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ABSTRACT

Do lobbies affect technology diffusion and growth? A number of authors have identified the importance of vested interests as a deterrent to technology diffusion and the relevance that this may have for growth. however, the evidence that exists about this mechanism is just anecdotal. In this paper we build a model of lobbying and technology diffusion where the speed of diffusion of new technologies depends on some dimensions of the political regime and on the whether there is an old technology that may be substituted by the new technology. This differential effect of institutions on the diffusion of technologies with a predecessor constitutes the central element of our identification strategy. To implement this test we use technology diffusion data from Comin and Hobijn [2004]. We find that the relevant institutional variables have a differential effect on the diffusion of technologies with a predecessor technology as predicted by the theory. We show that this result is unlikely to be driven by omitted variables, or reverse causality.

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Political barriers have long been believed to be an important deterrent of technology diffusion. This belief is founded in numerous examples: In 1299, an edict was issued in Florence forbidding bankers to use Arabic numerals (Stern, 1937, p. 48). In 1397, tailors of Cologne were forbidden to use machines that pressed pinheads. In the fifteenth century, the scribes guild of Paris succeeded in delaying the introduction of printing into Paris by 20 years. In the sixteenth century, the great printers revolt in Paris was triggered by labor-saving innovations in the presses. In 1561, the city council of Nuremberg, influenced by the guild of red-metal turners, launched an attack on Hans Spaichl, a local coppersmith who had invented an improved slide rest lathe (Klemm, 1964, p. 153). The ribbon loom was invented in Danzing in 1579, but its inventor was reportedly secretly drowned by orders of the city council. In 1733, John Kay invented the Flying Shuttle. Because of the labor-saving nature of the invention, it faced the resistance of weavers. In 1753 his housed was wrecked. Richard Arkwright was the inventor of the water frame which was the first economically viable machine that allowed for mechanized continuous spinning. In 1768 his mill at Chorely was destroyed by an angry mob of spinners. A US Senate report in 1949 found General Motors had been involved in the replacement of more than 100 electric transit systems with General Motors buses in more than 45 cities including New York, Philadelphia, Baltimore, St. Louis and Los Angeles (Snell, 1974). British road construction companies donated £714,000 to the Tories in 1991. Under the Tories, road construction took up 93 percent of funding for transportation infrastructures while rail took up just 4 percent.[1]

In all of these examples, some group of agents have a vested interest that is put in jeopardy by the diffusion of some new technology. The diffusion of the new technology, though, is socially desirable. To preserve their private benefits, they obtain political influence and use it to put up entry barriers that deter the diffusion of the new technology.

Despite the importance of the hypothesis that lobbies tend to slow down the technology diffusion, all the evidence we have so far is anecdotal. In this paper, we are interested in going beyond the existing anecdotal evidence and trying to assess the empirical importance of lobbies for technology diffusion. The lack of a systematic effort to answer this question is surely the consequence of three important difficulties. First, it is very hard to obtain good measures of these barriers. Second, many of the variables that can proxy for political barriers are endogenous and either have independent effects on income per capita or are correlated with other variables that affect the development of the country. Third, to explore the effects of lobbies on technology adoption it is necessary to have a comprehensive data set of technology adoption.

In this paper, we aim to overcome these difficulties by building a model of lobbying and technology diffusion that helps us understand under what circumstances lobbying efforts are successful in slowing down the diffusion of new technologies and by using a new data set on the diffusion of 20 technologies in 23 advanced countries for the last two centuries.

[1] See Mokyr (1990) for more examples.

More specifically, we consider a model in which the producers of goods associated with an old technology may continue to be competitive if the production processes that involve the use of new technologies are heavily regulated by the legislate authority. To induce the legislative authority to raise these barriers, the lobby of the old technology goods can offer the authority conditional (monetary) contributions.

In this context, it is crucial to understand under what circumstances there are effective lobbying efforts. The presence of effective lobbying depends on the benefits for incumbents if political barriers are raised to the diffusion of new technologies and on the costs of inducing the legislative authorities to raise such barriers. The benefits from lobbying for political barriers are very small when the new technology does not have a predecessor technology to substitute or when the producers of the previous competing technology are not very concentrated and, therefore, do not have important rents to protect. In these instances the new technology will diffuse quickly.

If, instead, the new technology has a predecessor technology that it (partially) substitutes and the rents associated to the previous technology are highly concentrated, the lobby of producers associated to the old technology may find it beneficial to make contributions right before the diffusion of the new technology to induce the legislative authority to regulate production with the new technology. Whether these lobbying efforts are successful will depend on how costly is to induce the legislative authority to pass the regulation. That ultimately depends on the legislative authority's cost of regulating against the new technology. These costs are of two types. The administrative cost of raising barriers is probably lower the more flexibility the legislative authority has and the less effective the judicial system is. In addition, current actions may affect the effective discount factor of the legislative authority. In democratic regimes, the probability that the current legislative authority continues in office in the future may be reduced by passing welfare reducing regulations such as the creation of barriers against new technologies. In non-democratic and military regimes, instead, adopting these welfare reducing policies probably does not have an important effect on the probability of continuing in power.

Our empirical strategy consists of identifying the effect of political barriers on development by estimating the different effects across technologies of the political variables that the theory relates to the size of the barriers. This strategy avoids the complexity of measuring the intensity of lobbying directly because it uses the theory to determine the political regimes and technologies where there should be lobbying.

By inspecting the differential effect of these determinants of lobbying on the diffusion of certain technologies we believe that we avoid most of the traditional identification problems.[2] Specifically, we believe that there are three virtues to this simple test. First, it focuses on the details of the mechanism

[2] Rajan and Zingales [1998] use a similar strategy to identify the effect of capital markets development on economic development. One important methodological difference, though, is that while they have various measures of capital market development (the exogenous variable in their test), we do not have any direct measure of lobbying intensity.

by which lobbying affects technology diffusion, thus providing a stronger test of causality. Second, while it may be relatively easy to think off omitted correlates of the institutional variables that conceivably may have an independent effect on the diffusion of technologies, it is very complicated to find reasons why these correlates should have an effect on the group of technologies with a predecessor technology above and beyond the effect they have on the technologies without one. This challenge is even more daunting given that we have a set of technology-time specific dummies as regressors and since most of the sectors represented in our sample have technologies in both groups. Similarly, reverse causality is probably not an issue because it is hard to argue that relatively micro technologies like the ones in our sample may have an effect on the institutions of a country. Further, for this effect on the institutional variables to invalidate our identification strategy, it must be relevant above and beyond our controls and must be triggered only by the diffusion of technologies with or without a technological predecessor.

The results from our analysis suggest a significant negative effect of lobbying on technology diffusion. We find that each and every of our measures of the political environment and regime has a significantly stronger effect on the diffusion of technologies with a competing predecessor than in the cases where there is no such an incumbent technology. Specifically, we find that in countries where the legislative authorities have more flexibility, the judicial system is not effective, without a democratic effective executive or with a military regime technologies with a technological predecessor that may be substituted by the new technology diffuse more slowly than technologies without such a predecessor technology. These effects are not only significant but also quantitatively important to understand technology diffusion. From these results we are inclined to conclude that the barriers raised by lobbies to deter the diffusion of new technologies are an important impediment to the diffusion of technologies.

Further, since technology diffusion is an important determinant of economic development, our findings also contribute to the literature of the effect of institutions on development. This important question has been traditionally addressed by estimating the correlation between various measures of institutions on income per capita in a panel regression with country fixed effects. In this context, institutions have no significant effect on development. This however may be the case because institutions are persistent and the country dummies capture all the institutional variation. An alternative approach consists on estimating the effect of institutions on development by instrumenting institutions in a cross-section of countries (Acemoglu, Johnson and Robinson [2001]). This approach, however, has two problems. First, it is very difficult to find good instruments for the quality of institutions. Second, with this approach, it is very complicated to point out what elements of the institutional environment of a country are critical for economic development.

This paper provides an alternative strategy to identifying the effect of institutions on development. Specifically, by using a multidimensional measure of development such as the adoption levels of various technologies, we are able to identify a specific mechanism by which certain dimensions of institutions affect the standards of living. Namely, through the effect institutions have in inducing lobbying activities which may slowdown the speed of diffusion of technologies. Interestingly, with this approach we have sufficient variation in the left hand side variable to identify what institutional characteristics are critical for development. Interestingly, we find out that institutional treats that are usually associated to countries with good institutions (such as an independent legislature) slow down the diffusion of new technologies when these have a previous competing technology.

The rest of the paper is divided in three sections. Section 1 contains the model, develops the empirical strategy and discusses the literature. Section 2 contains the empirical analysis. Section 3 concludes.

1 The model

We develop a model with the goal of understanding under what circumstances lobbies make contributions and when these contributions induce the legislative authority to raise barriers to slowdown the diffusion of new technologies. More specifically, the model will highlight the importance of a previous competing and/or concentrated technology for the diffusion of new technologies.

