Innovation, Inequality and Intellectual Property Rights

Diana Weinhold[Δ♣]
London School of Economics

and

Usha Nair-Reichert
Georgia Institute of Technology

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Abstract: The existing literature on intellectual property rights (IPRs) and innovation has largely neglected to consider whether the distribution of income could play a causal role in determining cross country differences in patenting. However, in their research on the sources of productivity growth during early U.S. industrialization, Sokoloff and others have identified the combination of IPRs with a large middle class and broad participation in markets as explanations for the extraordinary level and growth of innovation. This paper considers whether these factors could play a role in the contemporaneous evolution of innovation in a broad cross section of countries today. Our results indicate that IPRs and the size of the middle class help explain patterns of resident, but not non-resident patenting. Overall, the evidence suggests that non-resident patenting patterns are driven more by exogenous factors and global integration, while "home grown" innovation is more sensitive to internal structural and institutional factors.

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[♣] Correspondence to: Diana Weinhold, Development Studies Institute, London School of Economics, Houghton Street, London WC2A 2AE, United Kingdom. Email: d.weinhold@lse.ac.uk

1. Introduction

To the extent that economic progress is driven by innovation, a good understanding of what drives individuals and firms to invent new products and technologies is critical to explaining growth and development. In fact there is a broad literature employing economic theory and empirical analysis to ask questions about the relationships between innovation, market structure, and policies such as intellectual property rights (IPRs), usually at the level of the firm or industry, or (occasionally) across countries (for a good review see Dixon and Greenhalgh (2002).

There has been some work on the relationship between income inequality and innovation, but much of this literature primarily deals with the effects of technological change on wage inequality within an economy (see for example Mendez (2002), Aghion(2002), Acemoglu(2000), Huw (1999)). Relatively fewer studies examine the reverse relationship of the effect of population-wide inequality on innovation, although there is a fair amount of literature that looks at the market structure (i.e. concentration) of industry and its relation to innovation[1].

However a number of compelling arguments for the importance of population-wide income inequality (as opposed to industry structure) for innovation come from two main sources, namely the literature on the economic history of early U.S. industrialization and the literature on the impact of institutional quality on long run growth. In the former (see for example Sokoloff (1988, 1992) and Sokoloff and Khan (1989)), a strong middle class plays a direct role in spurring domestic innovation via two primary mechanisms; via the demand for standardized manufactures and via the supply of large numbers of economically active adults in close proximity to markets. In the both the former and the latter literatures (pioneered by Acemoglu et al. (2001)), inequality could play an indirect role via its effect on institutional quality, including (perhaps) intellectual property rights.

[1] Some exceptions are Murphy, Shleifer, and Vishny (1989) who argue that innovation in production requires large markets, and they emphasize the role of the agricultural sector in generating necessary demand. Zweimuller(2002) develops a theoretical model of innovation in which inequality has a role through its impact on the structure of demand (unlike the standard Schumperterian growth model in which consumers have homothetic preferences).

While the existence of a broad middle class plays a central role in the Sokoloff story of historical U.S. innovation, to these authors' knowledge the possibility that inequality could play a role in the international evolution of innovation today has not been examined. This paper thus considers both role of a broad middle class in addition to effective institutions (primarily IPRs) in spurring domestic innovation in a contemporary cross section of countries. In the process, we recognize that IPRs regimes, inequality, growth and innovation are likely endogenous (see, for example, Sutton (1998), Acemoglu et al (2002)), and address this possibility directly by using an instrumental variables estimation strategy. Thus the contribution of this paper is two-fold. Firstly we introduce income inequality as a determinant of domestic innovation in a cross country context; and second we explicitly address the possibility of endogeneity of IPRs, inequality, growth and innovation in our empirical specification.

The paper proceeds as follows. In section 2 we briefly review the literature on the role of inequality on early U.S. industrialization and the evolution of institutions. In section 3 we describe our data and outline the basic econometric method. Section 4 discusses the results and section 5 concludes. Results and figures and a list of countries appear in Appendix A.

2. Brief Literature Review

To date most economic studies of modern innovation have focussed on the role of IPRs, with little direct attention give the role of income inequality. However there is both direct and indirect evidence from other literatures that inequality might be a factor explaining differential innovative activity across countries. This evidence can broadly be categorized into (a) evidence of income distribution's direct effect on innovation via both demand and supply side effects; and (b) evidence of an indirect effect via the relationship between inequality and institutional quality. The most direct evidence comes from the study of early US industrialization, while more indirect evidence comes from a new but growing literature on the causal linkages between institutional quality and growth.

Finally, all three of these literatures, on IPRs and innovation, on early US growth and on the role of institutions emphasize the endogenous nature of institutional evolution, income growth and innovation.

The literature on early US industrialization suggests relative income equality could effect innovation via several channels. From the demand side, Sokoloff and Khan (2000) and Engerman and Sokoloff (1997) argue that the presence of a large middle class helped spur innovation via their high demand for relatively inexpensive, mass produced manufactured goods. While low income people could not afford much non-essential consumption and high income individuals tended to demand customized products and services, the middle classes were oriented towards more standardized manufactures. In some sense this is a similar argument to the demand structure story of Zweimuller (2002), but more nuanced with a focus on the incentives for innovation spawned by standardization. Sokoloff argues that much of the most fundamental advances in technology during the nineteenth century were concerned with the production of standardized manufacturing products.

