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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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1 Motivation

The presence of political barriers to the adoption of new technologies is believed to be a first order determinant of underdevelopment. The connection between lobbying and technology diffusion works as follows: 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 engage in some kind of activity to deter the diffusion of the new technology.

The different theoretical contributions to the literature differ in the nature of the rents and on the tools that the groups have to deter technology diffusion. In Krusell and Rios Rull [1996], the rents are associated to the specificity of human capital and the deterrence mechanism is the democratic election of a party that forbids the use of the technology. Acemoglu and Robinson [2000] associate the diffusion of the new technology to the lost of power for the political authority. This in turn can bar the diffusion of the new technology. In this paper, the producers of technological goods associated to an old technology may continue being competitive if the legislative authority taxes the goods produced with new technologies. To induce the legislative authority to raise these barriers, the lobby of the old technology goods can offer the authority conditional (monetary) contributions.

More specifically, a technology in our model consists on a set of intermediate goods that are used together. The producers of goods associated to a technology organize themselves in a guild that can offer conditional contributions to a legislative authority that can regulate on the sales tax rate for the new technology goods. Based on the technological superiority of the new technology, on the number of goods associated to each technology and on the sales tax rate for the new technology goods, the consumers of the technological goods decide which technology to use.

In this context, it is crucial to make a distinction between those technologies with and without a previous technology that they can substitute. When the new technology does not have such a predecessor technology, nobody has the incentives to lobby the legislative authority to raise barriers to the diffusion of the new technology. In these instances the new technology will diffuse quickly.

If instead the new technology has a predecessor technology, the lobby of producers associated to the old technology may find it beneficial to coordinate a conditional contribution to induce the legislative authority to raise the sales tax faced by the new technology. Whether these lobbying efforts are successful will depend on the costs faced by the legislative authority to pass the regulation. These costs are of two types. There may be a static cost of raising such barriers that probably is lower the more flexibility the legislative authority has. In addition, 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. Interestingly, the size of the static and dynamic costs depends on different dimensions of the political regime such as the independence of the legislators and whether the regime is democratic. When the political regime makes lobbying successful, our model predicts that the barriers raised by the legislative authority may be sufficient to delay the diffusion of new technologies that have a predecessor technology. This difference in the predicted diffusion patterns of new technologies that have or lack a predecessor substitute technology is central to our empirical strategy.

Despite the theoretical appeal of the hypothesis that lobbies are bad for technology diffusion, all the evidence we have so far is anecdotal.[1] In this paper, we are interested in going beyond the existing anecdotal evidence and trying to assess clearly the empirical importance of lobbies for technology diffusion. The lack of a systematic effort to answer this question is surely the consequence of two important difficulties. First, it is very hard to obtain good measures of the size of these barriers. Second, many of the determinants of the size of political barriers may have independent effects on development, may be endogenous and most likely are correlated to other variables that affect the development of the country.

The strategy we propose and implement in this paper consists on identifying the effect of political barriers on development by estimating the different effect across technologies that some of the country-level variables that according to our theory affect the size of the barriers have. 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]

More specifically, we take the measures of technology diffusion from the Historical Cross-Country Technology Adoption (HCCTA) data set that we introduced in Comin and Hobijn [2003]. This data set contains historical data on the adoption of 25 technologies over the last 215 years for 23 of the World's leading industrial economies. The technologies in our sample cover eight sectors (i) textiles, (ii) steel, (iii) telecommunication, (iv) mass communication, (v) information technology, (vi) transportation (rail-, road-, and airways), (vii) transportation (shipping), and (viii) electricity. Having this large coverage of sectors increases the representativeness of our results. Further, the long time series allows us to have significant variation in the political variables despite the fact that our sample only covers OECD economies.

In our regressions we control for technological elements that affect the diffusion of each technology with a set of time and technology specific dummies. In addition we include a set of controls such as income per capita, enrollment rates, country specific dummies and variables that measure various dimensions of the political regime. These variables capture determinants of technology adoption others than lobbies. Yet, probably, there are other variables that may have an

[1]See for example Mokyr [1990] for numerous annecdotes that support the hypothesis.

[2]Rajan and Zingales [1998] use a similar strategy to identifythe 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.

effect on technology diffusion and may be correlated to the regime variables that, according to the theory, affect lobbying activity. To overcome the possibility of such an omitted variable bias and successfully identify the effect of lobbies on technology diffusion we focus on the differential effect that institutional variables have on the diffusion of the technologies with a technological predecessor.

There are three virtues to this simple test. First, it focuses on the details of the mechanism 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 and 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 provide strong support for the 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, in closed economies, in countries with a non-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 this results we are inclined to conclude that the barriers raised by lobbies to deter the diffusion of new technologies are an important determinant of the speed of diffusion of technologies. Further, since technology diffusion is an important determinant of growth, our identification strategy also serves to pinpoint a specific mechanism by which certain dimensions of institutions affect growth. Namely, through the effect institutions have in inducing lobbying activities which may slowdown the speed of diffusion of technologies.

The rest of the paper is divided in section 2 that contains the model and section 3 that contains the empirical analysis. Section 4 concludes.

2 The model

Our model is a simple and flexible theoretical structure that allows us to understand the interaction between old and new technology producers, lobbies, the legislative authority in various political systems and how these affect the diffusion of new technologies.

2.1 Setting

Sectors- In the economy 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, while in old sectors, firms can use either a new or an old technology. Let Y be the sectorial output. In a new sector,

$$Y = dX_e^{\alpha},$$

where $d > 1$, $\alpha \in (0,1)$ and X_e is a composite of n_e intermediate goods associated to the new technology which takes the following CES form:

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

In an old sector, output is given by the following production function:

$$Y = \max\{X_i^{\alpha}, dX_e^{\alpha}\},$$

where 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:

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

Intermediate goods- Each intermediate good is produced by one and only one producer. This exclusivity allows intermediate goods producers to charge a price above the marginal cost of production, a. For intermediate goods associated to the old technology, a is equal to $\bar{a}$ units of final output. For goods associated to the new technology a is initially equal to $\bar{a}$ but with a (per-period) probability μ, 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 permanently reduced to $\underline{a}$.

In addition to the marginal cost of production, intermediate goods firms have to incur every period in an operating cost of o units of sectorial output before they start producing.