1.1 Setting

Sectors- In this economy, each sector faces a fixed demand of $\bar{Y}$ units of output. There are two types of sectors that differ in how many technologies are available to produce their output. In 'new sectors' only a new technology is available. In 'old sectors', instead, firms can use either a new or an old technology to produce sectoral output. In both types of sectors, output is produced competitively by a representative firm that decides, when relevant, what technology to use and how much of each intermediate good to demand.

Let Y be the final output produced in the sector. In a new sector,

$$Y = dX_e, \tag{1}$$

where $d > 1$, and X_e is a composite of n_e intermediate goods associated to the new technology which takes the following CES form:

$$X_e = (\int_0^{n_e} x_{ej}^{\rho} dj)^{1/\rho}, \text{ with } \rho \in (0, 1). \tag{2}$$

To capture the conflict between different interest groups, we assume that new and old technologies are perfect substitutes. Therefore, in an old sector, output is given by the following production function:

$$Y = \max\{X_i, dX_e\}, \tag{3}$$

where d measures the technological progress embodied in the new technology relative to the old one, X_e takes the same form as above and X_i is a composite of the n_i intermediate goods associated to the old technology:

$$X_i = (\int_0^{n_i} x_{ij}^{\rho} dj)^{1/\rho}. \tag{4}$$

Intermediate goods- Each intermediate good is produced by one monopolistic competitor that has incurred in a fixed cost of F units of a numeraire determined outside our model. In addition, intermediate goods firms may incur in the political contributions c dictated by their lobby. By paying the contribution, the lobby will grant a production authorization that is necessary to start producing in the next period. For intermediate goods associated with the old technology the marginal cost of production is $a = \bar{a}$. For goods associated to the new technology the marginal cost, a, is initially equal to $\bar{a}$ but at some point (specified below) intermediate goods firms learn the production possibilities of the new technology and the marginal cost of production for all the firms associated to the new technology is reduced to $\underline{a} < \bar{a}$.

Lobbies- New technologies' intermediate good producers would like the new technology to diffuse quickly while intermediate goods linked to old technologies have a vested interest in preventing the diffusion of the new technology. Common interest leads new and old technology' intermediate goods producers to organize in lobbies. Lobbies determine the political contributions that their members must make before they are given a production authorization required to produce in the next period. Contributions will be used to induce the legislative authority to set the desired policy. The ultimate goal of the lobby is to maximize the present discounted value of their members profits net of political contributions.

Institutions- The legislative authority (L) determines the level of regulation (τ) faced by the intermediate goods linked to the new technology. There are two possible levels of regulation.[3] Heavy regulation increases the marginal cost of producing new intermediate goods by $\bar{\tau}$ while no regulation (i.e. $\tau = 0$) does not affect the marginal cost of new intermediate goods.

The per period payoff of the legislative institution is the sum of three terms: a private value of being in power (b), the total contribution perceived from the lobbies (C) and the costs of bending the political constraints imposed by other institutions (S). S depends on the implemented regulation and on the political system. It is costless for the legislative authority to set $\tau = 0$ (*i.e.* $S(\tau = 0) = 0$). The cost of implementing $\bar{\tau}$ depends on the independence of the legislative authority. For an independent legislative authority the cost is $\underline{s}$ while for a less independent authority the cost of setting $\tau = \bar{\tau}$ is $\bar{s} > \underline{s}$.

The decisions taken by the legislative institution also may affect the probability of remaining in power. We model this effect by making the discount

[3] The feasibility of only two tax rates may be completely general if, as in Acemoglu and Robinson [1998], there is an informal sector where producers can avoid the sales taxes but operate at lower productivity. $\bar{\tau}$ would then be the rate that makes the producer indifferent between operating in the two sectors.

rate a function of the regulations passed by the legislative institution and of the political regimes. For the time being, we conjecture that in democratic regimes, the continuation of the legislative institution depends to a larger extent than in non-democratic regimes on the legislation it has passed. In particular, the discount factor faced by the legislative agent that has decided to implement $\bar{\tau}$ in a democratic regime is $\beta(\bar{\tau})$, lower than the discount factor faced in the rest of scenarios and by the other entities in the economy which is normalized to 1.[4,5] Below we elaborate more on this interpretation.

Timing- For simplicity, we consider a three period economy.[6] Old technologies arrive at time 1. Potential producers of intermediate goods associated to them decide at this point whether they incur in the fixed cost F to set up their business and start producing. New technologies arrive in period 2 and potential producers decide whether to incur in the fixed costs F this period or wait until next period. The incumbency of old technologies gives their lobby the advantage of making conditional contributions to the legislative authority at time 1, before the new technology has arrived and its lobby has been constituted.

In general, events within a period are ordered as follows: The producers that have incurred in the fixed cost F and that have made the contributions dictated by their lobbies in the previous periods can produce their goods to satisfy the demand of the final output producers; final output producers select the technology used and produce; existing lobbies dictate the contributions to be made to L; firms decide whether to incur in the contributions; contingent contributions are offered to the legislative authority; the legislative authority decides next period's level of regulation on the intermediate goods associated to the new technology; lobbies make effective the promised contributions to the legislative authority and parties observe whether the legislative authority remains in power or is replaced.

Finally, we assume that at the beginning of period 3 the new technology' intermediate producers learn to produce it efficiently and the technological component of the marginal cost of production for new technology intermediate goods declines to $\underline{a}$ units of final output.

1.2 Analysis

We first study the diffusion patterns in a sector without an old technology and then use this as a benchmark to investigate the effects of having an incumbent technology. The equilibrium concept we use to solve this game is Subgame Perfect Equilibrium.

Case 1: No incumbent technology

[4] What will be important for our results is not that the discount factor may be lower in democracies than in dictatorships but that the discount factor in democracies is more sensitive to the regulations passed by the legislative authority.

[5] Grossman and Helpman [1994] make a similar argument.

[6] None of the results derived in this model hinges on the finite time horizon. For an infinite time horizon version of the model, please contact the authors.

In a new sector only the new technology is available for production. Since intermediate goods are differentiated, they maximize profits by setting the price of each intermediate good to $p_e = (a_e + \tau)/\rho$. The operating profits of an intermediate goods (π_e) are

$$\pi_e = (p_e - (a_e + \tau))x_e = \bar{Y}(a_e + \tau)(1 - \rho)/(d\rho)n_e^{-1/\rho}. \tag{5}$$

The number of intermediate goods in the sector is determined by a free entry condition that equalizes the total profits enjoyed by an intermediate goods producer to the sum of the fixed cost and the political contributions made while in business. To write down this free entry condition we must first understand for how many periods intermediate goods producers operate and how much they spend in political contributions. These variables result from the interaction between the new technology lobby and the legislative authority. To find the subgame perfect equilibrium of this game we proceed by backwards induction.

At time 3, the continuation values of all agents are 0, therefore their best response function maximizes their static payoff. If the legislative authority sets $\tau = \bar{\tau}$ at time 3, his payoff will be $b - S(\bar{\tau}) + C(\bar{\tau})$, while if he does not pass any regulation he will get b. For the legislative authority to be willing to heavily regulate the production of new intermediate goods at time 3 he needs to receive a contribution $C(\bar{\tau}) \geq S(\bar{\tau})$. In the no incumbent case, only the new technology lobby can make contributions to L. However, the new technology lobby will not make any contribution to L because contributions reduce the static payoff and regulations approved at time 3 have no effect on its static payoff. Therefore, the legislative authority will not regulate at time 3.

At time 2, parties face a similar situation. The legislative authority requires a contribution $C(\bar{\tau}) \geq S(\bar{\tau}) + b(1 - \beta(\bar{\tau}))$ to regulate heavily the production of new intermediate goods, while the new technology lobby prefers the absence of regulation. Therefore at time 2, the new technology lobby does not make any contribution and L does not regulate.

Finally at time 1, since the new technology lobby has not been created yet, it cannot make any contribution to the legislative authority. At this point, L can set $\tau = \bar{\tau}$ and receive a payoff of $b - S(\bar{\tau}) + 2b\beta(\bar{\tau})$ or set $\tau = 0$ and obtain a payoff of $3b$. The latter is unambiguously higher than the former, and therefore L does not raise any barrier to the diffusion of the new technology at any subgame and the new technology lobby never makes a contribution to the legislative authority. This strategy profile determines the speed of diffusion of new technologies in new sectors as described in proposition 1.

Proposition 1 *: New technologies diffuse immediately in new sectors regardless of the institutional environment.*

Now that we know that intermediate goods producers associated with the new technologies can produce for the second and third periods and that they do not make any political contribution, we can write the following free entry condition to pin down n_e:

$$\bar{Y}(\bar{a}+\underline{a})\tau(1-\rho)/(d\rho)n_e^{-1/\rho} = F \tag{6}$$

This implies that in new sectors $n_e = \left(\bar{Y}(\bar{a}+\underline{a})(1-\rho)/(Fd\rho)\right)^{\rho}$.

