Liberalization, Democratization and Technology Adoption*

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Abstract

This paper provides a theoretical and empirical investigation of the role of liberalization, democratization and their interactions on the level of technology adopted in an economy. A general equilibrium theory with heterogeneous skills is set up to study the incentives of different groups to favor, or oppose, technology adoption in open and closed economies. The theory predicts the existence of a complementarity between liberalization and democratization for technology adoption. Liberalization should lead to an acceleration in productivity growth if coupled with democratization but may lead to a slow down if these institutional changes are imbalanced. The predictions are tested using panel data for the period 1980-2000 by exploiting within country variation and the heterogenous timing of liberalization and democratization in a difference-in-difference approach. The results confirm the existence of a robust positive interactions between these institutional changes for technology adoption and productivity growth. A transition from a closed autocracy to an open democracy substantially increases productivity. In turns, democratization alone does not significantly increase productivity while liberalization of autocracies may even lead to slow down in technology adoption or productivity. The results substantially qualify previous findings and have relevant policy implications.

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1 Introduction

Trade liberalization and democratization will bring about economic prosperity. Improvements in technology adoption or productivity are, in particular, natural outcomes of greater openness to trade and improved political freedom. This view has found large support in the last decades. The academic literature does not offer robust and unambiguous theoretical and empirical grounds in support of this unconditional view, however. The role of trade liberalization and democratization for income growth through technological change, or adoption, does not appear straightforward. Most importantly, it is not obvious whether institutional changes in terms of either more openness to the world market or improved political freedom should produce the same effects when also the status in the other dimension is taken into account. The role of interactions between trade liberalization and democratization for technological change is, however, essentially unexplored. This paper offers a theoretical and empirical investigation of the role of trade liberalization, democratization, and their interactions, for technological adoption and improved productivity.

The available literature, discussed in more details below, suggests that trade liberalization and democratization may favor technological progress and increased productivity mainly in an indirect way. Trade liberalization increases average productivity leading to a more efficient use of available resources and by reducing the scope for inefficient rent-seeking which is favored, or even made possible, by economic protectionism. Democratization should reduce the political power of rent-seeking oligarchic elites and increase the ability of the population to reap the benefits of their economic efforts. Trade liberalization may therefore erode the economic power of the elites while democratization may erode their political power. When considered jointly these arguments suggest the existence of a complementarity between trade liberalization and democratization: the former may help in reducing the scope for inefficient rent extraction and the latter in reducing the political ability of rent-seekers to react to protect their economic privileges. A relevant, but so far overlooked, implication of this view is that improving institutions in one dimension, but not in the other, may actually be harmful by creating an unbalanced shift in economic and political power. The main idea behind this argument is that, from a political economy perspective, an elite experiencing an erosion of economic benefits might attempt exploiting its political power to protect the declining rents. If larger openness reduces the ability of the political elites to extract resources from the economy in the face of technological advances then they may defend their vested interests for instance by implementing public policies that do not

favor, or even slow down, the adoption or diffusion of new technologies.[1] In other words, if trade liberalization reduces the scope for (politically rooted) rent seeking then we should expect that the its maximum positive effects on technology dynamics are achieved when it is coupled also with a more egalitarian allocation of political power, that is, a process of democratization.

The role of trade liberalization and democratization on the dynamics of technological change or productivity have been studied, mainly independently, by trade theorists and political economists, respectively. An argument often (informally) proposed relates to an affect *à la* Stolper-Samulson. In a developing country with a comparative advantage in producing labor-intensive goods a minority elite well-endowed with resources may loose, while the the majority of workers may benefit from trade liberalization.[2] Another argument relates to the possibility that trade openness increases the quality of intermediate goods in modern sectors thereby increasing total productivity.[3] Following the seminal contribution by Melitz (2003), a large number of recent contributions in international trade predicts aggregate industry productivity to grow with trade liberalization through a selection effect, produced by the reallocation of resources towards more productive firms. This last view finds increasing empirical support. This channel can contribute to explain part of the losses faced by the autocratic elites if they tend to concentrate their interests in relatively less efficient firms (or sectors of production). On the political economy side, it has been documented that oligarchic societies protect their rents by erecting significant entry barriers against new entrepreneurs, whereas more diffused political power in democracies tends to dismantle such barriers making it easier to take advantage of new technologies for the population at large, see Acemoglu (2008). Aghion, Alesina and Trebbi (2007) document that democracy fosters productivity growth in the more advanced sectors of an economy by reducing the protection of vested interests and granting freedom of entry in markets. The role of trade and political regimes is jointly considered by Falkinger and Grossman (2005) that study the interaction between democracy and trade-regimes for the incentive to provide public education. Aidt and Gassebner (2010) argue that it is harder for citizens in autocratic countries to hold their rulers accountable, rulers are more free to extract resources in countries protected by trade barriers by, e.g. exploiting trade taxes. To the best of our knowledge, no theoretical or empirical study addresses the question of the interaction between trade liberalization and democratization for

[1] Seen the other way, successful attempts of implementing policies in defence of vested interests should be less likely if liberalization is coupled with a shift in political power increasing the voice of the population that were not in control of the rents granted by protectionism.

[2] This view is, however, criticized since it should lead to a one shot adjustment while it is not clear why it should lead to a persistent larger growth in productivity.

[3] Halpern, Koren and Szeidl (2005) argue that liberalization increases the availability of new intermediate products and their quality raising the productivity of Hungarian firms. Given the availability of the data, it is however difficult to differentiate between the quality or variety effect of foreign inputs on productivity.

technology adoption and productivity, however.

To address this issue we set up a simple general equilibrium theory. The framework builds on the model by Yeaple (2005), which is extended in several dimensions. Production can take place in two sectors, one using skills more intensively (e.g. the modern sector) and one using unskilled labor only (e.g. the traditional sector). The model features heterogenous workers which can optimally relocate between the two sectors in a general equilibrium setting, where equilibrium wages in both sectors are endogenous.[4] We assume that the (group in control of the) state can extract part of the total production of the economy. Rent extraction takes place mainly (only) in the traditional sector. We consider the possibility of skill biased technology adoption which can take place in the modern (manufacturing) sector of production. Increases in productivity move the production possibility frontier outwards but, crucially, they do so non-neutrally: agents with heterogenous productivity (or skills) benefit differently from technological improvements. Technology adoption changes the allocation of workers between the two sectors thereby affecting output, wages, and prices.

We consider two extreme trade-regimes: autarky, where the demand must be covered by local production, and free-trade where relative prices cannot differ from the international ones. Similarly, we consider two extreme political regimes: autocracy, where a minority is in power, controls the state (and its rents) and chooses public policies, and democracy, where the rents controlled by the state are more evenly shared among the population and the policies are selected by majority voting with universal franchise.[5] The framework is used to characterized the preferences over technology adoption of the relevant political group in each trade and political regime. The results show that the autocratic elites would benefit from larger productivity in a closed, but not in an open economy since in the latter case technology adoption reduces the rents they can extract.[6] At the opposite extreme the model predicts that the majority of the population gains from technology adoption in an open economy while they may (or may not) gain in a closed economy. While all workers un-ambiguously gain from larger productivity in an open economy, a conflict of interests between skilled and unskilled exists in a closed one. As a results the model does not allow to conclude that democratization, *per se*, should lead to larger productivity in autarky. In contrast, the results reveal a complementarity between the trade

[4]Each worker may either supply unskilled (and equally productive) labor to the traditional sector or produce in the modern one. In the latter case individual earnings depend on individual productivity.

[5]We abstract from issues of fiscal redistribution for simplicity and concentrate on public policies aimed at favoring the adoption and spread of new technologies. See also Olson (1982) and, in particular, Mokyr (1998) for discussion on how public policies may facilitate, or slow down, technology adoption.

[6]Also, in a closed economy the ruling elite gain from technology adoption through a reduction in the price of modern goods, whereas in an open economy their demand can be met through imports.

and the political regime on the adoption of more productive technologies.

Empirically, the causal economic effects of trade liberalization or democratization has not been easy to identify. A first problem was the conceptualization and measurement of trade openness and democracy and the precise identification the timing of their changes. A second problem is the identification of the causal effects of these institutional changes on economic outcomes. These problems have been recently addressed by a carefully coding of these institutional changes. These data have been used to identify the causal effects of trade liberalization and democratization by exploiting the heterogenous timing of these institutional changes and restricting attention to within country variation overtime.[7] Rodrik and Wacziarg (2005), Persson and Tabellini (2005) and Papaioannou and Siouraounis (2008) document a positive and significant causal effects of democratization on income growth.[8] Using similar frameworks, Slaughter (2001) studies whether trade liberalization contributes to per capita income convergence across countries.[9] Limited data availability has until recently prevented the possibility of studying the effect of these institutional changes on technology or productivity.[10] Comin and Hobijn (2004) collected data for the pre and post WWII era across twenty five major technologies in twenty three countries over a period of 200 years and document that openness to trade increases the speed at which countries adopts technology. Giavazzi and Tabellini (2005) exploits a difference in differences approach to explore the dynamic feedbacks between economic liberalization (openness to foreign competition) and political liberalization (more egalitarian distribution of economic resources) determines the quality of governments, and hence economic outcomes such as growth and investment. They find positive feedback effects between economic and political reforms suggesting that studying the effects of each reform separately can be misleading. Their results suggest countries that first liberalize and then become democracies do better than those that pursue the opposite sequence.

The role of the interaction between changes in political regime, and increased openness, for the adoption of better technologies (or increased productivity), has not been empirically explored, however. In line with the arguments presented above, and the theoretical predictions, we should expect a positive complementarity between trade liberalization and democratization

[7] In this line of research, the difference-in-difference models have been used to reduce the usual concern of reverse causality (See for e.g Acemoglu, *et al.* (2008) and Papaioannou and Siouraounis (2008) on the effect of democratization on growth).

[8] There is vast literature on the economic effects of democratization on growth at the cross-country level. See for instance Barro (1996), Tavares and Wacziarg (2001) and Przeworksi and Limongi (2004, 2005).

[9] On trade liberalization and growth, the literature so far has used cross-country variations to find a positive robust relationship between the two. See for instance Greenaway, Morgan, and Wright (2002), Edwards (2008), and Wacziarg and Welch (2008).

[10] Dollar and Kraay (2003) study both the roles of institutions and trade for growth to find that countries with better institutions and those that trade grow faster.

for technology adoption. We test this hypothesis using two alternative data sources. The data on technology adoption from Comin, Hobijn and Rovito (2006) and the data on value added per worker from Mayer, Paillacar and Zignago (2008) as dependent variables. We exploit within-country variation in panel regressions with country, time (and technology) fixed effects for the period 1980-2000. The main dependent variables of interest are the timing of trade liberalization and the timing of democratization.[11] The baseline specification investigate the effects of both institutional changes separately and jointly by exploiting a difference-in-difference methodology.[12] The baseline results confirm previous findings by documenting that both trade liberalization and democratization tend to have positive effects on the different measures of productivity (if they are considered separately). The average (treatment) effect of both variables tend to be negative in specifications accounting for both institutional changes, however. This seemingly odd result can be interpreted by finally including an interaction term between the two institutional changes as predicted by the theory. In line with the predictions, the findings document a large positive, and highly statistically significant, interaction between trade liberalization and democratization for technology adoption and productivity. The results suggest that countries going through a joint process of trade liberalization and democratization experience a sizable acceleration in technology adoption. The results are very different from those of countries experiencing unbalanced institutional changes. A process of democratization in autarky does not appear to make any significant difference for productivity while trade liberalization within autocracies might actually slows down technological change and the dynamics of productivity. The results are robust to a set of checks including the use of alternative data, samples, specification and the inclusions of different controls. The findings document that the average (treatment) effects of trade liberalization or democratization might hide relevant heterogeneity and interactions and suggest that studying their role in linear regressions frameworks may potentially be misleading.