Guilds- All the intermediate goods producers that operate with a given technology are associated in guilds. Guilds are infinitely-lived entities that maximize the present discounted value of its members. They offer one period contingent contributions to the legislative parties in order to affect the legislations that determine the operating costs for the new technology firms.

There is an important asymmetry between the guilds of the old and the new technologies. The old technology guild exists before the new technology arrives. As a result, before the new technology guild has been constituted, the old technology guild can start making contributions to the legislative authority in order to lobby for a tax (τ) on the price of the intermediate goods linked to the new technology.

Institutions- The legislative institution determines the level of the sales tax (τ) on the intermediate goods linked to the new technology. This can take two values: 0 and $\bar{\tau} > 0$.[3] The static 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 guilds (C) and the costs of bending the political constraints imposed by other institutions (S). S depends on the implemented operating costs and on the political system. There is no political constraint when implementing $\tau = 0$ (*i.e.* $S(\tau = 0) = 0$). The cost of implementing $\bar{\tau}$ depends on the independence of the legislative institution. An independent legislative institution can implement the high level of taxes at a cost $\underline{\mathrm{s}}$ lower than the cost of implementing $\tau = \bar{\tau}$ by a constrained legislative institution: $\bar{\mathrm{s}}$.

The decisions taken by the legislative institution also may affect the probability of remaining in power the next period. We model this effect by making the discount rate a function of the operating cost induced 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.[4] To simplify the notation, we assume that the discount factor faced by the legislative agent that has decided to implement $\bar{\tau}$ in a democratic regime is $\hat{\beta}$, lower than the discount factor faced in the rest of scenarios and by the other entities in the economy: β. Later we elaborate more on this interpretation.

Timing- The timing of the stage game is as follows:

After having observed the tax level set on the price of intermediate goods associated to the new technology and the marginal cost of producing them:

0. a_e is realized.

1. The lobby of the intermediate goods firms in the old technology announces the contribution scheme contingent on a, τ and τ'.

2. Lobby e announces the contribution scheme contingent on a, τ and τ'.

3. Firms decide whether to pay the operating cost o and contributions. Production takes place.

4. Legislative authority decides next period's sales tax on the intermediate goods of the new technologies and passes the legislation necessary to implement this level.

[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.

[4]In section 2.3 we extend the model to allow for a reelection of the legislative authority and show that this is the case.

5. Guilds make effective the promised contributions and the legislative authority observes whether it will continue being in power next period.

This stage game is repeated infinitely.

Commitment technology- We assume that guilds can commit to the contingent contributions they make within the period and that the legislative institution cannot change the legislation passed until next period.

We use this setting to investigate the effect of three elements on the speed of diffusion of new technologies. These are: i) the presence or absence of a prior technology, ii) the flexibility of the legislative authority measured by $S(\bar{\tau})$, and iii) the insensitivity of the persistence in power to the barriers raised measured by $\beta(\bar{\tau})$.

2.2 Analysis

We study first 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 Markov Perfect Equilibrium.

2.2.1 Case 1: No incumbent technology

Production, profits and entry- In a new sector, output will be produced with the new technology because it is the only technology available. Let's normalize the price of sectorial output to 1. It is easy to show that

$$X_E = \left(\frac{\alpha d}{p_E}\right)^{1/(1-\alpha)}, \tag{1}$$

where $p_E = \left(\int_0^{n_e} p_{ej}^{-\rho/(1-\rho)} dj\right)^{-(1-\rho)/\rho}$ is the price of one unit of the intermediate good composite X_E. The demand faced by each intermediate good producer is:

$$x_{ej} = X_E \left(p_E/p_{ej}\right)^{1/(1-\rho)}, \tag{2}$$

where p_{ej} is the price of the intermediate good gross of sales taxes, τ. Optimal pricing by intermediate goods producers implies that $p_{ej} = (1+\tau)a_e/\rho$. Plugging this into the expression for p_E, we obtain

$$p_E = (1+\tau)a_e/\rho n_e^{-\frac{1-\rho}{\rho}}. \tag{3}$$

It is then straightforward to solve for the operating profits of the final (Π_E) and of an intermediate goods (π_e) producers:

$$\Pi_E = dX_E^{\alpha} - p_E X_E = (1-\alpha)\, d^{1/(1-\alpha)} \left(\frac{\alpha\rho}{(1+\tau)a_e} n_e^{(1-\rho)/\rho}\right)^{\frac{\alpha}{1-\alpha}} \tag{4}$$

$$\pi_e = (p_e/(1+\tau) - a_e)x_e = \left(\frac{1}{\rho} - 1\right) a_e \left(\frac{\alpha\rho d}{(1+\tau)a_e}\right)^{1/(1-\alpha)} n_e^{\frac{-(\rho-\alpha)}{\rho(1-\alpha)}} \tag{5}$$

Foreseeing these profits, intermediate goods firms decide whether to incur in the operating costs o and in the contributions to the lobby co. Note that π_e may be increasing or decreasing in n_e depending on whether ρ is smaller than α.[5]

Assumption 1: In what follows we assume that $\rho > \alpha$. This pins down the number of firms using the new technology:

$$n_e = \left(\frac{(1/((1+\tau)\rho) - 1) a_e^{\frac{-\alpha}{1-\alpha}} \left(\alpha d\rho/(1+\tau) \right)^{\frac{1}{1-\alpha}}}{o(1+c)} \right)^{\frac{\rho(1-\alpha)}{\rho-\alpha}} . \tag{6}$$

Guilds' contributions- The value of the new technology guild V^e, is a function of the sales tax for the intermediate goods firms (τ) and of their current marginal cost of production (a). This value can be defined recursively as:

$$V^e(\tau, a) = \max_{c_e} \left(\pi_{ej} - c_e \right) n_e o + \beta E V^e \left(\Upsilon(\tau, a, c_e), a' \right),$$

where $\Upsilon(\tau, a, c_e)$ is the policy function of the legislative authority that the guilds take as given and the expectations are taken with respect to a'.