On the supply side there are two channels through which a large middle class could matter for innovation. Sokoloff and Khan (1990, 2000) note that innovative activities in the US were widely dispersed across a population with a high degree of market participation. They cite evidence from US agriculture and manufacturing that suggest this broad based market activity in turn led to wide participation in the patenting of advances, based largely on incremental improvements on older technologies and organizations. They comment on the "wide range of industries to which American inventors had made technological contributions, the extraordinary creativity displayed in lowering the costs of producing standardized goods, and the broad spectrum of the population involved in inventive activity." Sokoloff and Khan (2000 p. 2)

Finally, a large and economically active middle class also helped spur innovation via its impact on institutional evolution. Sokoloff (1988), Sokoloff and Khan (2000) and Kahn (2002) point out that mass economic and political participation led to early American

IPRs that were significantly different from the prevailing European institutions. In the U.S., patenting was much simpler, less expensive and available to a much broader spectrum of the population. Thus the combination of a broad middle class and high quality IPRs combined to provide the basis for unprecedented levels of innovation in early American industrialization; "this close relationship between access to markets and patenting is certainly consistent with the view that inventive activity was responsive to material incentives as well as to the availability and security of property rights in technology" (Sokoloff and Khan (2000) p.6)

Support for the idea that the presence of a broad middle class could play an indirect role in determining innovative activity has come from the theoretical and empirical literature on institutions and economic growth. Theoretical models linking income inequality to growth via its effect on the quality of institutions (albeit not explicitly IPR) include Benabou (2000), Persson & Tabellini (1994), and Alesina & Rodrik (1994). In addition, recent literature on the relationship between initial natural endowments, European settlement patterns and the subsequent evolution of both income inequality and quality of institutions has emphasized the close link of these factors and their importance in explaining income differentials across countries. In particular, Engerman and Sokoloff (1997, 2000) hypothesize that differing initial climactic and natural resource endowments lead to differences in the ability to establish European settlements as well as agricultural and extractive activities that differ in their ease of expropriation by political and economic elites. Areas that were naturally amenable to large-scale cash crops and/or extractive activities based on low-skilled slave or native labor also tended to have (for natural or political reasons) relatively low rates of European immigration.

Acemoglu et al. (2001) argues that these initial inequalities in wealth and human capital between the European elite and the working class were exacerbated by the evolution of institutions designed to protect the status of the upper class and facilitate the extraction of rents. In contrast, in areas where there was significant European settlement and agriculture was smaller scale and more focused on staple foods such as wheat, broader political participation resulted in institutions to support private property and check the power of the State.

The Engerman and Sokoloff and Acemoglu et al. studies all suggest that inequality is intimately linked with the evolution of institutions, which in turn is an important determinant of income. Easterly (2002) and Chong & Gradstein (2004) make this link more explicitly. Easterly (2002) uses instrumental variables to show that a broad middle share does have a positive effect on development, and that the mechanism through which this effect takes place is through the effect inequality has on institutions. Chong & Gradstein (2004) use granger causality analysis to empirically demonstrate dual causality between income distribution and a variety of institutional quality measures.

Thus the literature suggests that income inequality could effect innovation via its effect on demand for standardized manufactures, via the supply of savvy market participants, and via its effect on institutional quality (and especially of IPRs). At the same time, however, a highly innovative community (for whatever reason) might in turn demand higher quality IPR protection (see, for example, Sutton (1998)), might evolve in more economically egalitarian fashion than more centralized systems, and might grow faster (and thus be able to afford higher quality institutions and income redistribution). The possible endogeneity of these processes suggests we must take care in interpreting any observed empirical correlation.

3. Data and Methodology

In this paper we propose to examine whether inequality and IPRs can help to explain differential innovation rates across countries in the late 1990's. For a measure of innovation we use data on patents granted to resident and non-residents from 1994-2000 across a sample of 53 countries. This provides us with a measure of significant inventions that are new, and covers many countries over the time period in question. Patent count data have been criticized on the several grounds. Firstly, they measure the output of innovation rather than the process itself. However, this is true of all static measures of innovation that present snapshots at particular points in time in the creative process. Patent counts may also potentially be a downwardly biased measure of innovation: for example, firms may apply for patents only if they believe that the benefits of patent protection outweigh the costs, certain areas may not have adequate patent protection, inventions may be protected by other methods such as trade secrets etc. These issues can be quite significant at the firm level and may create heterogeneity in firm patenting behavior.

At the highly aggregated national level, however, it is perhaps more reasonable to hope that (resident) patenting will be correlated with inventive activity overall and thus provide an adequate proxy for country-wide innovation. Not only will the firm and industry-level heterogeneity be smoothed, but the fact that a substantial number of countries in our sample are signatories to the patent treaties suggests that the criteria for obtaining a patent are converging. Table 4 indicates which of the countries in the sample were signatories to the Paris Convention for Protection of Industrial Property and the Patent Cooperation in 1994 (for those that became so after 1994 the year of ascension is noted). Out of 53 countries only 11 remained outside the treaty during the sample period. We include a dummy variable for membership in the Paris treaty in 1994 in our analysis (which makes a significant difference only to the results regarding non-resident patents) and argue that although clearly imperfect, our relatively current measure of patent counts (averaged across 6 years) *is* likely to capture cross country differences in innovation. This was also the conclusion reached by Griliches (1995) who suggests that "… patents appear to be a good indicator… for inventive activity...[only] at a very aggregated level."