Case 2: Exists an incumbent technology

In sectors where there is an old technology, final output firms have a technology choice. If final output is produced with the new technology, the expression for the intermediate good profits (π_e) is the same as in the no incumbent technology case. If, instead, final output is produced with the old technology, π_i are

$$\pi_i = (p_i - \bar{a})x_i = \bar{Y}\bar{a}\,(1-\rho)\,n_i^{\frac{-1}{\rho}}/\rho. \tag{7}$$

The representative final output firm uses the old technology if the marginal cost of producing output with the old technology (λ_I) is lower than the marginal cost of producing with the new one (λ_E). Equivalently, the new technology is adopted by the final output firm if the ratio of the marginal costs of production ($\lambda^R \equiv \lambda_e/\lambda_i$) is smaller than 1:

$$\lambda^R \equiv \frac{(a_e+\tau)}{\bar{a}d}\left(\frac{n_i}{n_e}\right)^{\frac{1-\rho}{\rho}} \leq 1 \tag{MCR}$$

Final output producers are more inclined to use the new technology the more advanced is the new technology relative to the old technology d), the lower is the marginal cost of producing the new technology intermediate goods (a_e), the lower is the regulation faced by new technology producers (τ) and the lower is the ratio of n_i over n_e.

Now that we have solved for the economic equilibrium for a given regulation level and for a given number of intermediate goods we can explore the political interaction between the old and new technology lobbies and the legislative authority. To find the equilibrium of this game we proceed again by backwards induction. In the no incumbent case we have already observed that, since the continuation payoff at time 3 is 0 for all the players, lobbies will not make any contribution to L and the legislative authority will not pass any regulation.

For the time being, we assume that when a_e is equal to $\underline{a}$ (i.e. at time 3), the final output producer demands the new technology regardless of the existing degree of regulation (i.e. the new technology diffuses). Note that, since the marginal cost ratio also depends on the ratio of n_i over n_e, we need to understand the entry of intermediate goods producers to pin down the condition that ensures that the marginal cost ratio at time 3 is smaller than 1. In particular, if the old technology is used for the three periods, the number of intermediate goods associated to the old technology would be $n_i = (3\bar{Y}\bar{a}(1-\rho)/(\rho(F+2\underline{c})))^{\rho}$, where $\underline{c}$ is the per-member contribution necessary to induce L to set $\tau = \bar{\tau}$. If the new technology is used only in the last period and $\tau = \bar{\tau}$, n_e will be equal to

$(\bar{Y}(\underline{a}+\bar{\tau})(1-\rho)/(\rho dF))^{\rho}$. Substituting this into the marginal cost ratio it follows that condition 1 is sufficient for the new technology to be used in period 3.

Condition 1: $\frac{(\underline{a}+\bar{\tau})}{\bar{a}d}\frac{3}{(1+2\underline{c}/F)} \leq 1.$

Since $\underline{c}>0$, condition 1b is sufficient for condition 1 to hold.

Condition 1b: $\frac{3(\underline{a}+\bar{\tau})}{\bar{a}d} \leq 1.$

Since regardless of the existing regulation, at time 3 only the new technology is demanded, the old technology lobby has no incentive at time 2 of making contributions to affect the regulations at period 3. Since the old technology lobby makes no contribution to L, and the new technology lobby is not going to make any positive contribution to induce L to set $\tau = \bar{\tau}$ at time 3, L finds optimal to pass no regulations at time 2, so that at time 3 $\tau = 0$.

At time 1, two scenarios are possible. If the new technology is sufficiently more productive than the old technology (i.e. d is sufficiently large) then, even if the old technology lobby has induced L at time 1 to heavily regulate the production of new intermediate goods at time 2, final output producers demand the new technology at time 2. Formally, this occurs if condition 2 holds.

Condition 2: $\frac{(\bar{a}+\bar{\tau})}{\bar{a}d}\frac{2}{(1+\underline{c}/F)} \leq 1.$

Again, condition 2b is sufficient for condition 2 to hold.

Condition 2b: $\frac{2(\bar{a}+\bar{\tau})}{\bar{a}d} \leq 1.$

Proposition 2 *: If conditions 1b and 2b hold, new technologies diffuse immediately regardless of the institutional setting also in old sectors.*

Alternatively, the new technology may not be so technologically superior to the existing one for final output producers to demand it in the presence of diffusion barriers. This is the case when $\frac{(\bar{a}+\bar{\tau})}{\bar{a}d}\frac{2}{(1+\underline{c}/F)} > 1$. That is, when condition 2 does not hold. This condition, however, is not sufficient to slowdown the diffusion of the new technology since, in addition, τ must be equal to $\bar{\tau}$ at time 2.

Before exploring whether L passes heavy regulation at time 1, recall that at this point in time ($t = 1$) only the old technology is available for production and only the old technology lobby can make contributions to L. If the legislative authority does not regulate he obtains a payoff of $3b$, while regulating heavily L obtains an expected payoff of $b(1 + 2\beta(\bar{\tau})) - S(\bar{\tau}) + C(\bar{\tau})$. This implies that L will set $\tau = \bar{\tau}$ at time 1 if and only if the old technology lobby makes a total contribution that covers for the costs of passing the regulation and probability of losing office because of the regulations passed. That is, if $C \geq 2b(1-\beta(\bar{\tau}))+S(\bar{\tau})$.

The immediate question that arises is whether it is feasible for the old technology lobby to make such a contribution to L. The total contribution made by the old technology lobby is equal to the per-member contribution (c_i) times the number of intermediate goods producers that operate in the period (n_i). At the end of time 1, the maximum per-member contribution ($c_i^{\max}$) that the old technology intermediate goods producers are willing to make is equal to the profits they will obtain in time 2 if the diffusion of the new technology is delayed (i.e. π_i). The free entry condition for the old technology producers gives us an expression for π_i when the contribution is maximum. In particular, free entry implies that $F + c_i^{\max} = 2\pi_i$. Since $c_i^{\max} = \pi_i$, it follows that the maximum per-member contribution made by the old technology intermediate goods producers is $c_i^{\max} = \pi_i = F$. Since $n_i = \left(2\bar{Y}\bar{a}(1-\rho)/(\rho(F+c_i))\right)^{\rho}$, the maximum total contribution made to the legislative authority is:

$$C^{\max} = n_i * F = F^{1-\rho}\left(\bar{Y}\bar{a}(1-\rho)/\rho\right)^{\rho}. \tag{8}$$

It follows from this analysis, that condition 3 is necessary to induce L, at time 1, to regulate heavily the production of new intermediate goods at time 2.

Condition 3: $C^{\max} = F^{1-\rho}\left(\bar{Y}\bar{a}(1-\rho)/\rho\right)^{\rho} > 2b(1-\beta(\bar{\tau})) + S(\bar{\tau})$

What are the circumstances that make $C^{\max} < 2b(1-\beta(\bar{\tau})) + S(\bar{\tau})$? For a given F, this is the case when $1-\beta(\bar{\tau})$ and/or $S(\bar{\tau})$ are large. That is, when heavily regulating the production of new goods considerably reduces the probability of reelection for L and/or when it is very costly for L to implement such a policy because it does not have much independence or because it is closely scrutinized by the judiciary power.

Note also that $C^{\max}$ has two important properties. Firstly, it is increasing in F. Secondly, as F tends to 0, the maximum contribution that the old technology lobby can make to L also tends to 0. That means that if F is very small,, no matter how lobby-prone the institutions are, it will not be possible to induce L to regulate heavily. When there are sufficient increasing returns in the production of the old technology intermediate goods (i.e. F is sufficiently large), then if institutions are easy to lobby (i.e. if $2b(1-\beta(\bar{\tau})) + S(\bar{\tau})$ is small) it may be feasible to induce L to set $\tau = \bar{\tau}$.

If it is feasible to induce L to regulate and if the inefficiency generated by regulation makes the old technology more profitable for final output producers than the new technology, then the old technology lobby may deter the diffusion of the new technology at time 2.