Legislative choices- The legislative authority decides the operating costs of the entrants taking as given the contribution schemes and the political regime. The value of the legislative authority can be defined as:

$$W(\tau, a, c_e) = \max_{\tau'} b + n_e(\tau, a, c_e(\tau')) c_e(\tau') o - S(\tau') + \beta(\tau') E W(\tau', a', c_e')$$

Equilibrium

A Markov Perfect Equilibrium of this infinitely repeated game is a policy function for the guild, $c_e(\tau, a, \tau')$, and a policy function for the legislative authority $\Upsilon(\tau, a, c_e)$ such that:

- $c_e(.)$ solves the guild problem for all $(\tau, a, \tau\prime)$ taking as given $\tau'(.)$.
- $\Upsilon(.)$ solves the legislative authority problem for all (τ, a, c_e) taking as given $c_e(.)$.

Candidate equilibrium- We consider the following strategy profile: Lobby e offers $c_e = 0$ in all the possible subgames, and the legislative authority always sets τ equal to 0.

This strategy profile constitutes an equilibrium because: i) the lobby's action maximizes its value in all the possible subgames provided that $\tau = 0$ and ii) given the lobby contribution scheme, if the legislative authority deviates to $\tau = \bar{\tau}$ in any subgame, its payoff would be $b - S + \beta(\bar{\tau}) E W(\bar{\tau}, a', 0) = b - S + \beta(\bar{\tau}) b/(1-$

[5] This is the case because n_e reduces p_E and p_E has two effects on the demand level x_{ej} : one direct by which a high price level, ceteris paribus, makes more attractive the j^{th} intermediate good, and one indirect by which a high price level reduces the number of units of the composite good (X_e) demanded.

$\beta) < b/(1-\beta)$ which is the legislative authority payoff if he conforms with the strategy profile in the candidate equilibrium.

Proposition 1: This is the unique Markov Perfect equilibrium of this game.

Proof: The new element in proposition 1 is the claim that the equilibrium is unique. The proof works by contradiction. Suppose that there was another equilibrium where the lobby makes some per member contribution to L that is strictly positive. Is it possible to induce the lobby to pay a positive contribution in equilibrium? Since they have the option of making zero contributions, for the lobby to be willing to make the contribution it must be the case that the legislative authority sets $\tau = \bar{\tau}$ in case the contribution of the lobby is smaller than the required level. But, can this strategy be part of a perfect equilibrium? The answer to this question is no, because if the lobby does not make the contribution, the best response for the legislative authority is to deviate and set $\tau = 0$, because in this way it avoids the cost S and the lower discount factor $\beta(\bar{\tau})$. Hence, any strategy profile with a positive contribution is not part of a MPE. Since there is no contribution for L, L will always set $\tau = 0$ in any equilibrium. Hence the only MPE is our candidate equilibrium.

Diffusion- Along the equilibrium path, the diffusion of the new technology is immediate: The period after its introduction, the number of firms that produce the intermediate good associated with the new technology reaches its steady state level $n_e^{ss} \equiv \left(\frac{(1/\rho - 1) a_e^{\frac{-\alpha}{1-\alpha}} (\alpha d \rho)^{\frac{1}{1-\alpha}}}{o} \right)^{\frac{\rho(1-\alpha)}{\rho-\alpha}}$.

2.2.2 Case 2: Exists an incumbent technology

Production, profits and entry- When there is a prior technology, final output firms have a technology choice. When the technology used is the new one, the expressions for X_E, x_{ej}, p_E, Π_E, π_e and n_e are given by expressions (1), (2), (3), (4), (5) and (6).

When final output is produced with the old technology,

$$X_I = \left(\frac{\alpha}{p_I} \right)^{1/(1-\alpha)}, \tag{7}$$

The demand faced by each intermediate good producer is:

$$x_{ij} = X_I \left(p_I / p_{ij} \right)^{1/(1-\rho)}, \tag{8}$$

where p_{ij} is the price of the intermediate good. Optimal pricing by intermediate goods producers implies that $p_{ij} = a_i/\rho$. Plugging this into the expression for p_I, we obtain

$$p_I = a_i/\rho n_i^{-\frac{1-\rho}{\rho}}. \tag{9}$$

It is then straightforward to solve for the operating profits of the final (Π_I) and of an intermediate goods (π_i) producers:

$$\Pi_I = X_I^\alpha - p_I X_I = (1-\alpha)\left(\frac{\alpha\rho}{a_i} n_i^{(1-\rho)/\rho}\right)^{\frac{\alpha}{1-\alpha}} \quad (10)$$

$$\pi_i = (p_i - a_i)x_i = \left(\frac{1}{\rho} - 1\right) a_i \left(\frac{\alpha\rho}{a_i}\right)^{1/(1-\alpha)} n_i^{\frac{-(\rho-\alpha)}{\rho(1-\alpha)}} \quad (11)$$

The number of firms using the new technology is:

$$n_i = \left(\frac{(1/\rho - 1)a_i^{\frac{-\alpha}{1-\alpha}} (\alpha\rho)^{\frac{1}{1-\alpha}}}{o(1+c)}\right)^{\frac{\rho(1-\alpha)}{\rho-\alpha}}. \quad (12)$$

Lobbies' contributions- As before, lobbies associated to the new and old technologies offer contribution schemes to the legislative authority taking as given the contribution scheme of the other guild and the strategy followed by the legislative authority. The value of the new (V^e), and old (V^i) technology guilds are given by:

$$V^e(\tau, a) = \max_{c_e} n_e (\pi_{ej} - c_e) + \beta E V^e (\Upsilon(\tau, a, c_e, c_i), a')$$
$$V^i(\tau, a) = \max_{c_i} n_i (\pi_{ij} - c_i) + \beta E V^i (\Upsilon(a, c_e, c_i), a'),$$

where $\Upsilon(\tau, a, c_e, c_i)$ is the policy function of the legislative authority and c_i is the contribution scheme of the incumbent technology guild.

Initial conditions- The presence of a prior technology introduces a fundamental asymmetry between the problems of the lobby for the incunbent and for the new technologies that determines the initial state. In particular, the period before the new technology arrives, only the old technology lobby is around. The new technology lobby has not been created yet and it has no members (i.e. $n_e = 0$). This gives lobby i the opportunity to bribe L to implement $\tau' = \bar{\tau}$ when the new technology is available next period. In addition, the marginal cost of production for the intermediate goods associated to both technologies is $\bar{a}$.

Legislative choices- The legislative authority decides the sales tax on new intermediate goods taking as given the contribution schemes and the political regime. Its value is

$$W(\tau, a, c_e, c_i) = \max_{\tau'} b + C(\tau', c_e, c_i) - S(\tau') + \beta(\tau') E W(\tau', a', c_e', c_i')$$

where $C(\tau', c_e, c_i)$ is the total contribution received by the legislative authority given the contribution schemes (c_e and c_i) and the selected sales tax for next period (τ').