In any case, while we have in the back of our minds that our (resident) patent counts are a proxy for innovation (and throughout the remainder of the paper tend to use these terms interchangeably), it must be kept in mind that actually what we are examining are patents. We test whether strong IPRs have a positive effect on patenting, and whether this is a specific effect of IPRs or just a proxy for good institutions more generally. Since high rates of innovative activity could itself lead to better institutions, we assess the exogenous contribution of IPRs to patenting by instrumenting for IPRs using a set of structural and geographic instruments that are (arguably) exogenous, or at least more exogenous than institutions themselves.

If inequality effects patenting via its effects on institutional (IPRs) quality, then there should be no significant effect in a regression of patenting on inequality once we control for quality of IPRs. However as we have discussed, a greater middle class share could also have direct effects independent of IPRs both through the increase in market participants who might be inspired to innovate, as well as through demand structure effects. It is reasonable to expect that these latter two direct mechanisms would have differential effects on resident and non-resident innovative activity. In particular, if the channel is through increased market participation then we would expect an increase domestic innovation (i.e. resident patenting), but not necessarily non-resident innovation. On the other hand, if the channel is through the demand structure then there could be incentives for both resident and non-resident innovators to file patents domestically.

These particular underlying theoretical mechanisms through which inequality, institutions and innovation could be linked are deeply structural and historical; it would be surprising to find that year-on-year changes in inequality would have an impact on patenting rates, for example. In any case, there is substantial evidence that within-country inequality (and particularly middle class share) tends to be highly persistent over time (Deininger and Squire (1996), Quah (2001), Easterly (2002)), with some studies suggesting that this stability extends back as far as several hundred years in some cases (i.e. Lindert (2000), Lindert and Williamson (2001)).

Furthermore, although in theory IPRs can be adapted quickly over time, our data shows that in practice changes occur very slowly. Any IPR regime is necessarily embedded in the larger society and subject to influences of greater institutional quality issues such as rule of law and independence of the judiciary. In as much as there is significant path dependency in these broader institutional factors (as is strongly suggested by Acemoglu et al. and the literature cited above), it is not surprising that the year-by-year effects of changes in IPRs are difficult to detect at the macroeconomic level over a relatively short period of time.

Thus the approach we adopt here is to examine how variation in the level of inequality and IPRs can explain variation in levels of resident and non-resident patenting across countries. This has both advantages and disadvantages. One disadvantage, as with any cross sectional analyses, is that there is increased scope for omitted variable bias driving the results. Any country-specific factors that are correlated with our variables of interest and that are not explicitly controlled for in the regression could be a problem.

On the other hand, our primary research question asks whether exogenous differences in initial conditions across countries can, via their effects on inequality and institutions, explain differential rates of innovation (as proxied by patenting rates). In this sense, the cross sectional analysis is actually more closely aligned with our theoretical question than would be a panel or time series estimation. Furthermore, our instruments for institutional quality are based on exogenous geographic and historical characteristics of countries that do not change over time. Thus we are able to discern only the deeper underlying differences in institutional quality across countries but cannot explain variations in year-by-year changes within a given country. For these reasons we feel a cross section specification is not only necessary but also adequate for the purposes of this paper.

Drawing on the literature on innovation discussed above, our basic specification is a cross section regression that takes the general form:

$$Innovation_i = a + b_1 IPR_i + b_2 Inst\_Quality_i + b_3 Midclass_i + b_4 Log(GDP)_i + b_6 Log(Pop)_i + \sum_k b_k X_{ki} + e_i \quad (1)$$

Where our proxy for innovation is the natural log of the average number of resident and non-resident patents over the period 1994-2000 and X denotes a set of k control variables.

The index of IPR, or patent protection, is **patave90** is from Ginarte and Parks (1998) and is based on an analysis of national patent laws. The overall composite index ranges between zero and five with higher values signifying greater patent protection[2]. While this index captures a broader range of characteristics regarding the variability in patent protection across countries than a simpler dummy variable approach (for example see Ferrrantino (1993) and Maskus and Penubarti (1995)), it may still be subject to measurement error. Gaps between measured and actual levels of protection could result from slow enforcement, industrial targeting, trade policies, etc. As there is a lag time between innovation and patenting, and as an additional control on endogeneity, we use the index value from 1990.

For inequality we use a measure of middle class share (**midclass**) from Deinenger and Squire (1996). Both the analyses of Sokoloff and the work of Easterly suggest that middle class share is the most appropriate measure of inequality for our purposes.

Our measure of general institutional quality (**inst96**) is an index, the average of two other indices on regulatory quality and the rule of law from Kaufmann, Kraay and Mastruzzi (2003). These indices are increasingly common in the literature to measure institutional quality and we adopt their measures for the year 1996. In an earlier version of this paper we used a measure of risk of expropriation from La Porta et. al. that was used in the Acemoglu (2001) and subsequent papers. However the use of this previous variable limited our sample size considerably without providing any extra explanatory power.