The paper is organized as follows. Section 2 builds the theoretical framework and characterizes the general equilibrium, studies the incentives for technology adoption in the different institutions and lays down a testable hypothesis on the effects of the institutional changes on productivity. Section 3 introduces the data, the estimation framework and the empirical results while Section 4 concludes.

[11] The benchmark data on liberalization is taken from Wacziarg and Welch (2003) while the data on democratization exploits variations in the Polity IV index and the dataset assembled by Papaioannou and Siouraounis (2008) as benchmark. Other data sources are used as robustness.

[12] This methodology essentially compares country that liberalized (or democratized) to countries that did not experience institutional changes.

2 Theoretical Analysis

2.1 Set-Up.

Endowments and Preferences. Consider a continuum of agents with unit mass divided into $\gamma < 0.5$ elite and $1-\gamma$ workers. Individual have preferences over a primary good Y and a modern good X,

$$U = Y^{1-\beta} X^{\beta}. \tag{1}$$

The market prices of the two goods are denoted P_Y and P_X. We set the price of the primary good to unity as the numeraire so that $P_Y \equiv 1$. There are two factors of production, natural resource T, owned by the elite, and labor L, supplied by workers. Each worker is endowed with a given amount of skills z distributed among the population according to $G(z)$ with density $g(z)$, where $z \in [1, \infty]$.

Production. Production of the two goods take place in two perfectly competitive sectors: (i) a resource-based primary sector, which uses a productive resource, T, and manual labor, L_Y, to produce good Y; (ii) a productivity-based modern sector, which uses skilled labor to produce good X. Workers can supply their labor to any of the two sectors. The main element that we want to capture with this set-up is that more advanced sectors of production are skill intensive and hence able to absorb the new technologies adopted, while primary goods predominantly rely on a natural resource put into use by manual work.[13]

In particular, Y uses resource T and manual labor L_Y in a constant return to scale aggregate production function,

$$Y(L_Y, T) = L_Y^{\eta} T^{1-\eta}. \tag{2}$$

For simplicity and without loss of generality, we normalize total amount of available resources in the economy to one, so that hereafter $T = 1$ and $Y(L_Y, T) \equiv Y(L_Y)$.

The effective labor supplied by any worker to sector Y is independent from his skill level z so that $l_Y(z) = 1$. On the contrary, the amount of effective labor supplied to X depends on z and it is equal to $l_X(z, A) = z^A$, where $A \geq 1$ represents the productivity of available technologies.[14] Denote by L_X the total amount of workers supplying labor in the X. Production in the modern

[13] In fact the results only require that productivity in the modern sector is relatively more influence by technology adoption than the primary sector. For simplicity we also abstract from the use of a second factor of production such as physical capital in the modern sector.

[14] This modeling strategy essentially follows Yeaple (2005). As shown in the Appendix, this formulation is also equivalent to modeling production in X in a monopolistically competitive sector.

sector is therefore given by the total amount produced by all workers employed in that sector,

$$X\left(L_X, G\left(z\right), A\right) = \int_Z l_X\left(z\right) dG\left(z\right). \tag{3}$$

The amount of production $X\left(L_X, G\left(z\right), A\right)$ therefore depends both on the amount of workers and their productivity.

Factor Income. The elite own all resources in the economy and use them to extract rents as their main source of income. The returns to natural resources is equal to their marginal productivity and given the normalization of T to one, is also equal to total production in the primary sector:

$$\rho\left(L_Y, 1\right) = \frac{\partial Y\left(L_Y\right)}{\partial 1} = Y\left(L_Y\right). \tag{4}$$

As no skills are utilized in production of the primary good in sector Y, a worker's marginal productivity or wage is independent from his skill level and is given by

$$w_Y\left(L_Y\right) = \frac{\partial Y\left(L_Y\right)}{\partial L_Y}. \tag{5}$$

On the other hand, in sector X for a given P_X, earnings by an individual supplying $l_X\left(z, A\right)$ units of effective labor is given by

$$w_X\left(z, A\right) = l_X\left(z, A\right) P_X = z^A P_X. \tag{6}$$

In sum, the wage in the primary sector depends on the amount of labor supply whereas the wage in the modern sector depends on the individual productivity of each worker.

Political Regimes and Technology Adoption. We consider two extreme political regimes. In an autocratic state, policies favor the elite who control natural resources in the country, while in a democratic regime policies reflect the preferences of majority workers, i.e. selected by the median voter. In particular, we study the possibility that the economy can implement policies which allow the productivity in the modern sector, denoted by A, to improve, but are non-neutral to the interests of the different economic agents. To focus on the conflict of interests across different groups with respect to technology adoption, we look at an increase in the productivity of skilled labor in the modern sector through a costless increases in A. This can be interpreted for example as a costless adoption of new technologies that allows a country to advance towards the world technological frontier, a policy aimed at attracting better technologies

through FDI, investing in R&D, the public promotion of education or the reduction of barriers to entry in modern business through better property rights protection, etc.[15]

Trade regimes. We simplify our analysis by looking at two extreme trade regimes. The economy can either be in autarky where there is no possibility to trade, or a fully open economy where all goods can be traded at zero cost. In autarky the entire demand is satisfied with internal production and the relative price of goods may differ from the one prevailing in international markets $P_X \gtreqless P_W$. The opposite is true in a fully integrated economy where internal demand is unrelated to internal production and domestic relative price coincides with the world relative price $P_X = P_W$.

As we are interested in studying the choice of adopting progressive technologies in a relatively backward economy, we restrict attention to the case in which the relative domestic price of the modern good X in autarky is larger than the world relative price $P_X > P_W$. This is true in equilibrium when, compared to the world, the domestic economy is relatively more efficient in producing primary goods. This could for instance be the case whenever productivity of the technology in the modern sector, A, is below the world technology frontier and/or the domestic economy has a (relatively) large endowment of natural resources.

2.2 Equilibrium in the Labor and Product Markets

The economy is in equilibrium when the allocation of workers across sectors is compatible with the market clearing conditions. The labor market equilibrium depends on the occupational choice of workers and the competitive determination of wages. For a given price P_X there is a unique labor market equilibrium. The price P_X emerging in equilibrium in the product market, however, crucially depends on the trade regime.

Labor market equilibrium. Individuals face the choice between working in the primary sector supplying the equivalent of one unit of unskilled labor, or in the modern sector. Consider a given relative price P_X. Workers take competitive wages, prices of goods and the technology of production as given. Making the optimal choice essentially amounts to comparing the expected income that can be earned in either sector, i.e. (5) and (6) given their individual skill level z. A

[15] We are interested in capturing the overall productivity in the so-called modern sectors. In the empirical exercise we consider as main dependent variable of interest both the aggregate level of technology adoption and the average level of manufacturing productivity in terms of average value added per worker.

worker with productivity $\underline{z}$ is indifferent between working in either sector if, and only if,

$$w_X(z, A) = \underline{z}^A P_X = w_Y(L_Y), \tag{7}$$

while any worker with a strictly higher level of skills optimally chooses to work in the X sector. This is true from (7) as all workers with $z > \underline{z}$ enjoy a skill premium,

$$z^A P_X = \left(\frac{z}{\underline{z}}\right)^A w_Y(L_Y) > w_Y(L_Y).$$

Any worker with $z < \underline{z}$ optimally chooses to work in the primary sector. This implies that given $\underline{z}$ the share of workers in the primary sector is

$$L_Y(\underline{z}) = \int_1^{\underline{z}} g(z)dz = G(\underline{z}).$$

The labor market is in equilibrium at $\underline{z}$ if (5) and (6) jointly hold which implies,

$$P_X = \frac{w(L_Y(\underline{z}))}{\underline{z}^A}. \tag{8}$$

Product market equilibrium. The equilibrium in the product market crucially depends on the trade regime.

In an open economy both goods are freely traded on the international market resulting in one world price P_W. Hence when equation (8) holds at $P_X = P_W$ the economy is in equilibrium in both the product and the labor market.

Lemma 1 *[Equilibrium in an Open Economy] In an open economy, for any A there exists a unique $\underline{z}^o$ for which (8) holds so that both the product and the labor market are in equilibrium:*

$$(\underline{z}^o)^A P_W = w(L_Y(\underline{z}^o)). \tag{9}$$

In a closed economy, in turn, production of each good must equal total demand in each sector. In the absence of savings all individual income is used for consumption. Denote expenditure of individual i and aggregate expenditure in the economy by E^i and E, respectively. With preferences (1) the individual optimal expenditure in each type of good is a fixed proportion of total expenditure. This also implies that in the aggregate total demand for each good is given

by,

$$XP_X = \beta E \text{ and } Y = (1-\beta)E.$$

Given $\underline{z}$, total expenditure is given by total income earned by workers and the elite in both sectors and is

$$P_X X\left(\underline{z}\right) = P_X \int_{\underline{z}}^{\infty} z^A dG(z) = \beta E, \tag{10}$$

and

$$Y(L_Y\left(\underline{z}\right)) = L_Y\left(\underline{z}\right)^{\eta} = \left(1-\beta\right)E, \tag{11}$$

in the X and the Y sector respectively. Therefore, the product market clears when (10) and (11) jointly hold. This is the case if, and only if,

$$P_X = \frac{\beta}{1-\beta}\frac{Y(L_Y\left(\underline{z}\right))}{\int_{\underline{z}}^{\infty} z^A dG(Z)}. \tag{12}$$

The product and the labor markets clear at $\underline{z}$ iff (12) and (8) hold simultaneously which implies

$$Y(L_Y\left(\underline{z}\right)) = \frac{1-\beta}{\beta}\frac{w(L_Y\left(\underline{z}\right))}{\underline{z}^A}\int_{\underline{z}}^{\infty} z^A dG(Z). \tag{13}$$

Given the production function (2) we have

$$w(L_Y\left(\underline{z}\right), T)L_Y\left(\underline{z}\right) = \eta Y(L_Y\left(\underline{z}\right)). \tag{14}$$

Using (14) and the definition $L_Y\left(\underline{z}\right) = \int_1^{\underline{z}} dG(Z) = G(\underline{z})$ we can rewrite the equilibrium condition (13) as,

$$G(\underline{z})\underline{z}^A = \eta\frac{1-\beta}{\beta}\int_{\underline{z}}^{\infty} z^A dG(Z). \tag{15}$$

Since the LHS of (15) is strictly increasing in $\underline{z}$ while the RHS is strictly decreasing in $\underline{z}$ we have,

Lemma 2 *[Equilibrium in a Closed Economy] In a closed economy, for any $\{A, G\left(z\right)\}$ there exists a unique $\underline{z}^*$ for which (15) holds so that both the product and the labor market are in equilibrium.*

The equilibria under different trade regimes differ in that in an open economy the equilibrium allocation of workers solely depends on the relative productivity of the two sectors in terms of A, while in a closed economy it also depends on the availability and distribution of skills $G(z)$.

