the results in Table 2. First, we have estimated the model by normalizing the standard errors of the coefficients by N - k (N is number of observation and k is the number of estimated coefficients) instead of N. Secondly, we used unadjusted US interest rates instead of adjusted interest rates for calculating the cost of capital. In both cases, the results remain consistent with those reported in Table 2.[3]

The third sensitivity check involved splitting the sample into two: countries with higher than sample average for per-capita GDP, governance score and economic globalization against those with lower than average in each year. The results from the split sample of higher-than-average countries are given in Table 4 below.

The signs of the coefficients in the split sample are largely in line with those obtained with the full sample – with the notable exception of the *rent* variable and its square. The coefficients on governance score (*gov_score*) and the interaction term (*gov_score*rent*) have the same sign as the full sample, but the magnitudes in the split sample are larger. Hence, it can be concluded that governance tends to have stronger effects on innovation when countries are wealthier, more open and have higher-than-average governance scores. This finding indicates governance quality is not subject to diminishing returns with respect to its effects on innovation: better governance is good for innovation and it matters even more when countries have higher-than-average governance scores.

Table 3: Predictors of patenting activity: Split samples

Dependent variable (log)	USPTO_Patents *(pc_gdp > mean pc_gdp)*	Triadic_patents *(pc_gdp > mean pc_gdp)*	USPTO_Patents *(gov_score > mean gov_score)*	Triadic_patents *(gov_score > mean gov_score)*	USPTO_Patents *(econ_global > mean ec_global)*
Regressors	(1)	(2)	(3)	(4)	(5)[++]
L1.rent	5.743***	2.158	7.517***	1.107	4.185***
	(1.818)	(1.715)	(1.971)	(2.040)	(1.588)
L1.rent_sq	-2.440***	-1.008	-2.783***	-0.397	-1.904***
	(0.706)	(0.635)	(0.784)	(0.786)	(0.525)
L1.gov_score	0.454***	0.107	1.312***	0.995**	0.506*
	(0.155)	(0.136)	(0.374)	(0.442)	(0.307)
*L1.gov_score*rent*	-0.476***	-0.221**	-1.266***	-0.985***	-0.579**
	(0.119)	(0.103)	(0.293)	(0.336)	(0.248)

[3] The results are not reported here, but they can be provided on request.

L1.gini_gross	-0.010	-0.014	-0.026**	-0.053***	-0.023*
	(0.009)	(0.010)	(0.011)	(0.011)	(0.013)
L1.lab_share	-0.021*	-0.022*	-0.002	0.018	-0.005
	(0.011)	(0.012)	(0.014)	(0.013)	(0.016)
L1.ln_pcgdp	2.485***	1.224***	2.506***	1.565***	2.251***
	(0.470)	(0.385)	(0.434)	(0.386)	(0.514)
L1.miltexp_gdp	0.576***	0.562***	0.521***	0.537***	0.630***
	(0.068)	(0.057)	(0.085)	(0.076)	(0.053)
L1.traded_stocks_gdp	0.004***	0.002**	0.006***	0.004***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
L1.econ_global	-0.053***	-0.052***	-0.068***	-0.058***	-0.024**
	(0.006)	(0.005)	(0.005)	(0.006)	(0.010)
L1.trips_dummy	0.225*	0.278**	0.353***	0.420***	0.308***
	(0.117)	(0.113)	(0.095)	(0.112)	(0.105)
L1.berd_va	0.249	0.509**	0.225	0.327	0.216
	(0.159)	(0.203)	(0.197)	(0.230)	(0.199)
L2.berd_va	0.346**	0.254	0.351*	0.271	0.250
	(0.174)	(0.199)	(0.207)	(0.219)	(0.190)
Constant	-17.399***	-4.050	-18.173***	-6.905	-16.493***
	(5.089)	(4.313)	(4.731)	(4.286)	(4.185)
Observations	252	252	216	216	178
Number of countries	18	18	20	20	17
Number of coeff.	14	14	14	14	14
R-squared	0.968	0.961	0.981	0.966	0.981
Chi^2	372.075	464.009	1018.880	560.996	374.668
Model d.f.	13	13	13	13	8
$P>Chi^2$	13	13	13	13	13
Constant	0.00	0.00	0.00	0.00	0.00

Estimates are based on Prais-Winsten regression with heteroskedastic panels, panel-specific AR(1) autocorrelation and contemporaneously correlated panel disturbances.
++ : The sixth model with triadic patents and countries with economic globalisation index higher than average could not be estimated as the variance matrix turned out to be non-symmetric.

The coefficients on the interaction term (*gov_score*rent*) also have the same sign as the full sample: they range from -0.22 to -1.27 and are significant in all models. Yet, their magnitudes are larger when compared to -0.16 and -0.24 in the full sample. Hence, it can be concluded that rent tends to have a stronger offsetting effect on innovation when interacted with governance in wealthier, more open and better-governance countries.

The coefficients on rent are significant only when we estimate the model with USPTO-granted patents, even though there is sign consistency between USPTO-registered and triadic patents. Moreover, the signs of the coefficients are opposite to the signs obtained with full sample. Focusing on USPTO-registered patents only, the results indicate that the relationship between market power and patenting activity has an *inverted-U* shape rather than *U-shape* when countries are characterized by higher-than-average per-capita GDP, governance scores and economic openness. Hence, higher market power is associated with higher (lower) levels of innovation when the initial level of market power is low (high). This is just the opposite of the finding with respect to full sample.

The turning points of the concave parabola take place at rent = 1.19 when the sample is split on the basis per-capita GDP; 1.36 when the split is based on governance scores; and 1.11 when it is based on economic openness. These values are lower than the average rent value in the full sample, which is 1.44. They are also lower than the average values of the rent for the split samples, which are 1.36, 1.38 and 1.33 respectively. Hence, we can conclude that market power drives innovation initially but begins to be detrimental for innovation relatively sooner when countries are characterised by higher-than-average per-capita GDP, governance scores and economic openness.