We additionally control for a number of other variables that have been theoretically linked in the literature to patents. In particular we control for:

- Log of real GDP per capita in 1980 (**Lgdp80**): Much of the work of Acemoglu et al. concerns the role of institutional quality in explaining broad differences in income per capita across countries. By controlling for "initial" income differentials, then, we will

[2] It is obtained by aggregating across five categories reflecting country specific characteristics of IPRs, each of which takes values between zero and one. The five categories are: coverage; membership in international patent agreements; provisions regarding loss of protection; enforcement mechanisms; and duration of protection. The analysis by Ginarte and Parks indicates that the ranking of countries by this index is not sensitive to the weighting scheme used.

also control for much of the exogenous (and endogenous) variation in general institutional quality. This variable could arguably be considered endogenous itself, however, so we will instrument for it in the analysis. Source: World Development Indicators

- Log of total population in 1990 (**Lpop90**): note that if the coefficient on this variable is significantly greater than one it would suggest increasing returns in line with some endogenous growth theories. Source: World Development Indicators

- Log of average years of schooling of adult (25+ yrs) population from 1960 to 1990 (**Lschool**): Basic endogenous growth theory would predict that countries with greater human capital would innovate more. Also, educational outcomes could be considered to jointly evolve with institutional quality, and thus leaving this variable out might attribute to our institutional variables some effect that is more fundamentally a function of education. Source: Barro and Lee (1996)

- Share of population in urban areas in 1980 (**Urbsh80**): Urban share could be quite correlated with middle class share but operate on innovation in distinct ways. For example a highly urbanized population provides much cheaper transport costs to markets, which can have an effect on innovation independently from the effects of inequality discussed above. Again, in the broad scheme of things this variable might also be endogenous (although certain exogenous geographic and historical characteristics are also likely to play a large role). Source: World Development Indicators.

- Openness to trade (**Frankrom**): The literature on innovation and IPRs has stressed the role of openness in this relationship. In contrast to protected markets, under an open trade regime there is greater competition, and hence greater incentive to invest in R&D and innovate in order to remain competitive.[3] However, trade policy itself could be endogenous with innovation and hence we use a measure of "natural" openness from Frankel and Romer in which trade volumes are modeled in a gravity equation as functions only of exogenous population and geographic characteristics. Source: **Frankel** and **Romer** (1999)

- **Small** = Dummy for small country area
- **Oecd** = Dummy for country member of OECD pre-1993 (except Turkey)
- **Latam** = Dummy for Latin American country
- **Africa** = Dummy for African country
- **Tiger** = Dummy for East Asian "tiger" country
- **Paris** = Dummy for signatory to the Paris Convention for Protection of Industrial Property and the Patent Cooperation in 1994

Other variables that we use as instruments for the endogenous variables are:

[3] Krueger (1978), Bhagwati (1978), World Bank (1987), Edwards (1992).

- Distance from equator in degrees (**Latitude**)
- Dummy variable for British origin of legal system (**legor_uk**)
- Percentage of the population in 1980 in each country that are Protestant (**prot80**)
- Log of country area (**larea**)
- Population concentration (**Hhi**): Herfindahl index of concentration of the population.
- Dummy variable for landlocked country (**landlock**)

4. Discussion of Results

4a. Resident Patents

In table 1 we present our results estimating equation (1) for resident patents. Columns 1 and 2 present standard OLS regressions, while (3), (4) and (5) instrument for our four possibly endogenous variables: **Patave90, midclass, inst96** and **lgdp80**. Several things are worthy of note here. First, in regressions 1 and 2 our measure of IPRs (**patave90**) has the expected positive sign and is statistically significant (but could be endogenous). Figure 1 illustrates that this relationship is a general one in this sample and not driven by outliers or a small subset of countries. However, our measure of general institutional quality is not statistically significant and is even negative (illustrated again in Figure 5). In a previous version of this paper an alternative measure of general institutional quality (risk of expropriation used in Acemoglu et. al. (2001)) was also statistically insignificant. Thus we interpret this as a sign that the importance of IPR for innovation is not simply as a proxy for good overall institutional environment. Finally, as expected the level of initial wealth has strong explanatory power (but is probably endogenous), as is illustrated in Figure 2.

Perhaps most importantly for the purposes of this paper, middle class share (**midclass**) also has a positive and significant effect, even controlling for IPRs. Thus, this result taken at face value would suggest that inequality plays a direct role in explaining innovation and not just through its effects on institutions. Figure 3 illustrates that this also could be interpreted as a general relation in the sample and not the result of outliers, although the clustering in the center suggests that this result could be sensitive to sample selection[4] . In addition this could be due to endogeneity.

It is interesting to note in regression (1) that our variable for openness (**frankrom**) is not statistically significant, contrary to the expectations of the literature. Figure 4 illustrates that this is also a general outcome; there really is no discernable relationship between openness and patent rates in this sample. Finally, the coefficient on population is slightly greater than one (but this is not robust), while the schooling variable is also positive and significant. Membership (in 1994) in the Paris treaty is not significant, however. Nor is urban share, and nor are several of our regional dummies, so these insignificant variables are dropped in subsequent regressions to save degrees of freedom.