2.3 Technology Adoption and Trade Openness

We now look at the possibility of adopting a superior technology that improves productivity in the modern sector, A.

We rule out full specialization to reduce the analysis to the more interesting case in which the economy produces both goods.[16] The effect of increasing productivity A on the equilibrium in an open economy can be summarized in the following Proposition:

Proposition 1 *[Technology Adoption in Open Economy] Under free trade where $P_X = P_W$, an increase in A, e.g. adopting a better production technology in the modern sector*

1. *increases the share of workers in the modern sector: $\partial \underline{z}^o(A)/\partial A < 0$;*
2. *limits extractable rents by the elite: $\partial Y^o(L_Y)/\partial A < 0$;*
3. *increases the minimum participation wage to work in the primary sector: $\partial w(L_Y(\underline{z}^o))/\partial A > 0$;*
4. *increases the skill premium for all workers in the X sector: $\partial[(z/\underline{z}^o(A))^A]/\partial A > 0$.*

Proof 1 *See Appendix.*

This Proposition states that technology adoption has non-neutral effects on the well being of heterogeneous individuals. In particular, an improvement in the productivity of the modern sector attracts more workers into that sector. As a result, total production in the modern sector increases, $\partial X^o/\partial A > 0$, while production in the primary sector falls, $\partial Y^o/\partial A < 0$. In the primary sector, where labor gets scarce and marginally more productive, the minimum participation wage (marginal product of labor) increases. A rise in productivity A increases the skill premium $(z/\underline{z}^o(A))^A$ both directly and by reducing the threshold skill level $\underline{z}^o$ required to work in the modern sector. Consequently, the adoption of a better technology increases the income of all workers (and more than proportionately for the most skilled) at the expenses of extractable rents by the elite, which given (4) fall with Y^o.

The analysis reveals that technology adoption in an open economy harms the elite by limiting their ability to maintain rents from their resources despite improved productivity in the modern sector. On the other hand, workers attain a higher bargaining power due to their increased productivity, and require a higher wage to work in the primary sector. In technical terms,

[16] Clearly, adopting a new technology A in the modern sector has no significance if the economy remains fully specialized in the primary sector (since e.g. endowment of natural resources is very large).

opening the economy to trade relaxes the demand constraint for the Y goods. The increased demand for these goods as a result of higher income can now be imported from the rest of the world. Therefore, $\underline{z}^o$ is free to move down when workers decide to move to the X sector where their skills become more valuable and wages higher as a result of technology adoption. This trend continues until wages in the two sectors are equalized in equilibrium.

The effect of adopting a better technology A in a closed economy is characterized in the following Proposition:

Proposition 2 *[Technology Adoption in closed Economy] In a closed economy an increase in A, e.g. a more productive modern technology*

1. *increases the share of workers in the modern sector: $\partial \underline{z}^* (A) / \partial A > 0$;*
2. *increases rents extracted by the elite: $\partial Y (L_Y) / \partial A > 0$;*
3. *reduces the minimum participation wage to work in the primary sector: $\partial w(L_Y (\underline{z}^*), T)/\partial A < 0$;*
4. *decreases (increases) the skill premium for less (more) skilled workers: $\partial[(z/\underline{z}^* (A))^A]/\partial A \gtreqless 0 \iff z \gtreqless \overline{z} (A)$ where $\overline{z} (A) > \underline{z}^* (A)$.*

Proof 2 *See Appendix.*

In a closed economy improvements in the productivity of the modern sector lead to a shift of workers away from this sector. As labor becomes more abundant in the primary sector, the bargaining power of workers and hence the wage they require to participate in the primary sector $w(\underline{z}^*)$ is reduced. This also reduces wages of all workers in the X sector, as $w(\underline{z}^*)$ is the base wage in the modern sector.[17] In equilibrium, the increase in $\underline{z}^*$ also reduces the skill premium of all X sector workers with respect to the new more skilled indifferent worker $\underline{z}^*$. As a result, rents extracted by the elite from natural resources increase with Y production at the expense of wages of workers in both sectors. The loss in skill premium of X sector workers due to a higher $\underline{z}^*$ more than compensates the gain in skill premium from improved productivity A for skill levels up to $\overline{z} (A)$. Only workers with sufficiently high skills $z > \overline{z} (A)$ experience a strict net gain in their skill premium from technology adoption.

The results uncover that technology adoption in a closed economy allows the elite to exploit more rents from their resources as a result of improved productivity in the modern sector. On the

[17] A higher $\underline{z}^*$ implies that the indifferent worker in X is more skilled than the indifferent worker prior to technology adoption, yet accepts a strictly lower wage in equilibrium.

other hand, it shifts the 'bargaining power' of workers from low to high skilled labor by moving the production possibility frontier outwards and results in an upward shift in $\underline{z}^*$. The primary sector absorbs residual labor and therefore provides an (inferior) outside option for workers in the modern sector. The seemingly counter-intuitive effect of an expansion of the primary sector is due to the fact that in a closed economy internal demand and supply must equalize in general equilibrium, i.e. all demand has to be met through local production. Technology adoption increases total income, which raises the demand for all goods including the primary good Y. Since the larger demand can only be satisfied by domestic production it requires a larger share of workers in the primary sector. Similarly, the larger demand for X is satisfied by an increase in production using less workers, who are nonetheless more productive when working with better technologies. In equilibrium the price of the X good decreases, that is $\partial P_X/\partial A < 0$, which also implies that the increase in its total production is larger than that of Y.

2.4 Technology Adoption Conditional on Trade and Political Regimes

The previous Section characterizes the effects of increasing productivity in the X sector through the adoption of a new technology on the income of different individuals in both an open and a closed economy. To investigate individual attitudes toward improvements in A we need to consider the change in the indirect utility of each group, which depends on both individual income and the relative price.

Recall that the nominal income of the resource-controlling elite is given by returns to total rents in the economy divided by the number of elites in the society, $Y(L_Y)/\gamma$, where we use $(T\rho)/\gamma = Y(L_Y)]\gamma$ with $T = 1$ and γ representing the size of elite in the society. Next, the nominal income of each primary sector worker is simply given by their wage, $w(L_Y)$. Finally, from (6) the income of an individual with skill z working in the modern sector is given by their skill-based individual wage, $w(z) = w(L_Y)(z/\underline{z})^A$.

We can now calculate the indirect utility of each individual i by

$$V^i = \left(Y^i\right)^{1-\beta}(X^i)^{\beta}. \tag{16}$$

As seen above, the maximization of individual utility requires that total expenditure in each good be a fixed proportion of total individual expenditure so that

$$X^i P_X = \beta E^i \text{ and } Y^i = (1-\beta)E^i,$$

where the price of primary goods is taken as the numeraire. Rewrite (16) as

$$V^i = \widetilde{\beta}\frac{E^i}{P_X^{\beta}}, \tag{17}$$

where $\widetilde{\beta} \equiv \beta^{\beta}(1-\beta)^{1-\beta}$. Since total expenditure of each agent equals his total income, equation (17) essentially states that the indirect utility of each individual is proportional to his real income, which is given by his nominal revenues divided by price index $p = P_X^{\beta}$.[18] Consequently each individual is better off after the improvement of technology A if and only if his real income increases.

Looking at the indirect utility of each group from (17) together with Propositions 1 and 2, we can observe changes in (policies towards) technology adoption in a country that goes through a shift in its political or trade regime. Assuming a closed autocracy as the baseline scenario, we investigate trade liberalization, democratization, and a transition that involves both.

We first look at the influence of trade liberalization on technology adoption.

Corollary 1 *[Trade Liberalization] An increase in A leads to an increase in the real income of the resource-owning elite since $\partial[Y^*(L_Y)/\gamma]/\partial A > 0$ and $\partial P_X/\partial A < 0$ in a closed economy, while it implies a reduction in their real income under an open economy since $\partial[(Y^o(L_Y)/\gamma]/\partial A < 0$ and $P_X = P_W$.*

Corollary (1) states that better productivity in the modern sector enhances the ability of the elite to extract rents from their resources in a closed economy, while it hampers their ability to do so in an open economy. Therefore, it is in the interest of the ruling elite in an autocracy to adopt new technologies when their economy is in autarky, and to block the such improvement when their economy is integrated with the world market.

Focusing on closed economies, following Corollary (1) we obtain,

Corollary 2 *[Democratization] In a closed economy, an increase in A raises real income of the resource-owning elite since $\partial[Y^*(L_Y)/\gamma]/\partial A > 0$ and $\partial P_X/\partial A < 0$, while it has ambiguous consequences for (all) workers: in the primary sector since $\partial w^*(L_Y)/\partial A < 0$ but $\partial P_X/\partial A < 0$, and in the modern sector since $\partial w^*(L_Y)/\partial A < 0$, $\partial P_X/\partial A < 0$ and $\partial[(z/\underline{z}^*(A))^A]/\partial A \gtreqless 0 \Longleftrightarrow z \gtreqless \overline{z}(A)$.*

To understand Corollary (2), first recall the distribution of political power, where we identify an economy as an autocracy if policies are made in favor of the minority elite, and a democracy

[18] Without normalization the price index reads $P = P_Y^{1-\beta}P_X^{\beta}$.

if majority rule prevails in support of workers. A more productive modern sector in a closed economy expands the primary sector, thereby increasing the income of owners of natural resources $Y^*(L_Y)$ and decreasing P_X. On the other hand, although workers also gain from a lower P_X, they experience a negative income effect. Labor in both sectors are affected negatively from a lower $w^*(L_Y, T)$, while the most skilled experience an additional gain from a larger skill premium. The net effect of technology adoption is ambiguous for workers and depends on whether the negative income effect or the positive price effect dominates. If the income effect dominates, workers in the primary sector are worse off, and the reverse holds if the price effect does so.[19] Nevertheless, workers are more likely to lose from technology adoption than the elite.

We conclude by studying the impact of trade liberalization, when accompanied by democratization.

Corollary 3 *[Trade Liberalization and Democratization] In an open economy an increase in A raises the real income of workers as* $\partial w^o(L_Y)/\partial A > 0$ *and* $\partial[(z/\underline{z}^o(A))^A]/\partial A > 0$. *While it is unclear whether there is more technology adoption in an open democracy than a closed autocracy since* $\partial[Y^*(L_Y)/\gamma]/\partial A > 0$, *an open democracy is more likely to adopt new technologies than an open autocracy since* $\partial[(Y^o(L_Y)/\gamma]/\partial A < 0$.