Equilibrium

A Markov Perfect Equilibrium of this infinitely repeated game is a policy function for each lobby, $c_e(\tau, a, \tau')$ and $c_i(\tau, a, \tau')$ and a policy function for the legislative authority $\Upsilon(\tau, a, c_e, c_i)$ such that:

- $c_e(.)$ solves the guild problem for all $(\tau, a, \tau\prime)$ taking as given $c_i(.)$ and $\Upsilon(.)$.
- $c_i(.)$ solves the guild problem for all $(\tau, a, \tau\prime)$ taking as given $c_e(.)$ and $\Upsilon(.)$.
- $\Upsilon(.)$ solves the legislative authority problem for all (τ, a, c_e, c_i) taking as given $c_e(.)$ and $c_i(.)$.

To start our search for the equilibrium, let's consider the per member contribution that maximizes the total contribution from lobby i to L (i.e. $o * c * n_{i0}$), where

$$n_{i0} = \left(\frac{(1/\rho - 1)(\alpha\rho/\bar{a}^{\alpha})^{1/(1-\alpha)}}{o(1+c)} \right)^{\gamma},$$

with $\gamma \equiv \rho(1-\alpha)/(\rho-\alpha)$. Let's $c^{\max} \equiv \frac{1/\gamma}{1-1/\gamma}$. This is the level of contribution that maximizes the total contribution for the legislative authority. Assumption 1 together with the fact that $\rho < 1$ implies that $\gamma > 1$. This ensures that $c^{\max}$ is well-defined.

In order to deter the diffusion of the new technology, two conditions must be satisfied. First, the contribution scheme made by the incumbent technology lobby must satisfy the incentive constraint of the legislative authority. But that may not be sufficient, because all the legislative authority can do is to pass a regulation that taxes heavily the intermediate goods associated to the new technology. Then it is up to the final output producers to decide which of the two technologies is more convenient to use based on the technological superiority of the new technology (d) and on the sophistication of each of the two technologies measured by the number of intermediate goods associated to them. Next we explore how these constraints shape the equilibrium.

Let's start by determining what is the contribution necessary to induce L to implement a high sales tax for the new technology goods. Initially $a_i = a_e = \bar{a}$. If L always implements $\tau' = 0$ and receives no contributions, its value is $b/(1-\beta)$. $L's$ value when implementing $\tau' = \bar{\tau}$ is $W(\bar{\tau}, \bar{a}, c_i, 0) = b + n_{i0}c_i o - s + \beta(\bar{\tau})EW(\bar{\tau}, a', c_i', c_e')$. The expected value of the legislative authority, $EW(\bar{\tau}, a', c_i', c_e')$, depends on the strategy profile. As we shall see below, in the relevant strategy profiles, lobby e never makes any contribution (i.e. $c_e = 0$) and lobby i always makes a per-member contingent contribution denoted generally by c_i. Further, assume that when the new technology experiences the exogenous reduction in the marginal cost of production (i.e. $a_e = \underline{a}$), the policy implemented by the legislative authority is $\tau' = 0$. Then,

$$W(\bar{\tau}, \bar{a}, c_i, 0) = \frac{1 - \beta(1 - \beta(\bar{\tau})\mu/\beta)}{1 - \beta(\tau)(1-\mu)} \frac{b}{1-\beta} + \frac{n_{i0}c_i o - S(\bar{\tau})}{1 - \beta(\tau)(1-\mu)}$$

It is useful to define the per member contribution level that makes L indifferent between the two possible sales taxes by $\widehat{c}$. Then $\widehat{c}$ is implicitly given by the following expression:

$$\widehat{c}(1+\widehat{c})^{-\gamma} = \frac{1}{\xi o}\left[\frac{b}{1-\beta}[\beta - \beta(\overline{\tau})] + S(\overline{\tau})\right],$$

where $\xi \equiv \left((1/\rho - 1)o^{-1}(\frac{\alpha\rho}{\overline{a}^{\alpha}})^{\frac{1}{1-\alpha}}\right)^{\gamma}$.

Candidate equilibrium 1- FAST DIFFUSION- Lobby i and e offer $c_i = 0$ and $c_e = 0$ in all the possible subgames, and the legislative authority implements always $\tau' = 0$.

Proposition 2: Suppose that assumption 1 holds. If $c^{\max} < \hat{c}$, The *fast diffusion* is a MPE of the game. Further in all the MPE, new technologies diffuse fast (i.e. in the second period).

Proof: $c^{\max}$ is the contribution level that maximizes the total contribution of a lobby (i.e. $c{*}n$). $\hat{c}$ is the contribution level that makes the legislative authority indifferent between implementing $\tau' = \overline{\tau}$ and $\tau' = 0$. $c^{\max} < \hat{c}$ implies that there is no contribution level that can induce the legislative authority to implement a sales tax of $\tau' = \overline{\tau}$. Therefore, $\tau' = 0$ is a dominant strategy for the legislative authority in all the subgames. Since the contributions of the lobbies have no effect on the policy implemented, it is optimal for them to adopt strategies that imply zero contributions in all the subgames such as the ones that compose the fast diffusion equilibrium.□

Discussion: In some circumstances, the maximum contribution that is feasible for the incumbent technology lobby is not sufficient to induce the legislative authority to deter the diffusion of the new technology. What are the circumstances that make $c^{\max} < \hat{c}$? This is the case when $\beta - \beta(\overline{\tau})$ and/or $S(\overline{\tau})$ are large. That is, when implementing a high sales tax for the new technology reduces considerably the probability of reelection for L and/or when it is very hard for L to implement such a policy because it does not have much independence.

However, even when the old technology lobby can propose L a contribution scheme that induces her to legislate a high sales tax for the new technology, it may still be the case that the new technology diffuses quickly. To see that, let's define as $\hat{d}$ the technological superiority of the new technology (d) that makes the final output producers indifferent between using the new and the old technologies. If d is higher than $\hat{d}$ the technology used will be the new one, while if d is below $\hat{d}$ only the incumbent technology will be demanded. $\hat{d}$ is given by the following expression:

$$\widehat{d} = \left(\frac{n_i}{ne}\right)^{\frac{(1-\rho)\alpha}{\rho}} \left(\frac{\tau a_e}{a_i}\right)^{\alpha}$$

It is clear from this expression that $\hat{d}$ is a function of some exogenous (i.e. a_e) and of some endogenous (i.e. n_i, n_e and τ) variables.