In regression (2) we drop the insignificant variables but the primary results remain robust. However, in all the regressions (1) and (2) there is a large potential endogeneity problem. As discussed above, we suspect possible endogeneity with our IPR measure, our inequality measure, our institutional quality measure and the level of GDP. To address this concern in regressions (3) and (4) we instrument for all of these variables using a set of arguably exogenous geographic variables such as latitude, area, landlocked, population concentration, English legal system, and protestant percentage. We take advantage of the fact that frankrom and several of our regional dummies were not significant in (1) to include these in our instrument set as well. We achieve respectable first stage R-squared measures (reported below table 1) and the instruments pass standard overidentifying chi-squared tests (also reported in table 1). Nevertheless the small sample size of 53 countries remains a problem for putting too much reliance on IVE as a form of estimation; we present these results as suggestive only.

In both the IVE regressions (3) and (4) our IPR variable is positive but has lost statistical significance (with a p-value of around .17). Whether this is due to a small sample size and poor instruments or by substantial reverse causality is impossible to say from this

[4] Indeed, in an earlier version of this paper when our sample was restricted to only 28 (mostly developing) countries by the inclusion of Acemoglu et al's colonial mortality and risk of expropriation variables, our

analysis alone, however the large theoretical and empirical literature on the effects of IPR on innovation suggest the first culprit is most likely. Another possibility is that the true causal effect of IPR is being usurped by our middle class share variable. In any case, the results suggest that further empirical work on the relationship between IPR and innovation should take the possibility of endogeneity seriously.

General institutional quality remains statistically insignificant in IVE regression (3), but perhaps our two institutional variables are collinear enough to be making it difficult to discern their independent effects. Thus in IVE regression (4) we drop our institutional quality variable, Inst96. Middle class share remains positive and highly significant. However the coefficient of the IPR variable hardly changes, nor does its level of significance.

Finally, in regression (5) we explore the possibility raised above that perhaps our IPR measure and middle class variable are highly correlated. This could be because there is not enough unique variation in the instrumental variables to clearly identify the two effects, and for whatever reason middle class share has come out the winner. In fact, when we drop middle class share our IPR variable once again becomes quite statistically significant and of a larger magnitude than before. However our instruments are not as good now, as the chi-squared tests fail to reject the over-identifying restrictions by a fairly meager magnitude. This likely reflects the findings from Easterly (2002) that middle class share is itself related to underlying geographic features, so those variables make less satisfactory instruments when middle class share is excluded. However it is a bit daring to speculate on this with so few observations; we again leave the results as suggestive.

Taking these results at face value suggests that the role income equality is playing is direct and causal. However, we cannot yet distinguish between the demand effects and supply effects described above. In summary, our analysis lends support to the idea that the role of the middle class is important determinants of domestic innovation, as proxied

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results on middle class share lost statistical significance by resident patents, in countries today. In particular, we find that inequality plays a direct role in explaining innovation and not just through its effects on institutions.

4b. Non-Resident Patents

We then consider both the role of a broad middle class as well as that of effective IPRs on non-resident patents. Much of the literature survey and discussion of underlying determinants of innovation and patenting apply primarily to domestic innovation and resident patents; we would not necessarily expect the same patterns to hold for non-resident patents (the reasons motivating foreigners to patent in a given country could be quite different from those we have discussed). If middle class share effects patenting via its effect on demand structure and returns to innovation, then it should influence non-resident patents as well as resident patents. However if the association has more to do with broad participation in economic life we would expect it only to be a factor influencing only resident patents. In addition, while we did not find openness to be significant in explaining domestic innovation, there are a number of reasons why it might play a larger role in explaining non-resident patents.

In table 2, column (6) we present an OLS regression explaining log of average non-resident patents and find that the drivers in this case are very different from those in the case of resident patents. In particular neither middle class share nor IPRs is significant in explaining non-resident patents. Neither schooling nor GDP per capita are significant. However, in direct contrast to the results for resident patents, in this case openness is positive and significant, as is being a signatory to the Paris treaty in 1994. Figure 6 illustrates that again the relationship between openness and non-resident patents is not driven by outliers. In fact, one might expect more naturally open countries to be more likely to sign the Paris treaty earlier and indeed when we drop the Paris variable, our openness variable becomes even more statistically significant (not reported). In sum, the variables providing the most explanatory power for non-resident patent rates across countries are openness, urban share of population, membership of the Paris treaty, and being an OECD or Asian Tiger country. This is consistent with the idea that foreign firms are patenting in countries in which they have investments or intend to invest in and which are more open to foreign trade and international IPR treaties.[5] Overall, the evidence suggests that non-resident patenting patterns are driven by relatively exogenous features and not by the kinds of internal, institutional factors that drive domestic innovation.

In regression (7) we re-estimate the equation using IVE, and this time drop the (insignificant) institutional quality and middle class variables to see if, as with resident patents, the significance of the IPR variable, patind90, will change. Even with IVE we find these variables are not statistically significant and the results basically mirror those from the OLS regression. Other IVE regressions suggest that these results are robust to a number of different specifications (not reported).

The finding that middle class share explains resident, but not non-resident patents, is interesting for several reasons. First, taken at face value it suggests that that the direct mechanism through which income equality effects innovation is via broad participation in markets and perhaps Furthermore, the results from table (2) suggest that the effects of middle class share and IPRs on resident patents from table 1 are not likely to be due to spurious correlation with country fixed effects. If we were simply picking up omitted variables associated with general high-patenting countries, then we might have expected to pick up the same effects when modeling non-resident patents. The fact that we find the middle class share having explanatory power in the case of resident patterns of patenting, but not non-resident patterns of patenting is reassuring and is consistent with a Sokoloff-type story of domestic innovation.