Proposition 3 *: Suppose that condition 2 does not hold and that condition 3 holds. Then, new technologies diffuse (slowly) in old sectors if condition 1 holds (i.e. they diffuse in period 3) or do never diffuse if condition 1 does not hold.*

The case where condition 1 does not hold is interesting because allows us to illustrate the pervasiveness of lobbying activities. The old technology lobby has the advantage of lobbying without opposition to the legislative authority before the new technology arrives. If condition 2 does not hold, this advantage has two consequences. On the one hand, it results in high barriers to the diffusion of the new technology in the form of heavy regulations at time 2. What is more interesting, though is that by executing the incumbency advantage, incumbents make the advantage persist. To be effective in lobbying it is necessary to have an "infrastructure". To create this "infrastructure" it is necessary to produce and create rents. But for new technology' intermediate goods producers to be willing to enter and produce, it is necessary that the regulatory barriers disappear. In our context, the "infrastructure" necessary to be successful in lobbying takes the form of the number of intermediate goods (n_e). If it is feasible to induce L to regulate and if condition 2 does not hold, the regulation faced by potential entrants in the production of new technology intermediate goods at time 2 will be heavy. That will deter them from entering at time 2 and therefore the new technology lobby will not be able to make any contribution to L that impedes heavy regulations at time 3. As a result, the initial incumbency advantage allows old technology lobbies to have very persistent effects on the diffusion of a new technology.[7]

One interesting issue is whether it is possible that the new technology lobby compensates the old technology lobby in exchange for not inducing L to raise barriers to the diffusion of the new technology. This arrangement would clearly increase social welfare but we believe that it is unlikely to occur for several reasons. First, it is not clear who will compensate the old technology lobby at time 1 (when the contribution to L takes place), before the new technology has arrived. Suppose for a moment that there is a wealthy benefactor that either uses his wealth or issues debt to finance the compensation to the old technology lobby. Then, the problem arises at time 1 when the new technology producers enter because they have no incentive to assume the debt issued by the benefactor. Therefore no such a benefactor will finance the transfer and the markets will not acquire the debt issued by the benefactor. Hence, the only possibility is that the old technology lobby assumes the risk of being paid at time 2 by the new technology producers when they start operating. However, at time 1, after the new technology has diffused, the old technology will have lost the incumbency advantage and the new technology lobby will have no incentive to honor its commitment. As a result, this kind of compensations between lobbies are very hard to take place.[8]

[7] Further, the interaction between the incumbency advantage of the old technology and the difficulty faced by the new technology to induce L to eliminate the barriers when thecurrent number of new intermediate goods producers is small is what what allows the extension of the results to an infinite horizon.

[8] Another difficulty for enforcing these kind of transfers is that since the goal is to avoid a contribution to L and this contribution may be illegal, and it is definitely moraly questionable, it is very hard to sue based on a breach of the agreement. Alternatively, the new technology lobby could offer the old technology lobby stock of the new intermediate goods companies in exchange for not bribing L at time 1. In this case, the commitment problems would take the

	No Previous Comp. Technology	Previous Comp. Technology	
		d High / F small	d Low / F large
Lobby-Free Institutions	Fast diffusion	Fast diffusion	Fast diffusion
Lobby-Prone Institutions	Fast diffusion	Fast diffusion	Slow Diffusion

Figure 1: Model Predictions

1.3 Testable predictions and discussion

The predictions of our model are summarized in figure 1:

- If in the sector there is no incumbent technology,[9] nobody tries to deter the diffusion of the new technology. Since the legislative authority has no innate preference for any technology, the new technology diffuses quickly.
- When an incumbent technology exist, then if the new technology is much more productive (i.e. condition 2 holds), or the old technology producers are very dispersed (i.e. F is very low), the new technology diffuses immediately.
- When the gap between the productivities of the new and old technologies is not sufficiently large (i.e. condition 2 does not hold) and there are some increasing returns in the production of the old technology intermediate goods (i.e. F is not very small), the new technology diffuses slowly when either the costs of bending the political constraints to pass regulation against the new technology, $S(\bar{\tau})$, are sufficiently low, or the persistence in power of L is not very affected by regulating against the new technologies (i.e. $\beta(\bar{\tau})$ is high). If these institutional characteristics are not present, new technologies diffuse immediately also when d is small and F is not small.

The foundation for our strategy to identify the effect of lobbies on technology diffusion is the differential in the effect of institutions on the speed of diffusion of new technologies across groups of technologies. First, we will explore the differential effect of institutions on the diffusion of new technologies when there is a previous technology that they can substitute (or d is small) and when there is no such a competing previous technology (or d is large). Second, we

form of an ex-post dillution of the control rights promissed to the old technology lobby.

[9] Note that, the presence or absence of an incumbent technology is a universal property that we will establish based on pure technological grounds.

explore the differential effect of institutions on the diffusion of technologies with a concentrated previous technology (F large) and with a previous technology with dispersed producers (F small).

One important question that we have to address when trying to bring these predictions to the data is what are the empirical counterparts of a low level of $S(\bar{\tau})$ or a high level of $\beta(\bar{\tau})$. Next we bridge this conceptual gap by mapping the type of regime, the independence of the legislative authority and the efficiency of the judiciary into our model.

Flexibility: It is natural to relate a low value of $S(\bar{\tau})$ to the flexibility of the legislative authority when passing the legislations. More independent legislative authorities face less constraints in passing regulations and therefore these result at a lower private cost than in countries where legislative authorities face stricter checks and balances. In the empirical section, we discuss one variable from the Banks data set that provides a direct measure of this notion.

Efficiency of Judiciary: In most regimes conditional contributions are illegal. In some cases, it is legal to make a contribution to a political agent but not with the explicit or implicit understanding that in exchange she must pass certain regulations. The efficiency of the judicial system to detect, judge and sentence violations of the law is an important determinant of the punishments exerted on the legislative authority if she is detected accepting a conditional contribution. Therefore an efficient judiciary increases the legislative authority's costs of accepting the lobbies bribes to raise barriers to the diffusion of ne technologies ($S(\bar{\tau})$).

Type of Regime: In the model we have treated the discount factor as parametric. However, it is very easy to extend the model slightly to relate the two values that it takes ($\beta(=1)$ and $\beta(\bar{\tau})$) to the *type of regime* in the country. Let's consider the following two scenarios: In countries where legislative officials are not elected democratically, the probability that they continue in power after the regulations they pass every period may be quite independent from their actions. Instead, in countries where they are democratically elected, whether they are reelected or not is decided by the voters. This decision will depend, at least in part, on whether the actions that the legislative authorities have taken while in office have contributed to increase the voters' welfare. Suppose that the voters are the stock holders of the company that produces final output.[10] Note that in the sectors where there is a previous competing technology, the policy that maximizes the profits of the final output firm is clearly to not impose any barrier to the operation of the new intermediate firms (i.e. $\tau' = 0$). In this sense, if voters are given the option to punish a legislative authority that has reduced their welfare to obtain a private benefit, they will tend to do so. Hence, in democratic regimes, there is an extra cost of imposing barriers to the new technologies in the form of lower probability of reelection or, equivalently, a lower

[10] It is straightforward to extend this argument to settings where the majority of the voters are workers employed in some other sector but that consume the final output of a sector with an incumbent technology. Then, the consumers' welfare is affected by the barrier to the new technology because this raises the m,arginal cost of production (and the price) of the final output in the sector.

discount factor. As we have observed in the previous section, the prospect of a reduction in the discount factor associated to the implementation of $\tau' = \bar{\tau}$ in a democratic regime tends to make harder for the lobby i to induce L to implement such a policy. As a result we should observe that in sectors where there is an incumbent technology, new technologies diffuse faster in democratic than in non-democratic regimes.[11]

Another dimension of the regime is whether it is a civil or a military regime. Based on similar arguments, we believe that in military the horizon of the legislative authority is more independent of the regulations passed. That is, $1 - \beta(\bar{\tau})$ is higher in non-military regimes.

1.4 Previous literature

Our model has some clear predecessors. In their pioneer work Krusell and Rios-Rull [1996] develop an OLG voting model where old agents have a vested interest in the old technologies while younger agents prefer the diffusion of a new technology. In the context of this voting model, technologies do not diffuse until young agents become a political majority. Acemoglu and Robinson [2000 and 2002] argue that political elites have incentives to block the diffusion of new technologies because new technologies erode their political power. In their model, there is an inverse-U shaped relationship between political competition and the blocking activity. Finally, in a recent paper, Acemoglu [2004] develops a model where new technologies diffuse faster in democracies than in oligarchies because oligarchs tend to raise the entry costs faced by all entrants to perpetuate their entrepreneurial rents.

Our model has one fundamental difference with these models which is key for our empirical strategy. Namely, that by focusing on the sectoral outcomes (i.e. speed of diffusion of new technologies at the sector level) instead of the aggregate outcomes (i.e. income per capita) we are able to make the crucial distinction between the effect of institutions on the sectors with and without a competing old technology and with and without a concentrated predecessor technology.

Beyond the intrinsic interest of the model, the main purpose of this paper is empirical. Specifically in the next section we estimate the effect of lobbies on technology diffusion by exploring the differential effect that certain institutional features discussed above have on the diffusion of new technologies that have a competing predecessor. To the best of our knowledge, our paper is the first attempt to determine empirically the effect of lobbies on technology diffusion. The closer predecessor that we have is Maggi and Goldberg [1999]. In a very interesting article, Maggi and Goldberg test the Grossman and Helpman [1994] theory of the role of special interest groups in the determination of trade pol-

[11] In principle one can write a model where a dictator has so much control over the political and military systems that he internalizes all the suboptimal policies undertaken by the other agents. We believe, however, that this a bad description of actual dictatorships. We believe that dictators need to buy the support of the elite by delegating power and that this delegation of power leads naturally to the separation between private and social optima.

icy. Specifically, Maggi and Goldberg, find that in 1983 US sectors that had made larger political contributions were also more protected from international competition. There are at least two important differences between our empirical exercise and Maggi and Golberg's. First and foremost, we are interested in technology diffusion. Second, since the diffusion of technologies is a dynamic phenomenon and since we are interested in understanding the determinants of diffusion also in countries other than the US, we do not have direct data on lobbying intensity. This difficulty is overcome by exploiting the model predictions about the institutional characteristics that facilitate successful lobbying.