It is also useful to define $\bar{c}$ implicitly by the following expression:

$$(1+\bar{c}) = d^{\frac{\alpha(1+\rho)-2\rho}{\rho(1-\alpha)}} (1+\bar{\tau})^{\frac{\rho+\alpha(\rho-\alpha)}{\rho(1-\alpha)}}$$

$\bar{c}o$ is the maximum per member contribution that lobby i can make in state $\bar{a}, \bar{\tau}$ and keep the market. When the per member contribution is larger than $\bar{c}o$, the sophistication of the old technology measured by the number of firms that operate producing intermediate goods associated to the old technology (n_i) is too low for final output producers to prefer using the old to the new technology.

Now we can study when the new technology will diffuse slowly.

Candidate equilibrium 2- SLOW DIFFUSION- Consider the following strategy profile: If the state of the economy is $\overline{a}, \overline{\tau}$, each member of lobby i contributes to the legislative authority $\widehat{c}o$ units of output if it implements a sales tax $\tau' = \overline{\tau}$ on the price of new intermediate goods, and contributes 0 otherwise. Each member of the lobby e contributes 0. Finally, the legislative authority implements a sales tax $\tau' = \overline{\tau}$ on the price of new intermediate goods if the contribution per member of the lobby i belongs to the interval $[o\widehat{c}, o\overline{c}]$, and sets $\tau' = 0$ otherwise. If the state of the economy is different to $\overline{a}, \overline{\tau}$, neither the members of lobby i nor the members of lobby e offer any contribution to the legislative authority, and the implemented sales tax is always $\tau' = 0$.

For this strategy profile to be an equilibrium the following two conditions must hold. First, when the state of the economy is $\overline{a}, \overline{\tau}$ and lobby i makes a per member contribution of $o\hat{c}$, the sophistication of the old technology is sufficient to induce the final output producer to demand the old technology composite.

Condition 1:

$$d < (d(1+\hat{c})))^{-\gamma} (1+\bar{\tau})^{\frac{\rho+\alpha(\rho-\alpha)}{\rho-\alpha}} = \widehat{d}(\bar{a}, \bar{\tau}, \widehat{c}, 0)$$

Condition 2 states that when the marginal cost of producing the new intermediate goods declines to $\underline{a}$, new intermediate goods producers will have incentives to operate even if the current sales taxes they face are high (i.e. $\tau = \bar{\tau}$). This condition ensures that, eventually, the new technology diffuses.

Condition 2:

$$\widehat{d}(\underline{a}, \bar{\tau}, 0, 0) = (d)^{-\gamma} (1+\bar{\tau})^{\frac{\rho+\alpha(\rho-\alpha)}{\rho-\alpha}} \left(\frac{\underline{a}}{\bar{a}}\right)^{\frac{\alpha(2\rho-\alpha)}{\rho-\alpha}} < d$$

Proposition 3: Under assumption 1 and conditions 1 and 2, if $c^{\max} > \hat{c}$, the slow diffusion is a MPE of the game.

Proof: Let's start for the subgames where the state is $\bar{a}, \bar{\tau}$. By the definition of $\widehat{c}$, The value of $\tau' = 0$ for the legislative authority is i) higher than its value if the implemented sales tax is $\tau = \bar{\tau}$ for any $c_i < \widehat{c}$, ii) lower for $c_i \in (\widehat{c}, \bar{c})$, and iii) higher when $c_i > \bar{c}$. These follow from the definitions of $\widehat{c}$ and $\bar{c}$ and imply that, given the strategies of lobbies i and e, the best response of the legislative authority is to implement $\tau' = \bar{\tau}$ whenever $c_i \in (\widehat{c}, \bar{c})$, and to implement $\tau' = 0$ otherwise.

Given the strategy of the legislative authority, the best response of lobby e is to contribute $c_e = 0$. Finally, since $c^{\max} > \hat{c}$, it is feasible for lobby i to have a per-member contribution of $o * \hat{c}$. Further, it is optimal for lobby i to make this contribution because if it does not make the contribution, next period tax rate will be $\tau' = 0$ and n_i will be 0 from then on. (Need to check the condition that $V_i > o * n_i(\bar{\tau}, 0)$).

In state $\underline{a}, \overline{\tau}$, condition 2 is sufficient to ensure that if no contributions are made by any of the lobbies, all the final output producers will use the new technology. The conclusion holds a fortiori if $c_i > 0$. This implies that the total contribution by lobby i is 0 and that L prefers to implement $\tau' = 0$ for all c_e.

This same argument holds a fortiori in the state $\underline{a}, 0$.

Finally, in state $\overline{a}, 0$, it is straightforward to show that

$$\widehat{d}(\bar{a}, 0, 0, 0) = d^{-\gamma} < d.$$

As in state $\underline{a}, \overline{\tau}$, this implies that the total contribution to L by lobby i is 0, that L implements $\tau' = 0$ from then on and that $c_i = c_e = 0$ is optimal.$\square$

For completeness, let's discuss now the case where even when the producers of the intermediate goods associated with the new technologies have learn how to produce these efficiently (i.e. $a_e = \underline{a}$) the new technology does not diffuse.

Candidate equilibrium 3- NO DIFFUSION- Consider the following strategy profile: In all the states of the world, each member of the lobby i contributes to L $\hat{c}o$ units of output if he implements a sales tax $\tau' = \bar{\tau}$ on the price of the new intermediate goods and contributes 0 otherwise. Each member of the lobby e contributes 0. L passes regulation that sets $\tau' = \bar{\tau}$ if the contribution per member of lobby i belongs to the interval $[o\hat{c}, o\bar{c}]$ and sets $\tau' = 0$ otherwise.

Proposition 4: Under assumption 1, if $c^{\max} > \hat{c}$ and if the following condition holds, the no diffusion equilibrium is the unique MPE of the game.