Corollary (3) is directly derived from the previous two Corollaries. An open democracy clearly favors technology adoption as it increases the real income of all workers, i.e. $\partial w^o(L_Y)/\partial A > 0$ and $\partial[(z/\underline{z}^o(A))^A]/\partial A > 0$. Given $\partial[(Y^o(L_Y)/\gamma]/\partial A < 0$, technology adoption is higher in an open democracy than an open autocracy, but is undeterminable with respect to a closed autocracy. The intuition behind the results is the integration of domestic prices to world prices and hence the absence of a price effect in the indirect utility of the population. Adopting a better technology under an open economy expands the modern sector, reducing the income of the elite while increasing nominal and real wages of all workers. We can hence conclude that starting from a closed autocracy, a joint movement towards democratization and trade liberalization is encouraged as it results in less restrictions on the adoption of new technologies than only opening to trade.

As a result the model predicts a strategic complementarity between trade and democracy for technology adoption. These results are our testable hypothesis and summarized in the following Proposition:

[19] Note that the effect of A on $\underline{z}^*(A)$, which is determined by the distribution of skills, plays an important role here: if this is large, then the income effect is also large and workers in the modern sector are more likely to lose from increased productivity in that sector.

Proposition 3 (Technology Adoption, trade Openness and Political Regimes) *Starting from a closed autocracy as the baseline scenario, for any $G(z)$:*

1. *Trade liberalization has an adverse effect on technology adoption.*
2. *Democratization has an ambiguous effect on technology adoption.*
3. *A joint policy of trade liberalization and democratization is encouraged as it results in less restrictions on technology adoption than only opening to trade.*

Proof 3 *See Corollaries 1-3.*

3 Empirical Evidence

3.1 Data and Empirical Methodology

Data on Labor Productivity and Technology Adoption. The CEPII *"TradeProd"* data build on data from the OECD and UNIDO to provide information on wages per worker in manufacturing for a broad sample of countries. The relatively large sample of the TradeProd data set comes at some costs to cross-national comparability. Most of countries report wages and salaries while few countries report compensation of employees. In order to draw cross-country comparison, we approximate wages by labor productivity calculated as the ratio of value added over employment. According to Rodrik (1999) manufacturing value added per worker explains on its own 80 to 90 percent of the cross-national variation in manufacturing wages. The data are available for 98 countries from 1980 to 2000. The list of countries is provided in Table 9.

Data on technological progress have been taken from the Cross-Country Historical Adoption of Technology (CHAT) dataset developed by Comin and Hobjin (2004) and extended by Comin, Hobjin and Rovito (2006). The data has the advantage to measure the technology directly. We restrict our analysis to the adoption of technologies between 1980 and 2000. Our period of analysis covers the Third Wave of Democratisation period described by Papaioannou and Siourounis (2008). Our baseline sample contains data on the adoption of 83 technologies for 129 developed and developing countries. The lists of countries and technologies are provided in Table 9 and 10 of Appendix 5.2. In Table 10, we follow Comin and Hobjin (2009) and classify the technologies in 8 broad categories: agriculture, financial, general, health, steel, telecommunication, tourism and transportation. Our sample is smaller than the initial CHAT dataset for two main reasons.[20] First, we restrict the analysis to the countries for which we

[20]The CHAT dataset contains information on the adoption of over 100 technologies in more than 100 countries.

have the information on the explanatory variables. Second, we eliminate the technologies for which we do not have information during the period considered or for which we have repeated information.

Because of data availability constraints, the technologies are measured in different units. For instance, many of our measures correspond to the number of specific capital goods per capita (computers), some technologies are measured by the output produced with the technology (steel production in electric arc furnaces) and others are measured directly by the technique's level of diffusion (number of credit and debit card transactions or cheques issued, both on per capita basis).[21] To control for this difference in measurement, we follow Comin and Hobjin (2007) by including a full set of time and technology specific effect in our estimations. This methodology has also the advantage to control for the fact that technologies follow different adoption paths.

Data on Trade and Political Regimes. We use an indicator of trade liberalization that has been taken from Wacziarg and Welch (2003). They update the Sachs and Warner (1995) openness indicators and trade liberalization dates. We focus on trade liberalization dates rather than openness indicators since our theoretical framework has only predictions on the former. The liberalization date is the date after which the Sachs and Warner's openness indicators are met. According to Sachs and Warner, a country is defined as being opened if none of the following criteria is met: (i) average tariffs exceed 40 percent, (ii) non-tariff barriers cover more than 40 percent of trade (iii) it has a socialist economic system (iv) the black market premium on the exchange rate exceeds 20 percent, or (v) there is a state monopoly on major exports. The trade liberalization variable is dichotomous. It takes the value of one at the starting date indicated by Wacziarg and Welch (2003), and zero otherwise.

The Sachs and Warner indicator has received many critics in the empirical literature. In particular, Rodriguez and Rodrik (2000), argue that the openness indicator as well as the liberalization dates are mostly driven by the last two criteria. In their empirical study, Wacziarg and Welch (2003) show that their updated liberalization dates do not simply capture changes in the black market premium and/or in the state monopoly status on export, but they also reflect broader liberalization. The liberalization dates *reflect thus important shifts in trade policy.*[22] We show in Table 9 that our sample is composed by 33 opened countries, 34 closed countries and 60 countries that have opened to trade during the sample period.

We consider two types of political regimes: autocratic and democratic. The political regime

[21] See Comin and Hobjin (2009) for a full description of the technologies and their different measurements.
[22] Wacziarg and Welch (2003), p. 196

are taken from the Polity IV database. The polity variable measures the quality of democratic institution and varies from +10 (strongly democratic) to -10 (strongly autocratic). We do not consider improvement in each type of regime, since our theory does not provide testable predictions on it. We assign the value of 1 to countries that are democratic and zero otherwise. As shown in Table 9, our sample is composed by 45 democracies, 25 autocracies and 59 countries that have switched their political regimes during the sample period.

A detailed description of the variables used, their data sources and the descriptive statistics, are presented in Appendix 5.2. Table 12 and 11 of Appendix 5.2 lists all countries included in the sample and their average number of technologies under each of their trade and/or political regimes.

Empirical Methodology. The theoretical framework suggests that the manufacturing wages and the level of technological progress might depend of a country trade and political regimes. In the econometric analysis, we will study the impact of trade liberalization and the political regime on both dimensions using two novel datasets. First, we make use of the CEPII country-level database developed by Mayer, Paillacar and Zignago (2008) to approximate the manufacturing value added per worker. Second, we use the data on technology diffusion brought by the Comin, Hobjin and Rovito (2006).

To estimate the predictions of the model, we need to estimate how the relationship of the trade regimes changes with the political regimes. We use different panel estimation techniques by including an interaction term between the trade and political regime variables. Our empirical models allow us to obtain the estimated wage and adoption differential among all of the following groups: closed democracies, opened democracies, closed autarkies and open autarkies. Yet, the estimated coefficients must be interpreted in comparison to a reference. We choose the set of closed autocratic countries to be the base group. The theoretical model implies to compare the economic outcomes of a country once it has liberalized. We use panel data techniques to estimate the *within-country* effect of political or/and trade regimes changes. Using the country fixed effects methodology has the advantage to control for omitted variables such as geography or social norms that may affect both wages and technology adoption.

Our first econometric model study the effect of trade and political regime on manufacturing value added per worker. The model suggests that the value added per worker of country j at time t, LP_{jt}, is smaller in autocratic countries that liberalize. We include thus a interaction term between the trade regime variable, LIB_{jt}, and the political regime variable, $DEMOC_{jt}$.

$$
\begin{aligned}
ln\left(LP_{jt}\right) &= \beta_0 + \beta_1 LIB_{jt} + \beta_2 DEMOC_{jt} + \beta_3 \left(LIB_{jt} \times DEMOC_{jt}\right) \\
&+ \mu_j + \mu_t + \varepsilon_{it}
\end{aligned} \tag{18}
$$

μ_j, is the set of time-invariant country-specific effects. In addition, we control for time trends and business cycle dynamics by including a full set of year specific effects, μ_t. ε_{ijt} is the usual error term.

In our second econometric model, we study the effect of trade liberalization and the political regime on the level of technology adoption. The adoption of technology i in country j at time t, $TechA_{ijt}$, depends on its trade regime LIB_{jt}, and its political regime $DEMOC_{jt}$. As in the previous model, we include country-specific effects and an interaction term between the trade and political regime variables. Following Comin and Hobjin (2007) we use of a full set of time and technology specific effects. We denote by ν_{it} the fixed technology $\times$ year fixed effects in equation 19. This means that our dependent variable is the deviation of the adoption level of each technology in country j at time t from the average adoption level in the technology and period across countries. Using country-specific effects, the estimated coefficients are identified on country that switch their political and/or trade regimes.

$$
\begin{aligned}
ln\left(TechA_{ijt}\right) &= \lambda_0 + \lambda_1 LIB_{jt} + \lambda_2 DEMOC_{jt} + \lambda_3 \left(LIB_{jt} \times DEMOC_{jt}\right) \\
&+ \nu_j + \nu_{it} + \varepsilon_{ijt}
\end{aligned} \tag{19}
$$

ν_j is a set of time-invariant country-specific effects. ε_{ijt} is the error term.

In all specifications of both models, we use clustered standard errors at country level (Wooldridge, 2003; Arellano, 1987).

3.2 The effect of Liberalization and Democratization on Productivity

The results are presented in Table 2. Overall, our specifications explain from about 22% to 88% of the variation of the log of the labor productivity variable as suggested by the adjusted R^2. Notice that the results should be interpreted in comparison to the base category which is the set of closed autocracies.

Baseline Results. As preliminary results, we report first the OLS regression that estimate the *cross-country* or *between* effect of political and trade regime on labor productivity. The OLS specification in column (4) shows a statistically insignificant effect of the democracy and openness variables. However the opened democracy variable is statistically significant at five percent level. The results does not change if we control for global shocks by adding year fixed effects as in column (5). The coefficient of the opened democracy variable is halved but estimated with more precision if we control for unobserved country-level heterogeneity, adding country fixed effects.

In columns (7) to (12), we include both time and country fixed effects to isolate the within effect of a regime change on labor productivity conditional on global trend. We do not find a robust effect of the political regime variable. Democracy is negative and marginally significant at 10% level of significance in columns (10) and (12). This result suggests that democratization alone does not bring labor productivity gains.

The specifications (7) to (12) consistently show that openness and the interaction between the political *and* the trade regime affect significantly labor productivity. In particular, from the coefficient of the openness variable in column (10), we find that autocracies are about 44.7% less productive when they liberalize. The coefficient of the interacted term is highly significant and positive. We find that autocracies that liberalize and democratize are about 35% more productive than closed autocracies.

Insert Table 2 about here

The openness variable and the interaction term are significant through all the remaining specifications. Since our study relies on the Polity IV index, the change in political regime may or may not be permanent. A first concern is whether the instability in political regime have affected the results of Table 2. In column (11), we take into account the durablity of the political regime which is defined by in Marshall and Jaggers (2007) as the number of years since the most recent regime change or the end of transition period. We exclude all the observations for which the political regime durability is smaller than 5 years. The findings remain similar even if the interaction term is estimated with a lesser degree of precision.