2 Empirics

Measurement

To test the predictions of the model we need to collect three type of variables. First we need to measure the diffusion of various technologies in different sectors and countries over time. We also need to classify technologies according to whether they have a previous competing technology and to the degree of concentration of the producers of the predecessor technology. Finally, the other determinant of the success of the lobbying activity is the institutional setting. Hence, to identify the role of lobbies in technology diffusion we also need to have information on the relevant institutions in a country over time.

The information on technology diffusion comes from our Historical Cross-Country Technology Adoption (HCCTA) data set. This data set contains historical data on the adoption of 20 major technologies over the last 215 years for 23 of the World's leading industrial economies.

Table 1 contains a list of the technologies used in this analysis with the countries that are included in our data set which is basically the subset of developed OECD economies. The technologies in our sample have been classified by us into eight groups that cover (i) textiles production technologies, (ii) steel production technologies, (iii) telecommunication, (iv) mass communication, (v) information technology, (vi) transportation (rail-, road-, and airways), (vii) transportation (shipping), and (viii) electricity. Table 1 lists the technologies in each group sequentially, in the sense that the earliest technologies are listed first. There is one exception. That is, for information technology there is no such historical sequence between industrial robots and PC's.

As can be seen in Table 1, we use five different proxies for the level of technology adoption. The first, used for textiles and shipping, measures capital shares rather than output shares. It measures the fraction of a capital stock that is made up of equipment that embodies a particular technology. Second, for other technologies that are predominantly used in production, like trucks and robots, we measure capital output ratios. That is, we use the amount of equipment of a particular technology as a ratio of real GDP. For some production technologies we do not have capital stock data but only data on output produced, like ton-kilometers (TKM) of freight transported using various transportation methods or tons of steel produced using various technologies. For those technologies we use production to real GDP ratios. Our final two measures normalize capital stocks and consumption by the population rather than real GDP. Capital stocks per capita are used for example for passenger cars per capita and mobile phones per capita. Consumption per capita is used for mail, telegrams, as well as passenger transportation variables.

Since we are interested in understanding the determinants of the speed of diffusion of new technologies along the transition path, for each technology we are going to use data only until a certain year. This year is determined by one of two criteria. First, it may correspond to the point in time where the distribution of the level of technologies across countries becomes constant. Second, for some technologies that become dominated, it corresponds to the year in which the level of technology starts declining. In any case, the truncation of the sample for a given technology is the same for all the countries.

We classify technologies according to two criteria. First we classify them according to whether they have a previous competing technology or they do not. The list of technologies in the new sectors is composed by steel produced with Bessemer and with electric arc furnaces, telegrams, newspapers, personal computers, industrial robots and passenger and cargo transportation in railroads. The group of technologies with a competing predecessor includes ring spindles, steel produced with blast oxygen and with open hearth furnaces, telephones, mobile phones, radios, TV's, cars, trucks, passengers and cargo transported by airplane and the share of shipping tonnage in steam and motor boats.

The Schumpeterian view claims that in a way or another all the technologies have a more or less direct predecessor. This is true also for our technologies. However we consider that for the technologies classified as not having competing predecessor, if these exist, they are sufficiently distant in their productivity (d) and in the actual use given to the technology for the producers of the old technology to have an incentive to lobby against the diffusion of the new technology. For example, personal computers and robots are very distant in capabilities and in productivity from typewriters and manual assembly. Steel started to be produced in large scale with the development of the Bessemer furnaces. The techniques available before the Bessemer did not make economically viable the mass production of steel. Similarly, arc electric furnaces allowed the production of different types of alloys (mainly stainless steel) which were not economically viable with the previous furnaces. Before railroads cargo could be transported by canals in those places that had navigable rivers. This geographic constraint did not make viable large scale trade between many areas. The improvement of locomotives and the construction of railroads greatly contributed to reducing geographical barriers to trade within countries. For passenger traffic, there was no significant predecessor to the railways. The closest are the diligences and similar transportations by horse. Prior to telegrams there was no quick way to communicate with people in other regions or even cities. Finally, newspapers do not have any clear previous technology.

The second classification of technologies we implement is whether the predecessor technologies were produced by a few concentrated producers or whether producers were dispersed. Unfortunately, we do not have any direct measure of the degree of concentration of production in each technology and country over time. However, the model gives us a good proxy for concentration, namely the size of the fixed costs necessary to start producing the intermediate goods associated to the technology. In the presence of large fixed costs, few agents will incur the costs of entering into the production of intermediate goods and the production of the technology will be concentrated. Using this logic we can classify technologies according to whether to produce the predecessor technology it was necessary to incur in large or small fixed costs. Note that, by construction, this classification will be correlated with the previous one because those technologies that have no clear predecessor will be classified as having no predecessor with large fixed costs. However, since the correlation will be less than perfect (about 75 percent), this second classification will provide us with a second identification scheme to estimate the effect of lobbies on the diffusion of new technologies.

More specifically, we consider that large fixed costs where required in the production of Bessemer and Open Hearth steel, in the installation of telegraphs, and telephone lines, railroads, the production of cars, trucks and sail ships. This means that open hearth and blast oxygen steel, telephones and mobile phones, trucks, cars, planes and steam and motor ships are technologies with concentrated predecessor technologies. Conversely, the production of mule spindles, artisan steel, messenger services, newspapers, radios, typewriters, manual labor, and diligences involves substantially smaller fixed costs than the technologies in the previous list. Therefore, we assume that ring spindles, Bessemer and electric arc furnace steel, telegrams, newspapers, radios, TV's personal computers, industrial robots, and railways are technologies without concentrated predecessor technologies.

We think that these are sensible ways to implement the technology classifications dictated by the theory. However, we have conducted some robustness checks to see how sensitive the results are to small variations in the classifications. One element that supports the robustness of the results is that we obtain very similar estimates using the incumbent technology and the concentrated predecessor classifications. We have also experimented estimating the differential effect of institutions on technology diffusion eliminating, one at a time, each of the technologies in our sample. In this exercise, the estimates have proven very stable showing that they are not driven by the classification of any single technology.

Finally, we use four variables to measure legislative independence, effectiveness of the judiciary, democracy and whether the regimes is military.

Legislative authorities that have a lot of flexibility to pass regulations need to incur in lower administrative costs to raise barriers to the diffusion of the new technology. Hence, a high legislative flexibility is associated to low values of $S(\bar{\tau})$. Legislative flexibility is measured by Banks by assigning 4 different values: (0) indicates that no legislature exists. (1) is assigned on three possible bases: first, legislative activity may be essentially of a "rubber stamp" character; second, domestic turmoil may make the implementation of legislation impossible; third, the effective executive may prevent the legislature from meeting, or otherwise substantially impede the exercise of its functions. A value of (2) for the flexibility variable corresponds to a situation in which the executives power substantially outweighs, but does not completely dominate that of the legislature. Finally, a value of (3) is assigned when a significant governmental autonomy is possessed by the legislature, including, typically, substantial authority in regard to taxation and disbursement, and the power to override executive vetoes of legislation.

As we have discussed in the previous section, in many regimes conditional contributions are illegal. In some cases, it is legal to make a contribution to a political agent but not with the explicit or implicit understanding that in exchange she must pass certain regulations. The efficiency of the judicial system to detect, judge and sentence violations of the law is an important determinant of the punishments exerted on the legislative authority if she is detected accepting a conditional contribution. Therefore an efficient judiciary increases the legislative authority's costs of accepting the lobbies bribes to raise barriers to the diffusion of new technologies ($S(\bar{\tau})$). We follow La Porta et al. [1998] and measure the efficiency of the judiciary with the cross-country measure compiled by the Business International Corporation. We take the average between 1980 and 1983 which is scaled between 0 and 10, with lowest scores meaning lower levels of judicial efficiency.

We explore two classifications of the regimes. First, we use the Polity IV measure of democracy to identify democratic regimes. This variable measures the general openness of political institutions. Specifically, it is the result of adding measures of the competitiveness of political participation, the openness and competitiveness of executive recruitment and the constraints on the chief executive. The result is a (0-10) scale variable with higher values for more democratic regimes.

Second, we classify regimes between those that are military and those that are not military. A military regime according to Banks is one that is explicitly or implicitly controlled by a military component of the nation's population.