Condition 3:

$$d < (d(1+\hat{c})))^{-\gamma} (1+\bar{\tau})^{\frac{\rho+\alpha(\rho-\alpha)}{\rho-\alpha}} \left(\frac{\underline{a}}{\bar{a}}\right)^{\frac{\alpha(2\rho-\alpha)}{\rho-\alpha}} = \widehat{d}(\underline{a}, \bar{\tau}, \widehat{c}, 0)$$

Proof:

Condition 3 ensures that in state ($\bar{\tau}$,$\underline{a}$) final output firms prefer to use the incumbent than the new intermediate goods. This is the critical condition to show that the there is an equilibrium where the new technology does not diffuse. To show this consider first the state $(\bar{\tau}, \bar{a})$. In these states, L is indifferent between the two sales tax rates given the contribution schemes, the members of lobby I are better off contributing to the legislative authority and the new technology lobby cannot make any contribution to the legislative authority because condition 3 ensures that no intermediate good producer will have incentives to pay the operating costs necessary to operate and make contributions. The same arguments are valid to show that the strategy profile is optimal for all the agents in state ($\bar{\tau}$,$\underline{a}$). Out of the equilibrium path, in states where $\tau = 0$, the strategy profile is an equilibrium because, i) given the strategy profiles, the legislative authority prefers to set $\tau = 0$, ii) since $\tau = 0$, both for a_e equal to $\bar{a}$ and $\underline{a}$, final good firms find more profitable to use the new technology and therefore there will be no demand for the intermediate goods associated to the old technology (i.e. $n_i = 0$) which will make any per member contribution of the old technology lobby equally ineffective to induce a high sales tax. Given that, the new technology lobby finds optimal to set $c_e = 0$. □

2.3 Discussion and testable predictions

Our model has the following predictions:

- If in the sector there is no incumbent technology,[6] nobody tries to deter the diffusion of the new technology. Since the legislative authority has no innate preference for any technology, the new technology will diffuse quickly.
- If there is an incumbent technology, the incumbent technology lobby can induce L to raise barriers to the diffusion of the new technology 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).
  - In these sectoral/institutional environments, if the new technology is much more productive than the incumbent technology (i.e. $d > \hat{d}(\bar{a}, \bar{\tau}, \hat{c}, 0)$) the diffusion of the new technology will also diffuse fast.
  - Instead, when the gap between the productivities of the new and old technologies is not sufficiently large (i.e. $d < \hat{d}(\bar{a}, \bar{\tau}, \hat{c}, 0)$) the new technology diffuses slowly in these sectoral/institutional environments.

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 trade policy, the type of regime and the independence of the legislative authority 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. In the empirical section, we discuss one variable from the Banks data set that attempts to provide a direct measure of this notion.

Trade policy also affects the effectiveness of political contributions from the lobby of old technology producers for at least two reasons. First, lobbying efforts to deter the operation of firms that produce intermediate goods associated to

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

the new technology may be irrelevant in countries that adopt an open policy to trade because final output producers can import the new technology from some foreign country.[7] Second, in countries that have opted for an aggregate policy of trade openness, it may be more costly for the legislative authority to pass regulation that restricts the imports of new technology goods in one particular sector than in countries that in general are more closed. In other words, trade openness probably increases $S(\bar{\tau})$. This interpretation of the model implies that trade openness should accelerate the speed of diffusion of new technologies more in sectors where there is an incumbent technology than in new sectors.

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 (β 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.[8] Note that in the sectors where there is an old 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 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 expect to observe that in sectors where there is an incumbent technology, new technologies diffuse faster in democratic than in non-democratic regimes.

2.4 Previous literature

Our model has two very natural 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

[7] This effect is emphasized by Holmes and Schmitz [2001].

[8] 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.

young agents become a political majority. Acemoglu and Robinson [2000] 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. Also, external threats associated to blocking reduce the elites incentives to block.

Both of these contributions are very interesting and we observe our model as complementary to them. In this sense, there are at least four important dimensions along which we extend the previous work. First, and most importantly, by focusing on the sectoral outcomes (i.e. speed of diffusion of new technologies at the sector level) instead than on 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 an old technology. This distinction is the key to the identification scheme presented below.

At this point, it is relevant to make two related observations. First, that the technologies in the model are embodied in intermediate goods. Second, that in our model institutions shift the composition of investment (between investing in old vs. new technologies), but in principle do not have any effect on total investment. In this sense, our model is consistent with Parente and Prescott [2000] and Hsieh and Klenow [2003] who find that the investment rate computed in domestic currency is uncorrelated with income per capita.

A second distinction between ours and the previous models in the literature is that our framework is flexible enough to investigate theoretically the effects on technology diffusion of a richer set of institutional dimensions. Third, this flexibility allows us to avoid making some shortcuts made by the previous contributions to this literature. In contrast to Acemoglu and Robinson [2000] we believe that most authorities do not have preferences defined over the speed of diffusion of technologies. This is in part the case because, in most instances, individual technologies are too micro for elites to have always a direct preference defined over them. Interestingly, if elites have a preference for new technologies not to diffuse, we should observe that institutions have an effect on the speed of diffusion of new technologies both in the old and in the new sectors. This observation could be used to test the theory proposed by Acemoglu and Robinson [2000].

Fourth, in contrast to both the Krusell- Rios Rull and the Acemoglu-Robinson modeling approaches, our paper emphasizes the special interest motivation of barriers to technology diffusion. Special interest compete to propose an incentive scheme to the legislative authority that induces her to regulate in favorable terms. When modeling that, we recognize the strategic advantage of the producers of the incumbent technology due to the fact that they can anticipate the arrival of the new technology to the market and use their more established organized structure to deter its diffusion. The legislative authority can then increase the operating costs for the producers of the new technology. That is the most it can do in our framework to deter the diffusion of the new technology. We believe that this is a realistic feature of our model since the possibility of operating in the informal sector is present in every regime.

After the legislations have been passed, it is up to the consumers of the technologies to determine what to demand. Hence, our modeling strategy leads to the recognition of and additional constraint that must be satisfied for the success of lobbying efforts in deterring the diffusion of a new technology. Namely, that after the legislative authority has been offered a contribution scheme that induces her to pass the appropriate regulation, entry in the production of both new and incumbent technologies is such that consumers still prefer to buy from the old technology producers. This additional restriction adds a second prediction that we do not test in this paper. Namely, that if a technology is sufficiently revolutionary (i.e. has a high relative productivity, d) it will diffuse quickly independently of the political regime and/or the presence of an incumbent technology. Instead, for less revolutionary technologies (i.e. low d) the political constraints that arise in the presence of an incumbent technology in a country with inappropriate institutions may be binding.