A second concern is whether the results are driven by the market reforms that the former socialist countries have implemented in the 1990s. There are 5 socialist countries in the labor productivity sample (Estonia, Georgia, Kyrgyzstan, Latvia, Lithuania). In column (12), we exclude these countries from the regression. Our findings remain robust and similar to those found in column (10).[23]

[23]The results remain valid if we also exclude India, a former mixed-socialist country that undertook market

We next conduct two robustness checks. We first check whether our findings are mostly driven by a change in political regime or by trade liberalization. Second, we use two alternative definitions for the political regime variable.

Impact of Trade Liberalization on Labor Productivity. We consider the sample of countries that have liberalized their trade regime and did not change their political regime. They are either democratic or autocratic. The sample reduces to 21 countries and 275 observations.[24] In Table 3, the openness variable and the interaction term remain highly significant confirming the predictions of our theoretical model. Liberalization reduces labor productivity by about 40% in autocratic countries while it has no significant effect for democracies.[25]. Democratization *and* liberalization bring about 37% more labor productivity.

Insert Table 3 about here

Alternative measures of political regime. We also provide two alternative measures of the political regime variable. The first is taken from Papaioannou and Siourounis (2008) and concerns permanent change in political regimes. The indicator developed by Papaioannou and Siourounis (2008) is based on the Freedom House measures of civil liberties and political rights and on the Polity Project composite democracy index. It has the advantage to identify regimes transitions rather than the level of political freedom. We extend their index to all countries that were either democratic or autocratic during the sample period.[26]

The second indicator is taken from Golder's (2005) database of regime characterization. The Golder (2005) methodology classifies a regime as democratic if those who govern are selected through contested elections. A regime is considered a dictatorship if the chief executive is not elected, the legislature is not elected, there is no more than one party, or there has been no alternation in power (Przeworski et al. 2000). As stressed by Papaioannou and Siourounis (2008), the Golder classification examines solely electoral outcomes and does not check whether these outcomes are accepted by the international or domestic community. The results shown in Table 4 are mostly in line with the previous findings. However, the estimated impact of the

reforms in 1991.

[24]Burkina Faso, Cameroon, Colombia, Costa Rica, Czech Republic, Dominican Republic, Ecuador, Egypt, Georgia, Honduras, Israel, Kenya, Kyrgyzstan, Latvia, Lithuania, Morocco, New Zealand, Slovenia, South Africa, Sri Lanka, Tunisia.

[25]In order to quantify the impact of liberalization in democratic countries, we compute the difference between both coefficients and its statistical significance: 0.368-0.398=-0.023, t-statistics=-0.19

[26]Few countries in the sample of Papaioannou and Siourounis (2008) are identify has transition countries while they have a permanent autocratic or democratic status in our sample (Czech Republic, Dominican Republic, Ecuador, Estonia, Honduras, Latvia, Lithuania, Portugal, Slovak Republic, Slovenia, South Africa). We consider them has having a transitory status as in Papaioannou and Siourounis (2008)

interacted variables is lower and estimated with a lesser degree of precision when we use both country and time specific effects.

Insert Table 4 about here

3.3 The effect of Liberalization and Democratization on Technology Adoption

We next analyze whether the deviation in a country's level of technology adoption from the average across countries is linked to a change in its political and trade regime. As in section 3.2, we use a set of country-specific effect to analyze the within effect of a change in political and/or trade regime. Following Comin et al. (2006), our estimations entail also a full set of technology $\times$ year specific effects to account for the difference in adoption paths across technologies.

Baseline results. The estimates are reported in Table 5. Our different specifications explain about 95% of the variation of the dependent variable. The results are mostly in line with the predictions of our theoretical model. In particular, we find a negative and significant coefficient of the openness variable meaning that autocracies adopt less technology once they have liberalized. In column (4), the adoption level of autocracies that have liberalized is about 19% smaller than in autocracies that have remain closed.

Insert Table 5 about here

The democracy variable is not robustly significant across specification. In particular,the effect turns to be insignificant once we control for the general level of development by adding the per-capita GDP variable. We find however that the interaction term is positive and significant across specifications. From the estimates of interaction variables, we find that the adoption level about 14% to 22% larger for countries that both liberalize and democratize.

In columns (5) and (6), we control for the overall level of development by including a per-capita GDP variable and for the market size by including country's GDP. We find that the size of the economy has a positive and significant effect on the level of adoption. It has often proven to be an important determinant of technological progress (Comin and Hobjin (2007)). The income per capita variable is also significant but has a negative impact on the level of technology adoption. A higher level of income per capita is associated with a lower level of technology adoption.

In column (7), we exclude all observations for which the political regime durability is smaller than 5 years. We find a slightly larger effect of the openness variable and the interacted term. In

column (8), we drop the socialist countries from the estimation. The estimates imply a smaller impact of the interaction variable on the level of technology adoption which remain significant.

In columns (9) and (10) we successively add controls for the educational level and countries' land endowments. The estimates a very small and are both statistically insignificant. Both control variables exhibit yet very small within country variation.

We have conducted several robustness checks to assess the validity of our results. We first analyze the impact of liberalization on a smaller sample of countries that have a permanent political regime during the sample period. We use next the two alternative definitions of the political regime variables proposed by Papaioannou and Siourounis (2008) and Golder (2005). Finally, we check whether our main results are driven by a particular category of technology.

Impact of trade liberalization in countries that have permanent political regimes In Table 6, we restrict the sample to the 28 developed and developing countries that are either autocratic or democratic and that have liberalized their trade during the sample period.[27] Since our model include country and technology×year fixed-effects, our model focuses on the differential impact of trade liberalization. The coefficient of the openness variable inform on the effect of liberalization on autocratic countries. Table 6 reports the estimates.

Insert Table 6 about here

The openness variable is negative and significant. This suggests that the post-liberalization adoption level of autocratic countries is smaller than there pre-liberalization level. This finding is robust to the exclusion of socialist countries in column (5).

Alternative Political Regime Definition. We replicate the results using the Papaioannou and Siourounis (2008) and Golder (2005) political regime measures. Table 7 presents the estimates for the two sets of indicators. We find a negative and significant impact of democratization on the level of technology adoption. Notice that the effect is estimated with a small degree of precision using the Papaioannou and Siourounis (2008) proxy which indicates permanent change in political regime. The Golder index examines the electoral outcomes. The main findings remain however robust to the use of alternative definition for the political regime.

Insert Table 7 about here

[27]Burkina Faso, Cameroon, Colombia, Costa Rica, Czech Republic, Dominican Republic, Ecuador, Egypt, Georgia, Guinea, Honduras, Israel, Kenya, Kyrgyzstan, Latvia, Lithuania, Macedonia, Mauritania, Moldova, Morocco, New Zealand, Slovak Republic, Slovenia, South Africa, Sri Lanka, Tajikistan, Tunisia, Venezuela

Outliers. The analysis hereto has focused on the full set of available technologies. In order to check the robustness of our results with regard to outliers, we run the same set of regressions as before but we drop observations for each individual category of technologies successively. The model is estimated using 122 countries and a set of country-specific effects.[28] Table 8 reports the estimates.

Insert Table 8 about here

We obtain essentially the same results as before. The adoption level of autocracies is about 14% to 21% smaller once they liberalize. Interestingly, the estimates of per capita GDP turn out to be insignificant when we exclude agriculture and health related technologies. This suggest that the level of development has a differential impact on the level of adoption.

4 Concluding Remarks

This paper provides a theoretical and empirical analysis of the interaction between trade liberalization and democratization for the dynamics of productivity and technology adoption. A theoretical model is set up to study the incentives of different social groups to favor, or oppose, technological change. The theory predicts the existence of a complementary between trade-liberalization and democratization for the dynamics of productivity. The predictions are supported by empirical evidence exploiting within country variation overtime. The results suggest that, against conventional wisdom, autocracies experience larger technology adoption when their borders are closed to the world economy. A process of trade liberalization in autocracies tends to reduce productivity and slow down technology adoption while the opposite is true if it is accompanied by a democratization process. The results substantially qualify available findings, are robust to a set of controls and have relevant policy implications. While the theory is static the results suggest that a dynamic extension of the model may be insightful for predicting the differential impact of different institutional reforms at different point in time. Similarly, the empirical analysis does not exploit the sequence of institutional reforms. Exploring the theoretical and empirical role of the sequence of these reforms for the economic dynamics appears a fruitful direction for future research.

[28]The number of countries reduce to 122 due to the inclusion of the per-capita GDP variable.

References

Acemoglu, D., 2006. Oligarchic versus Democratic Societies. Journal of European Economic Association 6 (1), 1–44.

Acemoglu, D., and J.A. Robinson, 2006. Economic Origins of Dictatorship and Democracy: Economic and Political Origins. Cambridge: Cambridge University Press.

Acemoglu, D., Johnson, S., Robinson, J.A., and P., Yared, 2008. Income and democracy. American Economic Review, 98(3), 808-42.

Acemoglu, D., P., Aghion, and F., Zilibotti, 2003. Vertical Integration and Distance to Frontier. Journal of European Economic Association 1 (2-3), 630–638.

Acemoglu, D., P., Aghion, and F., Zilibotti, 2006. Distance to Frontier, Selection, and Economic Growth. Journal of European Economic Association 4(1), 37–74.

Aghion, P., A., Alesina, and F. Trebbi, 2007. Democracy, Technology, and Growth. NBER Working Paper No. W13180.

Aidt, T.S., and M. Gassebner, 2010. Do Autocratic States Trade Less? The World Bank Economic Reivew, 24 (1), 38-76.

Alvarez, M., J.A. Cheibub, F. Limongi, and A. Przeworski, 2000. Democracy and Development: Political Institutions and Material Well-being in the World, 1950-1990. Cambridge: Cambridge University Press.

Arellano, M., 1987. Computing Robust Standard Errors for Within-Groups Estimators. Oxford Bulletin of Economics and Statistics, 49, (4), 431-34

Barro, R., 1996. Democracy and Growth. Journal of Economic Growth, 1(1), 1-27.

Caselli, F., and J. Coleman, 2006. The World Technology Frontier. American Economic Review 96(3), 499–522.

Chadhury, S., S., Yabuuchi, and U. Mukhopadhyay, 2006. Inflow of Foreign Capital and Trade Liberalization in a Model with an Informal Sector and Urban Unemployment. Pacific Economic Review 11(1), 87–103.

Comin, D. and B. Hobijn, 2004. Cross-country Technology Adoption: Making the Theories Face the Facts. Journal of Monetary Economics, 51, 39–83.

Comin, D., Hobijn, B., and E. Rovito , 2006. Five Facts You Need to Know About Technology Diffusion. NBER Working Paper 11928.

Dollar D., and A. Kraay, 2003. Institutions, Trade, and Growth. Journal of Monetary Economics 50, 133-162.

Falkinger, J., and V. Grossman, 2005. Institutions and Development: The Interaction Between Trade Regime and Political System. Journal of Economic Growth 10(3), 231–272.