For all the variables used in our analysis, we compute five year averages and use non-overlapping data in our regressions. Taking these five year averages increases the signal-to-noise ratio of our variables and, a priori, does not reduce much of the relevant variation in the data since both technology diffusion and institutional change are relatively high frequency phenomena.

Identification

Let's denote by y_{ict} our measure of technological diffusion for technology i in country c at time t. We can think off y_{ict} as being the sum of three terms.

$$y_{ict} = y_{it}^{f} + y_{ct} + u_{ict}$$

The first (y_{it}^{f}) can be interpreted as the level of diffusion for the i^{th} technology at time t in a frictionless environment (i.e. one where institutions are optimal) while the other two terms (y_{ct} and u_{ict}) represent the deviations from this frictionless pattern for technology i in country c at any given moment in time. Different technologies may have different diffusion pattern in a frictionless world for purely technological reasons. In our analysis, we will remove the first component (i.e. y_{it}^f) by including in the regressions a technology and time specific time dummy.

The term y_{ct} represents (possibly time-varying) country specific factors. The literature on growth and aggregate diffusion of technologies has presented a long list of country-specific factors that may affect the speed of technology diffusion. such as the human capital of the work force measured either by their schooling or by their experience dealing with some related technologies, the degree of development of the capital markets, some institutional variables such as the fiscal system (i.e. profits tax rate, existence of depreciation allowances, ...) or other dimensions of institutions that determine the risk of expropriation by the government or the rule of law, whether the country is involved in wars in a moment in a particular time period, the distance to the countries from where the technology is imported, the distance to the exports markets where the output that results from using the technology is sold, etc.

Finally, the term u_{ict} captures the (possibly time-varying) technology country specific components of technology diffusion. This is the critical term for our empirical analysis because the theory developed in the previous sections has direct implications about u_{ict}. Specifically, it predicts that for those technologies where there is a technological predecessor, the presence of certain institutions may lead to successful lobbying efforts that slowdown the diffusion of new technologies; that is, lead to lower levels of u_{ict}. In contrast, when the new technology does not have a technological predecessor, these same institutions should not have an effect on the speed of diffusion of the new technology and therefore u_{ict} should not be affected.

To identify the effect of lobbies in the data, we make the assumption that any differential effect of institutions on the diffusion of new technologies in new vs. old sectors, after controlling for the time and technology specific dummies, is due to the effects of lobbies.

This identification strategy may, a priori, have two potential problems. First, and most importantly, there may be some variable, z, omitted in our regression that is correlated to our measure of institutions that has an asymmetric effect in the diffusion of different technologies. For this to be an important concern, there must be a reason why, a priori, z has a different effect in the technologies that have a predecessor than in those that do not. Given the diversity of technologies in our sample and their homogenous distribution over time and sectors we believe that it is quite difficult to come out with one such variable. In any case, we try to make the case that effectively omitted variable bias is not a problem for our identification by allowing for some of the variables that a priori might affect an effect on the speed of diffusion of technologies to have a differential effect in our two groups of innovations.

A second potential pitfall of our identification strategy is that of reverse causality. This would happen if the speed of diffusion in the sectors with an incumbent technology (but not on the sectors without one) led to a democratic regime or to a legislative system where the authorities had no legislative independence. We believe that this is not an important concern for two reasons. First because, since we study the diffusion of quite narrowly defined technologies, it is highly unlikely that these micro phenomena have an effect on the political regime. Second, even if they could change the political system, our identification strategy would be safe as long as it is not the case that *only* the diffusion of technologies in the sectors with technological incumbents affects the transformation of institutions. This asymmetry seems to us even less likely to take place.

Implementation

The basic regression we run has the following form:

$$y_{ict} = \alpha_0 + \alpha D_{it} + \beta_1 X_{ct} + \beta_2 R_{ct} + \beta_3 I_i * R_{ct} + \epsilon_{ict}. \tag{9}$$

α_0 is a constant. D_{it} denotes a set of time and technology specific dummies. As explained above, these dummies remove the differences in the diffusion patterns that have the technologies for purely technological reasons. X_{ct} is a set of controls that includes the level of income per capita, various measures of educational enrollment, and the production of electricity over real GDP. There are various reasons for these variables to have an independent effect on the diffusion of the technologies in our sample. The logarithm of real GDP per capita captures both income effects that inherently contribute to the different rates of technology adoption as well as endowment differences across countries that are omitted in the other variables. Human capital endowments, are measured by the enrollment rates in primary and secondary schooling computed by us and by the world bank (for the years after 1970). Low energy prices measured by the intensity of electricity production may also accelerate the adoption of new technologies.

R_{ct} represents the set of institutional and policy variables. Remember that these contain two measures of the political cost for legislators of raising barriers to the diffusion of the new technology ($S(\overline{\tau})$) - legislative flexibility and trade openness- and two measures of the type of regime. Namely, a dummy that measures whether the regime is military and some dummies that capture the type of effective executive. Recall that the type of regime has an effect on the sensitivity of the legislative's authority discount factor to the barriers raised ($\beta(\overline{\tau})$).

The fourth set of regressors in (9) ($I_i * R_{ct}$) interacts the institutional variables (R_{ct}) with either a dummy variable for the technologies that have a predecessor technology or a dummy for the technologies with concentrated predecessors (I_i). β_3 is the critical vector of coefficients for the identification of the role of lobbying activity on technology diffusion. ϵ_{ict} is a zero mean error term.

Table 2 reports the coefficient estimates. Each column corresponds to a different regression. In all the regressions the dependent variable is the level of technology diffusion (y_{ict}). All the regressions include the time and technology specific dummies (D_{it}). Column 1 corresponds to a basic regression with only X_{ct} and R_{ct} as regressors. There we can observe that income per capita, the enrollment rates and the intensity of electricity production are positively associated to the level of technology diffusion. The positive coefficient of enrollment, however, only holds for enrollment before 1970. In the institutional variables, judicial is positive correlated to technology diffusion, democracy and legislative flexibility are partially un-correlated to technology diffusion while having a military regime is negatively correlated to technology diffusion.

Column 2 reports the coefficients from regression (9). In this regression we can also observe the positive association between technology diffusion and income per capita, enrollment (before 1970) and electricity production over GDP.

More interesting are the coefficients of R_{ct} and specially the coefficients that capture the differential effect that the institutions in R_{ct} have on the diffusion of the technologies with a competing predecessor. Allowing for this differential effect affects some of the coefficients of R_{ct}. In particular, the coefficients of the military regime dummy, and of judiciary effectiveness become insignificant.

Recall that our strategy to identify the effect of lobbies on technology diffusion is based on the differential effect that the institutional variables in R_{ct} should have, according to the theory, on the diffusion of technologies with and without a predecessor technology. Specifically, the theory predicts that in sectors with an incumbent technology, countries with high cost of raising barriers ($S(\overline{\tau})$) and with a high intertemporal punishment from raising barriers (low $\beta(\overline{\tau})$) should experience faster diffusion of technologies than in countries where legislators do not face these static and dynamic costs from raising barriers against the diffusion of new technologies. According to our model, lobbying activity is irrelevant for the diffusion of technologies without a predecessor. Hence, we should observe a significant differential effect of the variables in R_{ct} for the diffusion of the technologies with predecessor.

These predictions are supported by the estimates from the second regression. There we can see that judiciary effectiveness has a additional significant positive effect on the diffusion of technologies with a predecessor. The other proxy for the static political costs of raising diffusion barriers for the legislative authority is the legislative flexibility variable. Consistently with the theory, we also observe that a high degree of legislative flexibility reduces the speed of diffusion of the technologies with a predecessor. This differential effect of legislative flexibility is significant at the 10 percent significance level.

Similarly, we can observe in the second column that the regime variables also have a differential effect on the diffusion of technologies with predecessor consistent with the relevance of lobbying in slowing down the speed of diffusion of technologies. Specifically, technologies with a predecessor diffuse more slowly than technologies without one in military regimes and in countries that score lower in the Polity democracy index.

Column 3 reports the estimates for regression (9) when we interact institutions with a dummy (I_i) that takes the value of 1 in the production of the previous technology was concentrated and 0 if it was not. The differential effects of institutions in technologies with and without concentrated predecessors are very similar to the effect across technologies with and without predecessors. We find that democracy and judicial effectiveness have a positive and highly significant differential effect on the diffusion of technologies with concentrated predecessors. We also observe that legislative effectiveness and military regime have a negative and significant differential effect on the diffusion of technologies with a concentrated predecessor.