3 Empirics

Measurement: To test the predictions of the model we need to collect three type of variables. First we need to have measures of technology diffusion of various technologies in different sectors and countries over time. We also need to classify these sectors according to whether they are new (i.e. without an incumbent technology) or old (i.e. there is a prior technology that the new technology may substitute). Note that this variable is universal in the sense that it is not country or time specific. 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/policies 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 25 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 from Table 1, we use six different proxies for the level of technology adoption. The first, applied for the data on steel technologies, measures the output produced using a production technology over the output produced with this and with earlier technologies. The second, 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. Thirdly, 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. 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.

In spite of the different ways we measure technology adoption for the technologies in our sample, these measures have one important thing in common. All of them are a proxy of the intensity with which a technology is used in a particular economy at a given point in time.

We divide the sample of technologies in two groups: those technologies that have a previous technology in our sample, and those that do not. The list of technologies in the new sectors is composed by ring spindles, railroad, electricity production and electric arc furnace, computers and robots. The Schumpeterian view claims that in a way or another all the technologies have a more or less direct predecessor. That can be argued in these cases too. However we consider that the predecessors are sufficiently distant technologically and in time for them to have an incentive to lobby against the diffusion of the new technology.

Finally, we use five type of institutional/policy variables from the Banks data set to characterize the environments where the model predicts that lobbying efforts may be effective in deterring the diffusion of new technologies in old sectors.

The 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, trade openness is also a factor that leads to high values of $S(\bar{\tau})$. We measure openness with the exports plus imports share in GDP.

The effect of the legislation passed on the persistence in power depends on the type of regime. We consider two types of regime variables. First, we classify regimes between those that are military and those that are not military. A military regime is one that according to Banks is explicitly or implicitly controlled by a military component of the nation's population. A second dimension of the regime is the type of effective executive. This refers to the individual who exercises primary influence in the shaping of most major decisions affecting the nation's internal and external affairs. There are four possible types of effective executive: Monarch, President, Premier and other. The other category may refer to a military effective executive or to a situation in which the individual in question (such as the party first secretary in a Communist regime) holds no formal governmental post, or to one in which no truly effective national executive can be said to exist. In our regressions we include a set of dummies that identify each of the four possible types of effective executive.

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.

Regressions: The basic regression we run has the following form:

$$y_{ict} = \alpha_0 + \alpha D_{it} + \beta_1 X_{ct} + \beta_2 R_{ct} + \beta_3 I_i * R_{ct} + \epsilon_{ict}. \tag{13}$$

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 (13) ($I_i * R_{ct}$) interacts the institutional variables (R_{ct}) with a dummy variable for the technologies that have a predecessor technology (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 and policy variables, trade openness and legislative flexibility are partially uncorrelated to technology diffusion while having "other" regime is negatively correlated to technology diffusion.

Column 2 reports the coefficients from regression (13). 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 predecessor. Allowing for this differential effect affects some of the coefficients of R_{ct}. In particular, the coefficients of trade openness and the dummies for the president executive become negative while the coefficient for the military regime dummy becomes positive.

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. 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 trade openness has a additional significant positive effect on the diffusion of technologies with a predecessor. Indeed, it is only for these technologies that trade openness is associated positively with technology diffusion.

The other proxy for the static political costs of raising diffusion barriers for the legislative authority is the legislative flexibility variable. Here, 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. again, this differential effect for this set of technologies is highly significant.

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 where the effective executive is not a president, a monarch or a premier

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. 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 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 contraints 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.

The estimated effect of lobbies on technology diffusion, in addition to being statistically significant, is quantitatively relevant. The standard deviation of the diffusion level of the technologies with a predecessor after removing the effect of the technology-time dummies is 0.78. The dispersion induced by the estimated effect of the differential effect of institutional/policy variables on the diffusion of technologies with a predecessor is 0.29. This means that the estimated effect of lobbies on technology diffusion is 37 percent of the observed standard deviation in technology diffusion.

In the rest of table 2, 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 3 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 4 and 5 allow 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.

Finally, in columns 6 and 7 we also allow for a 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 trade openness and the predecessor dummy.

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 a few reasonable controls are included in the regression. 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.

This paper provides an alternative route to establish 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.

4 Conclusion

This paper has established theoretically and empirically the effect that lobbies have on technology diffusion. We have observed that lobbies significantly slow down the speed of diffusion of technologies. Further, our results provide evidence of a specific channel by which certain institutions/policies such as having independent legislative authorities, military or non-democatic regimes or closed economies affect development. Specifically, these institutions and policies make easier for lobbies to induce the legislative authorities to raise barriers to the diffusion of new (and superior) technologies.

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Table 1. Countries and technologies covered

			Period covered: 1788 – 2001
	Countries		Technology measures
1.	Australia (AUS)	*I.*	*Textiles*
2.	Austria (AUT)	1.	Fraction of spindles that are ring spindles
3.	Belgium (BEL)	*II.*	*Steel*
4.	Canada (CAN)	2.	Fraction of tonnage of steel produced using Open Hearth furnaces over steel producer with this and older technologies.†
5.	Denmark (DNK)	3.	Fraction of tonnage of steel produced using Blast Oxygen furnaces over steel producer with this and older technologies.‡
6.	Finland (FIN)	4.	Fraction of tonnage of steel produced using Electric Arc furnaces over steel producer with this and older technologies.↑
7.	France (FRA)	*III.*	*Telecommunication*
8.	Germany (DEU)	5.	(Log.) Mail per capita
9.	Greece (GRC)	6.	(Log.) Telegrams per capita
10.	Iceland (ISL)	7.	(Log.) Telephones per capita
11.	Ireland (IRL)	8.	(Log.) Mobile phones per capita
12.	Italy (ITA)	*IV.*	*Mass communication*
13.	Japan (JPN)	9.	(Log.) Newspapers per capita
14.	Luxembourg (LUX)	10.	(Log.) Radios per capita
15.	Netherlands (NLD)	11.	(Log.) Televisions per capita
16.	New Zealand (NZL)	*V.*	*Information Technology*
17.	Norway (NOR)	12.	(Log.) Personal computers per capita
18.	Portugal (PRT)	13.	(Log.) Industrial robots per unit of real GDP
19.	Spain (ESP)	*VI.*	*Transportation (rail, road-, and airways)*
20.	Sweden (SWE)	14.	(Log.) Freight traffic on railways (TKMs) per unit of real GDP
21.	Switzerland (CHE)	15.	(Log.) Passenger traffic on railways (PKMs) per capita
22.	United Kingdom (GBR)	16.	(Log.) Trucks per unit of GDP
23.	United States (USA)	17.	(Log.) Passenger cars per capita
		18.	(Log.) Aviation cargo (TKMs) per unit of real GDP
		19.	(Log.) Aviation passengers (PKMs) per capita
		VII.	*Transportation (shipping)*
		20.	Fraction of merchant fleet (tonnage) made up of steam and motorships
		VIII.	*Electricity*
		21.	MWhr of electricity produced per unit of real GDP