Edwards, S., 1998. Openness, Productivity and Growth: What Do We Really Know? Economic Journal 108, 383-398.

Giavazzi, F. and G Tabellini, 2005. Economic and Political Liberalizations. Journal of Monetary Economics, 52 (7), 1297-1330.

Golder, M. 2005. Democratic Electoral Systems around the World. Electoral Studies, 24: 103-121.

Greenaway D., Morgan, W., and P. Wright, 2002. Trade liberalization and Growth in Developing Countries. Journal of Development Economics 67, 229-244.

Jerzmanowski, M., 2007. Total factor productivity differences: Appropriate technology vs. efficiency. European Economic Review 51, 2080–2110.

Halpern, L., Koren, M., and A., Szeidl, (2005). Imports and Productivity. CEPR Discussion paper, DP5139.

Krueger, A., and M. Lindahl, 2001. Education for growth: Why and for whom? Journal of Economic Literature, 39, 1101–1136.

Lee, Jong-Wha, 2000. Education for Technology Readiness: Prospects for Developing Countries, mimeo Korea University.

Marshall, M., Jaggers, K., 2009. Political Regime Characteristics and Transitions 1800-2007. Polity IV Project, Center for Systemic Peace.

Mayer T., Paillacard, R., Zignago S., (2008). The CEPII Trade, Production and Bilateral Protection Database. CEPII, `www.cepii.fr`

Mokyr, J., 1998. The Political Economy of Technological Change: Resistance and Innovation in Economic History, in M. Bergand and K. Bruland (eds.) Technological Revolutions in Europe (Cheltenham: Edward Elgar) 39–64.

Olson, M., 1982. The Rise and Decline of Nations - Economic Growth, Stagnation and Social Rigidities, Yale University Press.

Rodrik, D., (1999). Democracies Pay Higher Wages. The Quarterly Journal of Economics, 114 (3) 707-738.

Przeworski, A., Limongi, F., , Cheibub, J. A. and Fernando, L. 1993. Political Regimes and Economic Growth. Journal of Economic Perspectives, 7, 51-70.

Przeworski, A., Alvarez, M.E., Cheibub, J. A. and Fernando, L. 2000. Democracy and Development: Political Institutions and Material Well-Being in the World, 1950-1990. New York: Cambridge University Press.

Reuveny, R., Li, Ol, 2003. Economic Openness, Democracy and Income Inequality. Comparative Political Studies, 36(5), 575-601.

Slaughter, M.J., 2001. Trade Liberalization and Per Capital Income Convergence: A Difference in Difference Analysis. Journal of International Economics, 55 (1), 203-228.

Vandenbussche, J. Aghion, P., and Meghir, C. 2006. Growth, distance to frontier and Composition of Human Capital. Journal of Economic Growth, 11, 97-127.

Wacziarg, R. and K., Welch, 2008. Trade Liberalization and Growth: New Evidence. World Bank Economic Review.

White, H., 1980. A heteroscedasticity-consistent covariance matrix estimator and: a direct test for heteroscedasticity. Econometrica 48: 817–830.

Wooldridge J.M., 2003. Cluster-Sample Methods in Applied Econometrics. American Economic Review 93, 133–138,May 2003.

Yeaple, S., 2005. A Simple Model of Firm Heterogeneity, International Trade, and Wages. Journal of International Economics 65, 1–20.

5 Appendix

5.1 Analytical Derivations and Proofs

Education. We can also interpret technological adoption and investments in education (skills) as an alternative explanation of an increase in A. The idea boiled down to the concept of appropriate technology requiring skills to be operated. This also justifies why countries do not jump at the technological frontier even if they can do it at zero costs. They first need to build skills.[29]

In this appendix, we show how an improvement in the initial distribution of human capital in a country through policies that encourage education or public expenditure on education can play the same role as an adoption of a more advance technology to move towards the world frontier. We use a Pareto distribution for skills in the country, which is accepted as a reasonable measure for human capital endowment. We use

$$G(Z^*) = 1 - \frac{1}{Z^{*\kappa}}, g(z) = \frac{\kappa}{Z^{\kappa+1}} \tag{20}$$

as the cumulative and the density functions. Parameter $\kappa \geq 1$ represents how skewed is the distribution; a larger κ gives a more skewed distribution, more heterogeneity, and thus a larger proportion of low-skilled population. Here more advanced education policies can be thought of as an increase in κ, which lowers inequality of skills and moves the population density towards the more skilled. Rewriting the equilibrium condition (23) using (20), we get

$$1 - \frac{1}{Z^{*\kappa}} = \eta \frac{(1-\beta)}{\beta} \frac{\int_{z^*}^{\infty} Z^A g(Z) dZ}{Z^{*A}}.$$

We also know that in the numerator

$$\int_{z^*}^{\infty} Z^A g(Z) dZ = \int_{z^*}^{\infty} Z^A \frac{\kappa}{Z^{\kappa+1}} dZ = \int_{z^*}^{\infty} \kappa Z^{A-\kappa-1} dZ =$$

$$\kappa \left[\frac{1}{A-\kappa} Z^{A-\kappa} \right]_{Z^*}^{\infty} = \frac{\kappa}{A-\kappa} \left[\infty^{A-\kappa} - Z^{*A-\kappa} \right].$$

It follows that for $A < \kappa$,[30] we have $\int_{z^*}^{\infty} Z^A g(Z) dZ = \frac{\kappa}{\kappa - A} \frac{1}{Z^{*\kappa - A}}$, which gives

$$1 - \frac{1}{Z^{*\kappa}} = \eta \frac{(1-\beta)}{\beta} \frac{\kappa}{\kappa - A} \frac{1}{Z^{*\kappa}}.$$

Solving for Z^* we have

$$Z^* = \left[\frac{1}{\kappa - A/\kappa} \eta \frac{(1-\beta)}{\beta} + 1 \right]^{1/\kappa},$$

which is decreasing in κ and increasing in A. This proves that an improvement in the distribution of skills/human capital (lowering κ) in the country has the same effect as skill-biased technology adoption (an increase in A). They both increase the threshold level Z^* by shifting workers from the manufacturing to the primary sector in autarky.

[29] See Caselli ().

[30] For $\kappa > A$ the level of technology adoption is very high with respect to the existing skill capacity of workers so that Z goes to infinity and $G(Z^*)$ goes to 1. This implies that a small amount of highly skilled workers in the X sector can produce an infinitely large number of the manufacturing goods.

Proofs of Proposition 2. We use the implicit function theorem to find the affect of technology adoption, an increase in A, on $\underline{Z}^*$. Using (15), define

$$F(\underline{Z}^*, A) = G(\underline{Z}^*)k - \frac{\int_{z^*}^{\infty} Z^A dG(Z)}{\underline{Z}^{*A}} = 0$$

where $k = \frac{1}{\eta}\frac{\beta}{1-\beta}$. To see the effect of an increase in A on $\underline{Z}^*$,we differentiate to get

$$\frac{\partial \underline{Z}^*(A)}{\partial A} = -\frac{\delta F(.)/\delta A}{\delta F(.)/\delta \underline{Z}^*} = -\frac{-\int_{z^*}^{\infty} Z^A (\ln Z - \ln \underline{Z}^*) dG(Z)/\underline{Z}^{*A}}{G'(Z^*)k - \frac{\underline{Z}^{*A}(-\underline{Z}^{*A}) - A\underline{Z}^{*A-1}\int_{z^*}^{\infty} Z^A dG(Z)}{[\underline{Z}^{*A}]^2}} > 0. \tag{21}$$

where by Leibniz rule

$$\frac{\partial \int_{z^*}^{\infty} Z^A dG(Z)}{\partial \underline{Z}^*} = -\underline{Z}^{*A} < 0$$

Since factor prices equal marginal productivity the result follows directly since $\partial L_Y(\underline{Z}^*)/\partial \underline{Z}^* > 0$.

The effect of an increase in A on the skill premium is given by

$$\frac{\partial \left(Z^A/\underline{Z}^*(A)^A\right)}{\partial A} = \left(Z^A/\underline{Z}^*(A)^A\right)[\ln Z - \ln \underline{Z}^*(A)\frac{\partial \underline{Z}^*(A)}{\partial A}] \tag{22}$$

¿From (21) $\partial \underline{Z}^*(A)/\partial A > 0$ and since $\ln Z$ is strictly monotonic in Z there exists a unique $\overline{Z}(A)$ such that (22) equal zero.

From the *RHS* of (12) we see that production in the Y sector increases and that in the X sector may increase (due to A) or decrease (due to higher $\underline{Z}^*$) depending on the sign of $d\left(\int_{z^*}^{\infty} Z^A dG(Z)\right)/dA$. But the equilibrium condition (**??**) proves that the positive direct effect of a better technology A dominates and always increases total output in the X sector. Consider the equilibrium condition

$$G(\underline{Z}^*)\underline{Z}^{*A} = \eta\frac{1-\beta}{\beta}\int_{z^*}^{\infty} Z^A dG(Z). \tag{23}$$

We know that A increases $\underline{Z}^*$ (proposition 1), so the LHS is increasing in A. Therefore, the RHS must also increase to keep the equality, meaning that the value of the integral must increase, i.e. $d\left(\int_{z^*}^{\infty} Z^A dG(Z)\right)/dA > 0$.

Monopolistically Competitive Manufacturing Sector. There is a primary good sector Y and a composite differentiated good X, which is CES over a continuum of varieties of X:

$$X = \left[\int_0^N x(i)^\rho di\right]^{\frac{1}{\rho}},$$

where the elasticity of substitution across varieties of X is $\sigma = \frac{1}{1-\rho} > 1$, and i represents each variety. Consumers consider the set of varieties consumed as an aggregate good, X, with aggregate price

$$P_X = \left[\int_0^N p(i)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}.$$

Total demand for each variety is

$$x(i) = Dp(i)^{-\sigma} \ ,$$

where $p(i)$ is the price of variety i and

$$D = \frac{\beta E}{P_X^{1-\sigma}}$$

is aggregate demand in the X sector, taken as given by firms.

Revenue of each firm in sector X with free entry is

$$R_X = C_X(x_X + F_X). \tag{24}$$

where x_X is production by one firm. Following Yeaple (2005), fixed costs is represented in terms of a quantity of output that must be produced but cannot be sold. Free entry ensures that profits for firms is equal to zero: i.e. revenue by firms must equal to its cost. In monopolistic competition settings with CES preferences, the revenue of a firm less its variable cost is a fixed multiple of its revenue R_X/σ, which with free entry must be less than or equal to its fixed cost $C_X F_X$ giving

$$R_X = \sigma C_X F_X \tag{25}$$

Putting this back to (24) we get

$$x_X = (\sigma - 1)F_X. \tag{26}$$

Output in the X sector goes to two ends: to the product market and to satisfy the fixed cost. Hence, total effective output implicit those used for the fixed cost by each firm is $x_X + F_X$, which given (26) is equal to σF_X. This is the total output by one firm. It follows that the total number of firms is the share of a firm in total output in the industry :

$$N_X(Z^*) = \frac{\int_{\underline{z}}^{\infty} Z^A dG(Z)}{\sigma F_X} \tag{27}$$

The equilibrium number of firms is therefore negatively correlated with Z^*. Firms charge a constant mark up over unit costs [31]

$$p_i = \frac{\sigma}{\sigma - 1} C_X.$$

We define unit cost C_X as

$$C_X = W(Z)/Z^A.$$

Firms minimize their costs given the equilibrium wage distribution. Given the wage distribution $W(Z) = C_X Z^A$, there must be some worker with skill $\underline{Z}$ who is indifferent about working in the X or the Y sector. We have therefore $w(L_Y, T) = W(\underline{Z}) = C_X \underline{Z}^A$. This gives

$$C_X = \frac{w(L_Y, T)}{\underline{Z}^A} \tag{28}$$

where the wage is decreasing in $\underline{Z}$ (due to decreasing marginal product of labor in the primary sector), while the denominator is increasing in Z^*. Unit cost is therefore a decreasing function of $\underline{Z}$.