As discussed above, we believe that we can interpret these results as evidence of a causal negative effect of lobbies on technology diffusion. This interpretation of the differential correlation between institutions and diffusion for the technologies with predecessor is motivated by how unlikely it is to find omitted variables that drive the correlation. Good governments, climate, unmeasured factors, high TFP,... and all the usual suspects that can explain why we find positive correlation between institutions and development levels fail to explain why the effect of the relevant institutional variables is stronger for technologies with a predecessor or with a concentrated predecessor. This failure is accentuated by two observations: First, the fact that we can identify simultaneously the differential effect of all the institutional variables on the diffusion of the technologies with a predecessor (and with a concentrated predecessor) raises the hurdle for the potential omitted variables since, to account for the estimated coefficients, they must be appropriately correlated with all the variables in R_{ct}. Second, the fact that the sign of the effect of many of the variables in R_{ct} on the diffusion of technologies without a predecessor technology is different than for the technologies with a predecessor puts some additional constraints on the variance and correlations of the omitted variables with the endogenous and exogenous variables necessary to account for the estimated coefficients.

Similar arguments lead to the conclusion that it is unlikely that reverse causality drives the observed differential correlation between technology diffusion for technologies with predecessor technologies and the institutional variables in R_{ct}. In addition, it is important to note that the technologies we are studying are quite micro and therefore the effect of their diffusion (or lack of) in aggregate macro variables such as GDP, the labor market outcomes and so on is quite limited.

To gain more confidence on the irrelevance of reverse causality in the estimated effect of institutions on the diffusion of technologies with a predecessor we can replace current institutions by past institutions. Indeed, our theory emphasizes the importance of this dynamic component to policy making. In the fourth column of Table 2, we run the basic regression replacing the institutional variables by their 5-year lag. Interestingly, all the results hold even a fortiori.

The estimated effect of lobbies on technology diffusion, in addition to being statistically significant, is quantitatively relevant. The variance of the diffusion level of the technologies with a predecessor after removing the effect of the technology-time dummies is 0.9. The dispersion induced by the estimated effect of the differential effect of institutional/policy variables on the diffusion of technologies with a predecessor is 0.46. This means that the estimated effect of lobbies on technology diffusion is 50 percent of the observed variation in technology diffusion.

In Table 3, we try to increase our confidence on the robustness of the estimated differential effect of institutions on the diffusion of technologies with a predecessor. In column 1 we include country fixed effects as regressors. This does not affect whatsoever the estimates of the interaction between institutions and the dummies for the technologies with predecessors.

Columns 2 and 3 include as regressors various measures of the size of the country such as area, population and real GDP. We allow these variables to have a differential effect on the technologies with and without a competing predecessor. Though these measures of size have a significant differential effect on the diffusion of technologies with a predecessor technology, the differential effects of institutions on the diffusion of technologies with competing predecessors are virtually unaffected.

Columns 4 allows for a differential effect of the controls in X_{ct} (income per capita, enrollment and electricity production) on the diffusion of the technologies with a predecessor. The differential effect of institutions on the diffusion of technologies with a predecessor is robust to the presence of differential controls. It is interesting to note that, for the technologies without a predecessor, the institutional variables either do not have a significant effect or the coefficient has the opposite sign than for the interaction between the institutions and the predecessor technology dummy. This observation reinforces our believes in the causal interpretation of the relationship between institutions and the diffusion of technologies with a predecessor.

In columns 5 and 6 we also allow for country fixed effects to have a different effect on the technologies with and without a predecessor. This again does not affect by-and-large the significance of the estimates of the interactions between institutions and the predecessor technology dummy. The only relevant variable that becomes insignificant after allowing for different effects of the country dummies is the interaction between the effectiveness of the judiciary and the predecessor dummy. That is not very surprising provided that the judiciary variable is constant over time.

In column 7 we try to understand the source of the identification for the interaction between technologies and institutions. In particular, we explore whether we are obtaining any identification from the time-technology dimension or whether all the identification comes from the country-technology dimension. To do that we include in the regression both country fixed effects and country fixed effects interacted with the previous technology dummy. After eliminating the country-technology dimension, the differential effects of the military dummy and of democracy on technologies with incumbent technologies become insignificant (though the coefficients keep the sign).[12] However, the differential effect of the flexibility of the legislative remains negative and significant at the 2 percent significance level. This means that we are identifying some of the differential effects of institutions on technology diffusion exploiting the time series variation of the institutions.

[12] The effectiveness of the judiciary drops from the regression because it only has cross-country variation.

Table 4, reports the same robustness checks as in table 3 but now we estimate the differential effect of institutions on the diffusion of technologies with a without a concentrated predecessor. With this alternative classification of technologies, the results hold a fortiori. In particular, the negative differential effects of the legislative flexibility and the military dummy, and the positive differential effects of democracy and the effectiveness of the judiciary are very significant and robust to controlling for measures of size, interacting the rest of the controls with the technology classification and adding country dummies or adding country dummies interacted with the dummy for the concentration of the predecessor technology.

In column 7 of table 4 we explore again the source of the identification of the differential effect of institutions on technology diffusion by including in the regression both country fixed effects and country fixed effects interacted with the concentration of the predecessor technology dummy. When doing that, the differential effects of the military dummy, of democracy and of the flexibility of the legislative are still significant (the first two at the 10 percent and the last one at the one percent significance levels). This means that we are identifying an important portion of the differential effects of institutions on technology diffusion through the time series variation of the institutions.

In addition to providing evidence on the slowdown in the speed of diffusion of technologies induced by lobbies, the findings of this paper also illustrate one channel by which institutions affect development. Namely, institutions affect the parties incentives to engage in lobbying activities, lobbying slows down technology diffusion and technology adoption affects crucially development. The empirical identification of this mechanism is a contribution to the institutions and growth literature.

This literature has followed two routes to progress: In standard regression analysis, it has tried to identify the effect of institutions on income per capita by controlling for elements other than institutions that may affect income per capita differences. This route has typically been unsuccessful because institutions become insignificant after including in the regression either a few reasonable controls or country fixed effects. A second route has argued that attenuation bias is responsible for this insignificance and has tried to find good instruments of institutions. This approach has been more successful but it is still not clear whether the proposed instruments are truly valid.[13] Further, since income per capita is highly correlated with many indicators of "good institutions", it is very hard for IV's to detect the specific institutional traits that drive income per capita differentials.

This paper provides an alternative route to establishing empirically the link between institutions and development. This approach hinges on two pillars. First, the use of measures of diffusion for various technologies as dependent variable. Second, the identification of the effect of institutions by interacting institutions to a relevant ex-ante classification of technologies.

[13] See the debate between Acemoglu, Johnson and Robinson [2001] and Glaeser et al. [2004] and Acemoglu et al [2005].

We believe that our approach has some interesting virtues. First, as we have argued above, it is very robust to omitted variable and reverse causality biases. Second, by using a multidimensional dependent variable with so much variation both over time and in the cross-section as technology diffusion the test of the null that lobbies have no effect on technology diffusion is more powerful. Indeed, we have identified the effect of lobbies on technology diffusion through the differential effects of institutions on technology diffusion even after introducing country fixed effects and the interaction of country fixed effects with the a priori classification of technologies. Finally, with our approach we have been able to pinpoint some specific institutional traits that affect importantly technology diffusion. This step is very important for two reasons. First and foremost, it is critical to draw specific policy recommendations from this kind of empirical analysis. Second, we have observed that not all the institutional characteristics that are usually associated to advanced economies accelerate the speed of diffusion of technologies. In particular, more flexibility of the legislative authority makes easier for lobbies to induce her to raise political barriers to the diffusion of new technologies that ultimate slow down their diffusion.

3 Conclusion

Differences in the available technology are believed to be a first order determinant of cross-country income per capita differentials. In this paper we have explored the empirical relevance of one of the determinants of technology diffusion. Namely, lobbying efforts by producers of incumbent technologies. We have observed that lobbies significantly slow down the speed of diffusion of new technologies. Further, our results allow us to understand better which specific institutions affect economic development and one specific channel by which this effect takes place. Specifically, having independent legislative authorities, an ineffective judiciary, military or non-democratic regimes slow down development. These institutional characteristics make easier for lobbies associated with old technologies to induce the legislative authorities to raise barriers to the diffusion of new (and superior) technologies.

The empirical strategy used in this paper can be applied to identify mechanisms other than lobbies by which institutions affect technology diffusion and income per capita. As we have seen in this paper, these exercises may provide us with a better understanding of the specific institutional traits that drive various components of development such as technology adoption. If, as this and other papers suggest, institutions are important for development, identifying the relevant institutional traits is as necessary for the advancement of poor countries as sequencing the DNA is for curing genetic diseases.