4c. Robustness checks: US patents filed by foreigners

In order to check the robustness of the results outlined above to alternative measures of innovation we turn to data on foreign patents filed in the U.S. This measure has some advantages and some disadvantages over the national patent data we used in 4a and 4b.

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[5] Some studies indicate that most FDI is disproportionately allocated to a few countries.

One advantage is that all patents are subjected to the same regulations and level of scrutiny, so individual country effects in that regard are no longer a factor. A potential disadvantage is that it measures only patents filed in the U.S. Insomuch as this procedure could vary in difficulty from country to country a new set of country-specific issues could be brought into play. Furthermore, this may not be as precise a measure of national innovation as it is a measure of global market-orientation. Finally, in using this measure we lose four observations from our data set (including the US). Nevertheless it makes for a reasonable robustness check on the primary findings.

The results are presented in table 3. In regression (8) we include all the regressors used in the previous analysis and find that apart from initial GDP, nothing is statistically significant. We then pare down the number of variables, omitting those with the lowest t-statistics. The result of this reduction process is presented in column (9). Although both take positive signs, neither of our institutional variables are significant. Middle class share is positive and marginally significant at 10%. We then explore whether our institutional measures could be capturing more or less the same thing, and drop our measure of general institutional quality. In regression (10), controlling only for IPR for institutions we find that IPR is now significant (albeit only at 10%) and now middle class share more convincingly so (at 5%).

Our attempts to explain foreign national patenting in the U.S. falls somewhere in between our regressions of resident patents and those of non-resident patents. Certain structural and institutional variables do seem to play more of a role determining patents filed in the US than determining non-resident patents, but less of a role than for explaining resident patents.

5. Conclusions and Discussion

This paper examined whether the presence of a well-developed middle class and effective IPRs are as relevant today as factors spurring domestic innovation across countries as they were during the early stages of industrialization in the U.S. While there has been a considerable literature reviewing the latter question from both theoretical and empirical perspectives, we have taken a slightly different approach from (to these authors' knowledge) other papers.

In particular, for the case of IPRs and innovation we are concerned whether the positive observed correlation between strong IPR's and innovation might be due to either endogeneity or omitted variable bias. In the first case it could be that particularly innovative countries (for whatever reason) have a bigger incentive to enact stronger IPRs. In the second case perhaps the correlation is simply picking up the effects of good quality institutions generally, of which IPR's are just one component. We address these concerns by both instrumenting for strength of IPR and controlling for general institutional quality. We find some evidence that exogenous variation in IPR has predictive power for innovation and thus at least some of the causality in that relationship runs from IPR's to innovation. However when we control for middle class share, the significance of this relationship is greatly reduced (p-value=.17), casting some doubt on our ability to adequately instrument for all these variables with such a small data set and so few uniquely varying instrumental variables. The results are thus suggestive and call for further empirical work to look into this relationship.

In the case of income distribution, this is the first paper to the authors' knowledge that empirically introduces middle class share as a possible explanatory factor in the variation in innovation across countries today. To date most, if not all, of the evidence that suggests inequality might play a role comes from primarily from US economic history and secondarily from the institutions and growth literature. These suggest that inequality could have an effect on innovation either indirectly via its effects on institutional quality (including IPRs) or directly via market participation and demand effects (the US historical story).

Thus while there are several plausible mechanisms through which inequality could be related to innovation, we would expect that the two more direct mechanisms (participation and structure of market demand) would have differential effects on resident and non-resident innovation and patenting activity. In particular, if the channel is through increased market participation, then we would expect this to increase domestic innovation, but not necessarily non-resident patenting. On the other hand, if the channel is through demand structure then there could be incentives for both resident and non-resident innovators to file patents domestically.

Our results indicate that the size of the middle class and, to some extent, IPRs explain resident patterns of patenting, but not non-resident patterns of patenting in a modern cross section of countries. These results are robust to controlling for quality of institutions and instrumenting for endogeneity. Thus our results are consistent with the general Sokoloff story from US economic history that income inequality is plays a direct role in domestic innovation via a broader market participation of the population. On the other hand, the evidence suggests that non-resident patenting patterns are driven by relatively exogenous features and degree of global integration rather than by the kinds of internal, institutional factors that drive domestic innovation.

The analysis is based on a basic cross country regression design and the sample of countries is inherently limited by the data available; certainly more research along these lines is necessary. Given these constraints, however, exploring the role of a broad middle class in spurring innovation, and carefully controlling for possible endogeneity in the relationships between growth, innovation, IPR institutions and income distribution seems to be a promising channel for future research.