[31] Note that the revenue of each firm can also be fond using the marked up price to get $R_i = (p_i - C_X)x_X = \frac{x_X C_X}{(\sigma-1)} = \sigma C_X F_X$ where we have used (26) to rewrite x_X.

5.2 Data Sources and Tables

Data Description and Sources.

- **Labor productivity**: LP_{ist}. The data on manufacturing value added per worker are taken from the CEPII "*TradeProd*" database described by Mayer, Paillacar and Zignago (2008). The data are freely available at `www.cepii.fr`.
- **Technology adoption**: $TechA_{ijt}$. The data on technology measure are taken from the Cross-Country Historical Adoption of Technology (CHAT) described by Comin, Hobjin and Rovito (2006). The data are freely available at `www.nber.org`.
- **Trade liberalization**: LIB_{jt}. The data on trade liberalization have been taken from Wacziarg and Welch (2003). The dataset gives a date from which a country is defined as being opened. The trade liberalization variable is dichotomous. It takes the value of one at the starting date indicated by Wacziarg and Welch, and zero otherwise.
- **Political Regime**: $AUTOC_{jt}$. The political regime are taken from the Polity IV database. The variable takes the value of one for negative polity scores, i.e. if the country is considered to be an institutionalized autocracy. The variable takes the value of zero for positive polity score, i.e. the country is considered to be an institutionalized democracy.
- **Education (%)**: Edu_{jt}. The data on educational attainment have been taken from Barro and Lee, (2000). We approximate human capital by the population educational attainment. We use the percentage of the population aged 15 and over that have completed their post-secondary education level.
- **Land (%)**: $Land_{jt}$. We approximate the land endowment by the share of arable land. The data are taken from the World Development Indicators.
- **Per-capita GDP (log)** and **Market Size (log)**: $GDPC_{jt}$ and **Market Size (log)**: GDP_{jt}. The data on population and real GDP are taken from the CHAT data.

Table 1: Summary Statistics

Variable	Label	Obs	Mean	Std. Dev.
Labor Productivity Sample: 98 countries				
Labor productivity	LP_{it}	1365	2.65	1.03
Autocracy (polity)	$AUTOC_{it}$	1365	0.35	0.48
Openness	LIB_{it}	1365	0.62	0.48
Interaction	Int_{it}	1365	0.11	0.31
Technology Adoption Sample				
Technology Adoption (log)	$TechA_{ijt}$	56959	8.13	5.77
Autocracy (polity)	$AUTOC_{it}$	56959	0.36	0.48
Openness	LIB_{it}	56959	0.59	0.49
Interaction	Int_{it}	56959	0.08	0.28
Education (log)	Edu_{it}	11557	6.37	5.08
Land (log)	$Land_{it}$	55410	15.02	1.70
GDP per Capita (log)	$GDPC_{it}$	54431	1.53	1.12
GDP (log)	GDP_{it}	54431	11.15	1.82

Table 2: Impact of trade and political regimes on labor productivity. (Dependent variable, $\ln(LP_{jt})$)

Variables							(Time FE & Country FE)					
	OLS	OLS	OLS	OLS	Time FE	Country FE	All	All	All	All	No Political Instability	No Socialist countries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Democracy	0.710^a		0.362^b	-0.000	-0.004	-0.071	-0.147		-0.105	-0.204^c	-0.205	-0.204^c
	(4.367)		(2.187)	(-0.003)	(-0.022)	(-0.921)	(-1.507)		(-1.035)	(-1.847)	(-1.024)	(-1.840)
Openness		0.912^a	0.749^a	0.329	0.342	-0.095		-0.218^b	-0.197^b	-0.447^a	-0.451^a	-0.446^a
		(6.029)	(4.564)	(1.354)	(1.342)	(-1.036)		(-2.415)	(-2.143)	(-4.301)	(-4.204)	(-4.300)
Opened Democracy				0.710^b	0.717^b	0.428^a				0.348^a	0.356^b	0.347^a
				(2.368)	(2.383)	(3.837)				(2.961)	(2.588)	(2.963)
Observations	1365	1365	1365	1365	1365	1365	1365	1365	1365	1365	1085	1344
Adjusted R^2	0.106	0.182	0.204	0.224	0.219	0.827	0.868	0.870	0.870	0.872	0.882	0.869
Number of countries	98	98	98	98	98	98	98	98	98	98	92	93

Robust standard errors adjusted for clustering around the country's identity, $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table 3: Liberalization impact on labor productivity in autocratic or democratic countries. (Dependent variable, $\ln(LP_{jt})$)

	All	No Political Instability	No Socialist Countries
Openness	-0.398^a	-0.448^a	-0.392^a
	(-5.570)	(-5.194)	(-5.381)
Opened Democracy	0.368^b	0.418^a	0.363^b
	(2.498)	(2.981)	(2.428)
Observations	275	233	262
Adjusted R^2	0.880	0.895	0.862
Number of countries	21	20	17

Regressions include time and country specific effects. Robust standard errors adjusted for clustering around the country's identity, $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table 4: Impact of trade and political regimes on labor productivity: alternative measures of political regime. (Dependent variable, $\ln(LP_{jt})$)

(a) Papaioannou and Siourounis (2008)

				(Time FE & Country FE)		
Variable	OLS	Time FE	Country FE	All	No political instability	No socialist countries
Democracy	-0.079	-0.093	-0.069	-0.264^{c}	–	-0.261^{c}
	(-0.280)	(-0.324)	(-0.484)	(-1.758)	–	(-1.739)
Openness	0.422^{c}	0.411	0.059	-0.350^{a}	–	-0.351^{a}
	(1.749)	(1.621)	(0.741)	(-3.339)	–	(-3.351)
Opened Democracy	0.626^{c}	0.644^{c}	0.285^{b}	0.230^{c}	–	0.231^{c}
	(1.776)	(1.807)	(2.442)	(1.845)	–	(1.850)
Observations	1,106	1,106	1,106	1,106	–	1,085
Adjusted R^2	0.195	0.189	0.806	0.865	–	0.860
Number of countries	70	70	70	70	–	65

(b) Golder (2005)

				(Time FE & Country FE)		
	OLS	Time FE	Country FE	All	No political instability	No socialist countries
Democracy	0.057	0.057	-0.025	-0.187	-0.219	-0.186
	(0.296)	(0.295)	(-0.292)	(-1.658)	(-1.291)	(-1.655)
Openness	0.420^{b}	0.441^{b}	0.055	-0.340^{a}	-0.412^{a}	-0.341^{a}
	(2.135)	(2.084)	(0.651)	(-3.514)	(-4.048)	(-3.527)
Opened Democracy	0.630^{b}	0.629^{b}	0.254^{b}	0.231^{c}	0.345^{b}	0.233^{c}
	(2.250)	(2.242)	(2.153)	(1.845)	(2.370)	(1.866)
Observations	1,365	1,365	1,365	1,365	1,085	1,344
Adjusted R^2	0.234	0.228	0.826	0.871	0.882	0.868
Number of countries	98	98	98	98	92	93

Robust standard errors adjusted for clustering around the country's identity, $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table 5: Trade and Political Regime Impact on Technology Adoption. (Dependent variable, $\ln(TechA_{ijt})$)

	(1)	(2)	(3)	(4)	(5)	(6)	No Political Instability (7)	No Socialist Countries (8)	(9)	(10)
Democracy	-0.108^{c}		-0.097	-0.159^{b}	-0.097	-0.056	-0.086	-0.048	-0.041	-0.040
	(-1.821)		(-1.645)	(-2.408)	(-1.605)	(-1.259)	(-0.925)	(-1.099)	(-0.954)	(-0.709)
Openness		-0.073	-0.054	-0.194^{a}	-0.115^{b}	-0.165^{a}	-0.219^{a}	-0.141^{b}	-0.180^{a}	-0.212^{b}
		(-1.403)	(-1.048)	(-3.294)	(-2.216)	(-2.827)	(-2.751)	(-2.423)	(-3.315)	(-2.359)
Opened Democracy				0.207^{a}	0.144^{b}	0.162^{a}	0.215^{b}	0.137^{b}	0.167^{a}	0.211^{b}
				(2.826)	(2.249)	(2.651)	(2.405)	(2.332)	(2.931)	(2.277)
GDP per Capita					0.464^{a}	-0.578^{b}	-0.502^{b}	-0.337^{c}	-0.331	-0.658^{a}
					(3.438)	(-2.188)	(-2.105)	(-1.661)	(-1.582)	(-2.656)
GDP						1.168^{a}	0.837^{a}	0.838^{a}	0.885^{a}	1.098^{a}
						(4.092)	(3.252)	(3.574)	(3.875)	(4.075)
Land									0.040	-0.049
									(0.332)	(-0.350)
Education										0.002
										(0.139)
Observations	56959	56959	56959	56959	54431	54431	41716	51896	52895	1105
Adjusted R^2	0.950	0.950	0.950	0.950	0.951	0.952	0.953	0.952	0.952	0.953
Number of Countries	129	129	129	129	122	122	118	107	121	94

All regressions contain technology×year fixed effects and country-specific effect. Robust standard errors adjusted for clustering around the country's identity, $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table 6: Liberalization impact on adoption level in autocratic or democratic countries. (Dependent variable, $\ln(TechA_{ijt})$)

Variables	(1)	(2)	(3)	(4)	No Socialist Countries (5)
Openness	-0.159^a	-0.273^a	-0.259^b	-0.277^a	-0.243^b
	(-3.188)	(-3.055)	(-2.741)	(-2.792)	(-2.433)
Opened Democracy		0.183^c	0.185^c	0.273^b	0.273^b
		(1.723)	(1.742)	(2.639)	(2.554)
GDP per Capita			0.544^b	-0.829	-0.930
			(2.434)	(-1.583)	(-1.658)
GDP				1.476^a	1.592^a
				(3.232)	(3.241)
Observations	10053	10053	9453	9453	8423
Adjusted R^2	0.958	0.958	0.959	0.959	0.962
Number of Countries	28	28	26	26	20

All regressions contain technology×year fixed effects and country-specific effect. Robust standard errors adjusted for clustering around the country's identity, $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table 7: Using the Papaioannou and Siriounis (2008) and Golder (2005) political regime measure. (Dependent variable, $\ln(TechA_{ijt})$)