† Older technologies for open hearth are acid and basic Bessemer and other. ‡ Older technologies for blast oxygen are open hearth, basic and acid Bessemer and other. ↑ Older technologies for Electric arc furnace are the older technologies for blast oxygen plus blast oxygen.

Table 2: Dependent variable: *Technology Diffusion (yict)*

Variable	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Controls (Xct)							
ln(RGDPpc)	1.01	1.05	0.91	0.62	0.53	0.94	0.71
	(22.25)	(23.54)	(10.14)	(10.16)	(5.60)	(10.88)	(5.92)
Prim.enr. 70-	0.39	0.40	0.34	0.38	0.30	0.33	0.46
	(3.91)	(4.10)	(2.85)	(2.84)	(2.08)	(2.89)	(2.86)
Sec.enr. 70-	0.20	0.20	-0.01	0.17	-0.01	-0.04	-0.02
	(2.35)	(2.33)	(-0.09)	(1.38)	(-0.05)	(-0.41)	(-0.12)
Prim.enr. 70+	0.31	0.29	-0.26	0.71	0.17	-0.19	-0.05
	(0.93)	(0.90)	(-0.76)	(1.44)	(0.34)	(-0.57)	(-0.10)
Sec.enr. 70+	-0.19	-0.25	-0.44	0.64	0.51	-0.37	-0.06
	(-0.67)	(-0.93)	(-1.52)	(1.51)	(1.20)	(-1.34)	(-0.14)
ln(MWHR)	0.16	0.17	0.31	0.14	0.31	0.30	0.18
	(7.96)	(8.66)	(6.15)	(5.24)	(5.88)	(6.20)	(2.74)
Policy/Institut (Rct)							
Openness	0.02	-0.39	-0.31	-0.25	-0.19	-0.02	-0.01
	(0.19)	(-3.78)	(-2.66)	(-2.36)	(-1.64)	(-0.18)	(-0.09)
Legislative Flexibility	0.02	0.03	0.00	0.06	0.03	0.02	0.03
	(0.65)	(1.28)	(0.08)	(2.33)	(1.11)	(0.70)	(0.84)
Mil.Reg	-0.02	0.45	0.09	0.08	-0.24	-0.02	-0.04
	(-0.24)	(3.58)	(0.62)	(0.60)	(-1.64)	(-0.12)	(-0.27)
Ex.Mon.	0.55	0.45	0.47	0.57	0.57	0.32	0.40
	(3.79)	(2.90)	(2.81)	(3.69)	(3.43)	(1.86)	(2.27)
Ex.Pres	0.05	-0.33	-0.49	-0.11	-0.29	-0.06	-0.06
	(1.04)	(-5.00)	(-4.65)	(-1.58)	(-2.81)	(-0.48)	(-0.44)
Ex.Other	-0.28	-0.18	0.23	0.00	0.38	-0.07	-0.05
	(-5.08)	(-2.45)	(1.80)	(-0.01)	(3.00)	(-0.42)	(-0.33)
*Controls*Incumb.Tech. (Xct*I)*							
ln(RGDPpc) * Incumb.Tech.				0.83	0.82		0.46
				(9.96)	(9.99)		(2.65)
Prim.enr. 70- * Incumb.Tech.				0.09	0.04		-0.26
				(0.48)	(0.23)		(-1.17)
Sec.enr. 70- * Incumb.Tech.				-0.04	-0.04		-0.04
				(-0.23)	(-0.22)		(-0.18)
Prim.enr. 70+ * Incumb.Tech.				-0.77	-0.78		-0.29
				(-1.21)	(-1.26)		(-0.44)
Sec.enr. 70+ * Incumb.Tech.				-1.50	-1.51		-0.52
				(-2.75)	(-2.85)		(-0.92)
ln(MWHR) * Incumb.Tech.				0.04	0.03		0.24
				(1.00)	(0.93)		(2.49)
*Institut*Incumb.Tech. (Rct*I)*							
Openess * Incumb.Tech.		0.87	0.87	0.56	0.59	0.25	0.23
		(6.16)	(6.32)	(3.73)	(3.96)	(1.32)	(1.21)
Legislat. Eff. * Incumb.Tech.		-0.08	-0.06	-0.14	-0.11	-0.08	-0.08
		(-4.18)	(-3.11)	(-6.60)	(-5.37)	(-3.61)	(-3.63)
Mil.Reg * Incumb.Tech.		-0.92	-0.80	-0.22	-0.13	-0.55	-0.47
		(-5.65)	(-5.00)	(-1.29)	(-0.77)	(-2.59)	(-2.17)
Ex.Mon. * Incumb.Tech.		0.59	0.60	0.42	0.44	0.96	0.78
		(1.74)	(1.80)	(1.26)	(1.33)	(2.81)	(2.24)
Ex.Pres * Incumb.Tech.		0.79	0.81	0.38	0.42	0.00	0.00
		(8.90)	(9.33)	(3.90)	(4.38)	(0.02)	(0.01)
Ex.Other * Incumb.Tech.		-0.20	-0.18	-0.58	-0.56	0.26	0.15
		(-2.05)	(-1.91)	(-5.61)	(-5.54)	(1.19)	(0.66)
Country Dummies	No	No	Yes	No	Yes	Yes	Yes
Country Dummies * Incumb.Tech.	No	No	No	No	No	Yes	Yes
No. of obs.	2915	2915	2915	2915	2915	2915	2915
R^2 (within)	0.351	0.390	0.426	0.416	0.451	0.480	0.482