The *inverted-U* shape of the relationship between market power and innovation in the split samples contradicts the findings of Aghion et al (2002, 2005) at firm level and those reported by Griffith et al (2006a, 2006b) at sector levels across EU countries. We explain the difference as follows: the potential threat of entry is higher when countries have higher-than-average per-capita GDP, governance scores and economic openness. This is because higher-than-average per-capita GDP indicates deep markets and encourages new comers with low initial profits to contest the market through drastic innovation. Similarly, higher-than-average governance quality provides better protection of property rights and induces new entrants with drastic or neck-and-neck innovations. Finally, higher levels of economic openness erode profits and induce drastic innovation as a means of escaping competition. However, the average levels of rent in relatively richer and more open countries with higher-than-average governance scores the levels of rents (1.36, 1.38 and 1.33, respectively) are lower than the average for the full sample (1.44). Stated differently, the level of competition in these countries is higher than the sample average and therefore an increase in market power is necessary to convert the potential threat of entry into actual entry based on investment in innovation. Hence, we can conclude that the Schumpeterian hypothesis that innovation is driven by market power is more likely to hold when countries are relatively richer, more open to international competition and have better governance institutions.

The relationship between income inequality and innovation has the same sign as the full sample, but the relationship is significant only in countries with higher-than-average governance and economic openness scores. The relationship between labour share and innovation, however, has the opposite sign compared to full sample; but the negative relationship is significant only in countries with higher-than-average per-capita GDP. Economic openness is related negatively to innovation across models and both in full and split samples.

The TRIPS dummy is positive in both full and split samples and across estimations. However, it is also important to note that the coefficient on the dummy variable is larger when estimation in the split sample and especially when the dependent variables is triadic patents. This finding indicates that countries tend to register relatively larger number of triadic patents after the conclusion of the Paris Convention and of the TRIPS agreement within WTO. It appears that better protection of intellectual property rights has induced countries to increase the number of better-value patents. This can be explained by better scope for making claims against infringement after the conclusion of the Paris Convention and the TRIPs agreement.

Two interesting findings relate to effects of stock market turnover and military expenditures as percentage of GDP. The size of the stock market is positively related to patenting activity in full and split sample, but the relationship is stronger in the split samples. This finding indicates that the stock market could be a more important source of finance for innovation in wealthier, more open and better-governance countries. Similarly, military expenditures also tend to have a stronger positive effect on patenting activity in countries with higher-than-average per-capita GDP, economic openness and governance scores.

Finally, we have found positive but partial evidence between lagged R&D expenditures and patenting activity. However neither the lag structure nor its significance is stable across samples and between USPTO-granted and triadic patents.

CONCLUSIONS

The analysis above indicates that patenting activity in OECD countries from 1988-2007 is related to a range of country characteristics, which include governance quality, profit mark-ups, income distribution, labour share in national income, per-capita GDP, size of the stock market, and economic openness. With the exception of market power, the sign of the relationship between the explanatory variables and patenting activity is consistent between the full sample and the split samples based on higher-than-average levels of per-capita GDP, openness and governance quality. Hence, we can conclude that the number of USPTO-registered and triadic patents is positively related to governance quality, per-capita GDP, size of the stock market relative to GDP, military expenditures as percentage of GDP, and TRIPs dummy. The positive relationship between these explanatory variables and patenting activity is stronger in countries with higher-than-average per-capita GDP, economic openness and governance scores.

The relationship between economic openness and innovation is consistently negative across samples and patent types. Similarly, the relationship between income inequality and patenting activity is also negative; but it is significant for both patent types only in the full sample and in some of the split samples.

We have also found that the relationship between market power and patenting activity is non-linear. The relationship has a *U-shape* in the full sample but an *inverted-U* shape in countries with higher-than-average per-capita GDP, economic openness and governance scores. This finding strengthens the case for non-linear modeling of the competition-innovation relationship. However, it also indicates that it is necessary to check whether the relationship is convex or concave to the origin. In this study, we have found that the relationship is convex to the origin in the full sample but it is concave in countries with higher-than-average per-capita GDP, economic openness and governance scores. The difference is due to higher levels of entry threat in these countries, which have average rent levels that are lower than the full-sample average.

In full and split samples market power has an offsetting effect on patenting activity when it is interacted with governance; and the offsetting effect is stronger in countries with higher-than-average per-capita GDP, economic openness and governance scores. The stronger offsetting effect, coupled with stronger and positive partial effects, suggest that rents are the main driver of patenting activity in countries with higher-than-average per-capita GDP, economic openness and governance scores.

These findings suggest that partial-effect estimates of the relationship between governance and innovation and/or between competition and innovation are likely to be subject to model misspecification bias. In addition, they suggest that the innovation rhetoric in national and international policy debate tends to rely on short cuts and as such may be misleading. The OECD sample does not provide evidence to support the assertions that competition and openness are drivers of innovation – either in the full sample or in split samples. In the full sample, the relationship between competition and innovation is positive only when the initial levels of market power are low. In split samples, the competition-innovation relationship is positive only when the initial level of market power is high. Furthermore, openness is negatively related to innovation in both full and split samples.

Our findings also suggest that better governance is associated with higher patenting activity in full and split samples; and the positive relationship is stronger in countries with higher-than-average per-capita GDP, economic openness and governance scores. However, when interacted with rent, the latter tends to offset the positive effect of governance on innovation; and the offsetting effect is stronger in split samples. This finding suggests that governance is a significant driver of innovation in its own right, but its positive effects on innovation is mediated through market power.

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