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Table 1:Technologies and Countries in Sample

Period covered: 1788-2001			
	TECHNOLOGIES		
I.	Textiles	Prev. Tech.	Concen. Prev. Tech.
1.	Fraction of spindles that are ring spindles	Yes	No
II.	Steel		
2.	Tons of steel produced with Bessemer over GDP	No	No
3.	Tons of steel produced with Open Hearth over GDP	Yes	Yes
4.	Tons of steel produced with Blast Oxygen over GDP	Yes	Yes
5.	Tons of steel produced with Electric Arc over GDP	No	No
III.	Telecommunications		
6.	(Log.) Telegrams per capita	No	No
7.	(Log.) Telephones per capita	Yes	Yes
8.	(Log.) Mobile phones per capita	Yes	Yes
IV.	Mass communication		
9.	(Log.) Newspapers per capita	No	No
10.	(Log.) Radios per capita	Yes	No
11.	(Log.) TV's per capita	Yes	No
V.	Information technology		
12.	(Log.) Personal computers per capita	No	No
13.	(Log.) Industrial robots over GDP	No	No
VI.	Textiles		
14.	(Log.) Freight traffic on railways (TKMs) over GDP	No	No
15.	(Log.) Passenger traffic on railways (PKMs) over GDP	No	No
16.	(Log.) Trucks per unit of real GDP	Yes	Yes
17.	(Log.) Passenger cars over GDP	Yes	Yes
18.	(Log.) Aviation cargo (TKMs) over GDP	Yes	Yes
19.	(Log.) Aviation passengers (PKMs) per capita	Yes	Yes
VII.	Merchant shipping		
20.	Share of steam and motorships in merchant fleet tonnage	Yes	Yes
	COUNTRIES		
	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal Spain, Sweden, Switzerland, United Kingdom, United States		

Table 2: Dependent Variable: Technology Diffusion (yict)

Variable	I	II	III	IV
Controls (Xct)				
ln(GDP/Pop)	0.97	0.95	0.95	0.93
	(12.03)	(11.78)	(11.83)	(11.68)
Prim. Enr. 70-	1.66	1.76	1.71	1.62
	(7.48)	(7.92)	(7.73)	(7.57)
Sec. Enr. 70-	0.10	0.08	0.08	0.18
	(0.67)	(0.54)	(0.53)	(1.12)
Prim. Enr. 70+	0.61	0.68	0.58	0.58
	(1.28)	(1.44)	(1.24)	(1.23)
Sec. Enr. 70+	-0.65	-0.67	-0.64	-0.68
	(-2.36)	(-2.45)	(-2.34)	(-2.42)
ln(MWHR)	0.18	0.18	0.18	0.19
	(5.97)	(5.93)	(5.96)	(6.31)
Institutions				
Legislative Effectiveness	-0.04	0.11	0.10	
	(-0.58)	(1.07)	(1.14)	
Military Regime	-0.32	0.12	0.01	
	(-2.01)	(0.53)	(0.02)	
Democracy	-0.03	-0.11	-0.10	
	(-1.35)	(3.72)	(-3.62)	
Judicial Effectiveness	0.09	0.01	0.03	
	(3.85)	(0.41)	(1.12)	
Institut* Incumb. Tech.				
Legislat. Eff. * Incumb. Tech		-0.23		
		(-1.73)		
Mil. Reg. * Incumb. Tech		-0.69		
		(-2.30)		
Democracy * Incumb. Tech		0.14		
		(3.84)		
Judicial. Eff. * Incumb. Tech		0.11		
		(2.98)		
Institut * Concen. Pred.				
Legislat. Eff. * Concen. Pred.			-0.26	
			(-1.96)	
Mil. Reg. * Concen. Pred.			-0.60	
			(-2.01)	
Democracy * Concen. Pred.			0.13	
			(3.66)	
Judicial. Eff. * Concen. Pred.			0.12	
Lagged Institutions			(3.22)	
Lagged Legislative Effectiveness				0.11
				(1.23)
Lagged Military Regime				0.23
				(1.05)
Lagged Democracy				-0.08
				(-3.48)
Lagged Judicial Effectiveness				0.01
				(0.45)
Lagged Institut * Concen. Pred.				
Lagged Legislat. Eff. * Concen. Pred.				-0.34
				(-2.51)
Lagged Mil. Reg. * Concen. Pred.				-0.89
				(-2.95)
Lagged Democracy * Concen. Pred.				0.13
				(4.04)
Lagged Judicial. Eff. * Concen. Pred.				0.12
				(3.17)
No. of obs	2452	2452	2452	2427
R^2 (within)	0.225	0.2397	0.2387	0.2386

t-statistics in parenthesis.

Table 3: Robustness: Technology Diffusion with and without Incumbent Technologies

Variable	I	II	III	IV	V	VI	VII
Controls * Incumb. Tech.							
ln(GDP/Pop) * Incumb. Tech				0.17			
				(0.97)			
Prim. Enr. 70-* Incumb. Tech				0.03			
				(0.06)			
Sec. Enr. 70-* Incumb. Tech				1.02			
				(2.77)			
Prim. Enr. 70+* Incumb. Tech				-0.26			
				(-0.25)			
Sec. Enr. 70+* Incumb. Tech				0.67			
				(1.17)			
ln(MWHR)* Incumb. Tech				-0.07			
				(-1.05)			
ln(Area) * Incumb. Tech		0.08					
		(2.89)					
ln(Population) * Incumb. Tech		-0.13					
		(-3.06)					
ln(GDP) * Incumb. Tech			-0.05				
			(-1.44)				
Institut* Incumb. Tech.							
Lagged Legislat. Eff. * Incumb. Tech	-0.25	-0.43	-0.42	-0.25	-0.30	-0.26	-0.36
	(-1.82)	(-2.02)	(-1.95)	(-1.78)	(-2.12)	(-1.81)	(-2.3)
Lagged Mil. Reg. * Incumb. Tech	-0.92	-1.29	-1.39	-0.95	-0.88	-0.82	-0.43
	(-2.99)	(-3.65)	(-3.95)	(-2.96)	(-2.93)	(-2.59)	(-1.33)
Lagged Democracy * Incumb. Tech	0.13	0.12	0.14	0.12	0.13	0.11	0.05
	(3.8)	(2.86)	(3.31)	(3.49)	(3.83)	(3.05)	(1.29)
Lagged Judicial. Eff. * Incumb. Tech	0.13	0.14	0.17	0.09	0.13	0.10	-
	(3.36)	(2.76)	(3.24)	(1.94)	(3.48)	(1.39)	
Dummies							
Country Dummies	No	No	No	No	Yes	No	Yes
Country Dummies * Incumb. Tech.	No	No	No	No	No	Yes	Yes
No. of obs	2427	2210	2210	2427	2427	2427	2427
R^2 (within)	0.2399	0.2024	0.1887	0.244	0.2729	0.2648	0.3096

t-statistics in parenthesis. All regressions control for income per capita, enrollment in primary and secondary education and electricity production. Regression 2 controls in addition for ln(area) and for ln(population). Regression 3 controls in addition for ln(GDP)

Table 4: Robustness: Technology Diffusion with and without Concentrated Predecessors

Variable	I	II	III	IV	V	VI	VII
Controls * Concen. Pred.							
ln(GDP/Pop) * Concen. Pred				0.08			
				(0.48)			
Prim. Enr. 70-* Concen. Pred				0.53			
				(1.24)			
Sec. Enr. 70-* Concen. Pred				0.32			
				(0.99)			
Prim. Enr. 70+* Concen. Pred				0.32			
				(0.34)			
Sec. Enr. 70+* Concen. Pred				-0.07			
				(-0.13)			
ln(MWHR)* Concen. Pred				-0.06			
				(-0.98)			
ln(Area) * Concen. Pred		0.10					
		(4.05)					
ln(Population) * Concen. Pred		-0.18					
		(-4.81)					
ln(GDP) * Concen. Pred			-0.07				
			(-2.15)				
Institut* Concen. Pred.							
Lagged Legislat. Eff. * Concen. Pred	-0.34	-0.46	-0.46	-0.37	-0.36	-0.37	-0.39
	(-2.51)	(-2.23)	(-2.19)	(-2.72)	(-2.7)	(-2.62)	(-2.63)
Lagged Mil. Reg. * Concen. Pred	-0.89	-1.19	-1.34	-0.90	-0.90	-0.76	-0.57
	(-2.95)	(-3.41)	(-3.84)	(-2.87)	(-3.06)	(-2.46)	(-1.84)
Lagged Democracy * Concen. Pred	0.13	0.13	0.16	0.12	0.13	0.11	0.06
	(4.04)	(3.13)	(3.76)	(3.51)	(3.92)	(3.09)	(1.67)
Lagged Judicial. Eff. * Concen. Pred	0.12	0.11	0.15	0.12	0.12	0.18	-
	(3.17)	(2.17)	(2.96)	(2.64)	(3.38)	(2.35)	
Dummies							
Country Dummies	No	No	No	No	Yes	No	Yes
Country Dummies * Concen. Pred.	No	No	No	No	No	Yes	Yes
No. of obs	2427	2210	2210	2427	2427	2427	2427
R^2 (within)	0.2386	0.2094	0.1903	0.2402	0.2723	0.2684	0.3107

t-statistics in parenthesis. All regressions control for income per capita, enrollment in primary and secondary education and electricity production. Regression 2 controls in addition for ln(area) and for ln(population). Regression 3 controls in addition for ln(GDP)