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APPENDIX A

Table 1: Dependent Variable = Log of Average Resident Patents, 1994-2000
(robust *t*-statistics in parentheses)

	(1) OLS	(2) OLS	(3) IVE*	(4) IVE*	(5) IVE*
constant	-33.52	-33.097	-37.056	-34.158	-30.716
	(-9.38***)	(-10.3***)	(-8.24***)	(-10.02***)	(-9.21***)
patave90	0.749	0.856	0.753	0.400	1.080
	(2.61***)	(3.65***)	(1.38)	(1.32)	(3.91***)
inst96	-0.744	-0.586	-1.082		
	(-1.33)	(-1.27)	(-1.16)		
midclass	5.572	5.440	8.393	6.710	
	(2.16**)	(3.53***)	(4.35***)	(3.86***)	
lgdp80	1.484	1.601	2.064	1.783	1.392
	(3.88***)	(5.22***)	(4.77***)	(4.47***)	(3.18***)
lptot90	1.079	1.037	0.996	1.060	1.122
	(6.26***)	(9.59***)	(9.81***)	(9.58***)	(9.20***)
lschool	1.200	1.149	0.968	0.722	0.966
	(2.39**)	(3.09***)	(1.98**)	(1.68*)	(1.61)
urbsh80	.000				
	(0.03)				
frankrom	0.136				
	(0.47)				
oecd	0.436				
	(0.55)				
latam	.237				
	(0.47)				
africa	-1.219	-1.139	-0.809	-0.506	-1.496
	(-1.61)	(-1.74*)	(-0.96)	(-0.63)	(-3.32***)
tiger	1.619	1.373	1.791	1.558	.903
	(1.55)	(1.69*)	(2.26**)	(1.56)	(0.92)
paris	0.508				
	(1.26)				
No. Obs.	53	53	53	53	53
R-sq.	0.9203	0.9160	0.9081	0.9060	.8936
Sargan c^2 Over-id test			p= 0.6408	p=0.5850	p=0.1697

***Notes on IVE:**

- instruments: hhi, larea, latitude, legor_uk, prot80, frankrom, oecd, latam, urbsh80, landlock
- Endogenous Variables instrumented (1st stage R-sq from (3)): **patave90** (.7839), **inst96** (.8898), **midclass** (.6836), **lgdp80** (.9214)

Table 2: Dependent Variable = Log of Average Non-Resident Patents, 1994-2000
(robust *t*-statistics in parentheses)

	(6) OLS	(7) IVE
Constant	-19.031	-21.356
	(-4.83***)	(-4.27***)
patave90	-0.146	-.398
	(-0.68)	(-1.11)
inst96	-0.981	
	(-1.40)	
Midclass	-0.628	
	(-0.39)	
lgdp80	0.412	.718
	(0.89)	(1.26)
lptot90	0.999	1.05
	(7.17***)	(8.53***)
Lschool	0.730	.244
	(1.33)	(0.36)
urbsh80	0.038	.031
	(2.25**)	(1.94*)
Frankrom	0.599	.579
	(2.35**)	(2.64**)
Oecd	3.085	2.230
	(4.55***)	(3.95***)
Latam	-0.550	-.4529
	(-1.08)	(-0.87)
Africa	-0.137	.397
	(-0.24)	(0.56)
Tiger	2.306	2.026
	(4.48***)	(4.02***)
Paris	1.171	1.182
	(2.12**)	(2.08**)
No. Obs.	53	53
R-squared	.9442	.8959
Sargan Over-id		.7090

Table 3: Dependent Variable = Log of Average US patents filed by Foreigners, 1994-2000
(robust *t*-statistics in parentheses)

	(8) IVE	(9) IVE	(10) IVE
Constant	-32.370	-32.953	-36.82508
	(-2.88***)	(-6.87***)	(-9.15***)
patave90	0.706	0.640	0.942
	(0.36)	(1.12)	(1.76*)
inst96	1.717	1.041	
	(0.23)	(1.23)	
Midclass	14.171	10.821	13.745
	(0.45)	(1.86*)	(2.81***)
Lgdp80	1.646	1.495	1.877
	(2.42**)	(3.41***)	(4.36***)
Lptot90	0.788	0.910	0.840
	(0.53)	(4.70***)	(4.29***)
Lschool	-0.467		
	(-0.20)		
Africa	0.749		
	(0.29)		
Oecd	-0.980		
	(-0.24)		
Latam	1.799	1.498	1.618
	(0.65)	(1.76*)	(1.92*)
Tiger	2.073	2.108	2.496
	(0.45)	(3.09***)	(4.77***)
Paris	-0.365		
	(-0.28)		
Frankrom	-0.318		
	(-0.15)		
No. Obs.	49	49	49
R-squared	0.8372	0.8721	0.8517
Sargan Over-id	0.4443	0.7245	0.7583

Figure 1: Partial Correlation Between Resident Patents and IPR (OLS)

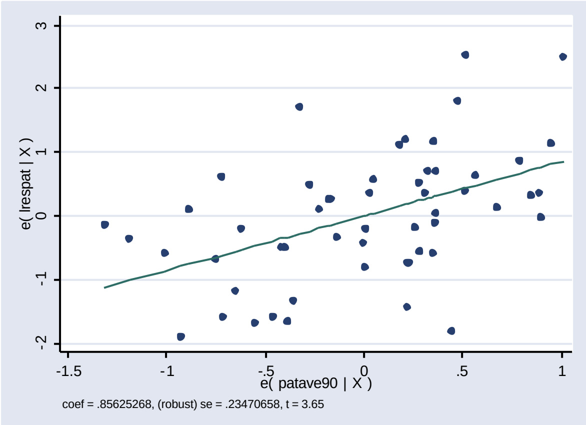

Figure 2: Partial Correlation between Resident Patents and Initial GDP (1980)

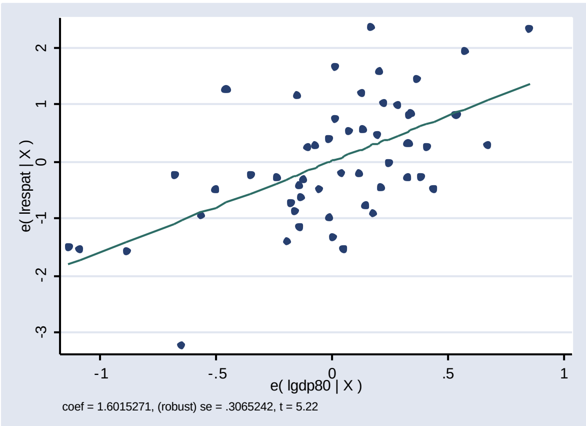

Figure 3: Partial Correlation between Resident Patents and Middle Class Share (OLS)

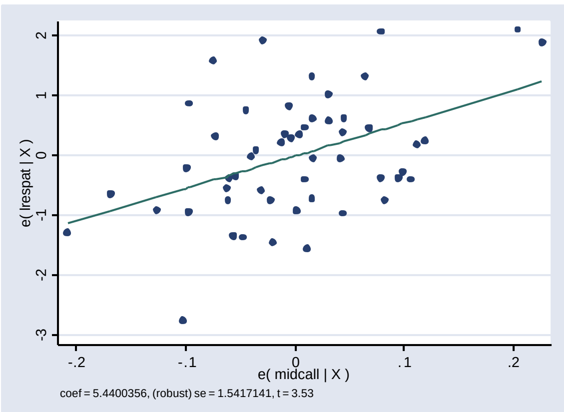

Figure 4: Partial Correlation between Resident Patents and Natural Openness

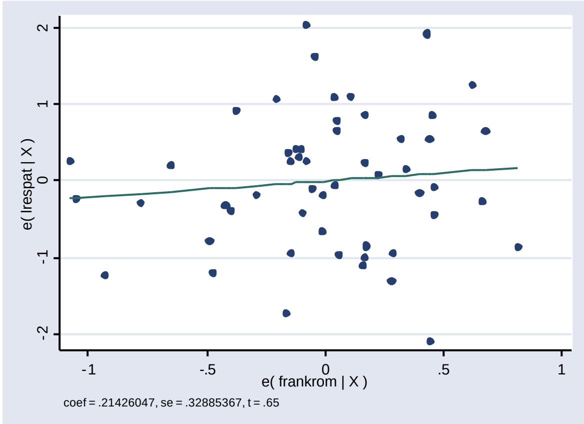

Figure 5: Partial Correlation between Resident Patents and Institutional Quality (OLS)

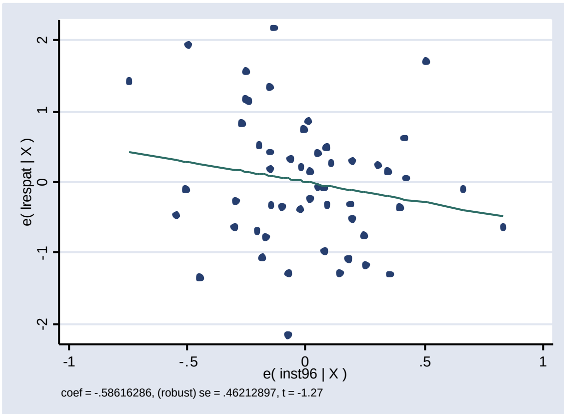

Figure 6: Partial Correlation between Non-Resident Patents and Natural Openness (OLS)

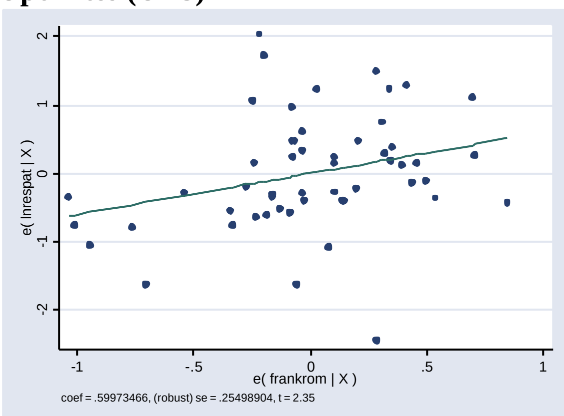

Table 4: List of Countries

Country Code	Paris Treaty		Country Code	Paris Treaty
ARG	1		JAM	0
AUS	1		JPN	1
AUT	1		KOR	1
BEL	1		LKA	1
BGD	1		MEX	1
BOL	1		MYS	1
BRA	1		NIC	0
CAN	1		NLD	1
CHE	1		NOR	1
CHL	1		NPL	0
COL	1		NZL	1
CRI	0		PAK	0
DNK	1		PER	0
ECU	0		PHL	1
ESP	1		POL	1
FIN	1		PRT	1
FRA	1		SLV	1
GBR	1		SWE	1
GHA	1		THA	0
GRC	1		TTO	1
GTM	0		TUR	1
HND	1		UGA	1
HUN	1		USA	1
IND	0		VEN	0
IRL	1		ZMB	1
ISR	1		ZWE	1
ITA	1			