Variables	Papaioannou & Siourounis (2008) (S1)	(S2)	No Socialist countries	Golder (2005) (S4)	(S5)	No Socialist countries
Democracy	-0.166^{c}	-0.114^{c}	-0.132^{c}	-0.135^{a}	-0.084^{b}	-0.090^{b}
	(-1.890)	(-1.668)	(-1.890)	(-2.659)	(-2.150)	(-2.338)
Openness	-0.260^{a}	-0.211^{a}	-0.204^{a}	-0.188^{a}	-0.177^{a}	-0.162^{a}
	(-3.798)	(-3.356)	(-3.123)	(-3.299)	(-3.306)	(-2.976)
Opened Democracy	0.247^{a}	0.205^{a}	0.221^{a}	0.223^{a}	0.214^{a}	0.201^{a}
	(3.515)	(3.211)	(3.441)	(3.900)	(4.266)	(3.945)
GDP per Capita		-0.430^{c}	-0.426^{c}		-0.611^{b}	-0.364^{c}
		(-1.808)	(-1.765)		(-2.269)	(-1.848)
GDP		0.889^{a}	0.852^{a}		1.198^{a}	0.856^{a}
		(3.543)	(3.226)		(4.054)	(3.751)
Observations	44128	43114	41289	56959	54431	51896
Adjusted R^2	0.952	0.953	0.953	0.950	0.952	0.952
Number of Countries	91	88	77	129	122	107

All regressions contain technology×year fixed effects and country-specific effect. Robust standard errors adjusted for clustering around the country's identity, $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table 8: Sensivity analysis. (Dependent variable, $\ln(TechA_{ijt})$)

Variable	Excluding technologies related to:							
	Agriculture	Financial	General	Health	Steel	Communi-cation	Tourism	Transportation
Democracy	-0.079	-0.036	-0.039	-0.086^{c}	-0.054	-0.061	-0.071	-0.003
	(-1.439)	(-0.826)	(-0.888)	(-1.832)	(-1.208)	(-1.201)	(-1.582)	(-0.070)
Openness	-0.173^{b}	-0.140^{b}	-0.117^{b}	-0.199^{a}	-0.146^{b}	-0.168^{b}	-0.175^{a}	-0.188^{a}
	(-2.425)	(-2.544)	(-2.078)	(-3.127)	(-2.500)	(-2.572)	(-2.977)	(-3.295)
Opened Democracy	0.143^{c}	0.175^{a}	0.129^{b}	0.197^{a}	0.147^{b}	0.208^{a}	0.167^{a}	0.104^{c}
	(1.850)	(2.906)	(2.095)	(3.059)	(2.356)	(3.007)	(2.707)	(1.864)
GDP	1.115^{a}	1.065^{a}	1.289^{a}	1.090^{a}	1.138^{a}	1.235^{a}	1.141^{a}	1.319^{a}
	(3.242)	(3.974)	(4.414)	(4.434)	(3.929)	(3.886)	(3.909)	(4.863)
GDP per Capita	-0.426	-0.549^{b}	-0.750^{a}	-0.395	-0.585^{b}	-0.621^{b}	-0.579^{b}	-0.746^{a}
	(-1.385)	(-2.172)	(-2.758)	(-1.652)	(-2.209)	(-2.126)	(-2.134)	(-2.924)
Observations	42214	53115	50599	4461	51835	43641	50762	44241
Adjusted R^2	0.958	0.953	0.935	0.950	0.953	0.952	0.952	0.957
Number of Countries	122	122	122	122	122	122	122	122

All regressions contain technology×year fixed effects and country-specific effect. Robust standard errors adjusted for clustering around the country's identity. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Additional Material: Not Intended for Publication

Trade and Political Regimes.

Table 9: Country List (1980-2000)

Country	Political Regime Polity IV index	Trade Regime Wacziarg and Welch (2003)
Albania (*)	1991 (d)	1992
Algeria (*)	Autocracy	Closed
Angola	1992 (t)	Closed
Argentina (*)	1983 (d)	1991
Armenia	1996 (a) 1998 (d)	1995
Australia (*)	Democracy	Liberalized
Austria (*)	Democracy	Liberalized
Azerbaijan	1992 (d) 1993 (a)	1995
Bangladesh (*)	1991 (d)	1996
Belarus	1995 (t) 1996 (a)	Closed
Belgium (*)	Democracy	Liberalized
Benin (*)	1990 (t) 1991 (d)	1990
Bolivia	1982 (d)	1985
Botswana (*)	Democracy	Liberalized
Brazil (*)	1985 (d)	1991
Bulgaria (*)	1990 (d)	1991
Burkina Faso (*)	Autocracy	1998
Burma	Autocracy	Closed
Burundi (*)	1993 (t) 1996 (a)	1999
Cameroon (*)	Autocracy	1993
Canada (*)	Democracy	Liberalized
Central African Republic (*)	1993 (d)	Closed
Chad	1984 (a)	Closed
Chile (*)	1989 (d)	Liberalized
China (*)	Autocracy	Closed
Colombia (*)	Democracy	1986
Costa Rica (*)	Democracy	1986
Croatia (*)	1999 (d)	Closed
Czech Republic (*)	Democracy	Liberalized
Democratic Republic of the Congo	1992 (t)	Closed
Denmark (*)	Democracy	Liberalized
Dominican Republic (*)	Democracy	1992
Ecuador (*)	Democracy	1991
Egypt (*)	Autocracy	1995
El Salvador (*)	1981 (t) 1982 (d)	1989
Estonia (*)	Democracy	Closed
Ethiopia (*)	1991 (t) 1994 (d)	1996
Finland (*)	Democracy	Liberalized
France (*)	Democracy	Liberalized

Table 9 – continued from previous page

Country	Political Regime Polity IV index	Trade Regime Wacziarg and Welch (2003)
Gabon (*)	Autocracy	Closed
Gambia (*)	1994 (a)	1985
Georgia (*)	Democracy	1996
Germany (*)	Democracy	Liberalized
Ghana (*)	1981 (a) 1996 (d)	1985
Greece (*)	Democracy	Liberalized
Guatemala (*)	1986 (d)	1988
Guinea	Autocracy	1986
Guinea-Bissau	1994 (d) 1998 (t) 1999 (d)	1987
Haiti (*)	1990 (d) 1991 (a) 1994 (d) 2000 (a)	Closed
Honduras (*)	Democracy	1991
Hungary	1989 (d)	1990
India (*)	Democracy	Closed
Indonesia (*)	1999 (d)	Liberalized
Iran	1997 (d)	Closed
Iraq (*)	Autocracy	Closed
Ireland (*)	Democracy	Liberalized
Israel (*)	Democracy	1985
Italy (*)	Democracy	Liberalized
Japan (*)	Democracy	Liberalized
Jordan (*)	Autocracy	Liberalized
Kazakhstan	Autocracy	Closed
Kenya (*)	Autocracy	1993
Kyrgyzstan (*)	Autocracy	1994
Latvia (*)	Democracy	1993
Lesotho (*)	1993 (d) 1998 (t) 1999 (d)	Closed
Liberia	1990 (t)	Closed
Lithuania (*)	Democracy	1993
Macedonia	Democracy	1994
Madagascar (*)	1991 (d)	1996
Malawi (*)	1994 (d)	Closed
Malaysia (*)	Democracy	Liberalized
Mali	1991 (t) 1992 (d)	1988
Mauritania	Autocracy	1995
Mauritius (*)	Democracy	Liberalized
Mexico (*)	1988 (t) 1994 (d)	1986
Moldova	Democracy	1994
Morocco (*)	Autocracy	1984
Mozambique	1994 (d)	1995
Nepal (*)	1990 (d)	1991
Netherlands (*)	Democracy	Liberalized
New Zealand (*)	Democracy	1986
Nicaragua (*)	1981 (a) 1990 (d)	1991

Table 9 – continued from previous page

Country	Political Regime Polity IV index	Trade Regime Wacziarg and Welch (2003)
Niger (*)	1991 (d)	1994
Nigeria (*)	1984 (a) 1999 (d)	Closed
Norway (*)	Democracy	Liberalized
Pakistan (*)	1988 (d) 1999 (a)	Closed
Panama (*)	1989 (a)	1996
Papua New Guinea (*)	Democracy	Closed
Paraguay (*)	1989 (d)	1989
Peru (*)	1992 (a) 1993 (d)	1991
Philippines (*)	1986 (d)	1988
Poland (*)	1989 (d)	1990
Portugal (*)	Democracy	Liberalized
Republic of the Congo	1992 (d)	Closed
Romania (*)	1990 (d)	1992
Russia	1992 (d)	Closed
Rwanda (*)	Autocracy	Closed
Senegal (*)	2000 (d)	Closed
Sierra Leone (*)	1996 (d) 1997 (t)	Closed
Singapore (*)	Autocracy	Liberalized
Slovak Republic	Democracy	Liberalized
Slovenia (*)	Democracy	Liberalized
Somalia (*)	1991 (t)	Closed
South Africa (*)	Democracy	1991
South Korea	1987 (d)	Liberalized
Spain (*)	Democracy	Liberalized
Sri Lanka (*)	Democracy	1991
Swaziland (*)	Autocracy	Closed
Sweden (*)	Democracy	Liberalized
Switzerland (*)	Democracy	Liberalized
Syria	Autocracy	Closed
Taiwan (*)	1992 (d)	Liberalized
Tajikistan	Autocracy	1996
Tanzania	2000 (d)	1995
Thailand (*)	1991 (a) 1992 (d)	Liberalized
Togo (*)	Autocracy	Closed
Tunisia (*)	Autocracy	1989
Turkey (*)	1983 (d)	1989
Turkmenistan	Autocracy	Closed
Uganda (*)	1985 (t) 1986 (a)	1988
Ukraine	Democracy	Closed
United Kingdom	Democracy	Liberalized
United States	Democracy	Liberalized
Uruguay (*)	1985 (d)	1990
Uzbekistan	Autocracy	Closed

Table 9 – continued from previous page

Country	Political Regime Polity IV index	Trade Regime Wacziarg and Welch (2003)
Venezuela	Democracy	1996
Yemen (*)	Autocracy	Liberalized
Zambia (*)	1991 (d)	1993
Zimbabwe (*)	1987 (a)	Closed

Countries marked by a (*) also belong to the productivity sample. The numbers denote the year at which a country switch from its political or trade regimes. We denote by (a) the year from which the polity IV index takes negative values. We denote by (d) the year from which the polity IV index takes positive values. We denote by (t) the transition period for which the value of the polity IV index is equal to zero

Table 10: List of Technologies

Category	Variable Description
Agriculture	Fertilizer consumed, total
	Harversters
	Irrigated area
	Milking machines
	Percent of cultivated land using modern variety crops
	Percent of irigated land out of cultivated land
	Pesticide consumed, total
	Tractors
Financial	ATMs
	Cheques issued
	Debit and credit card transactions
	Electronic funds transfers
	Points of service for debit/credit cards
General	Electricity production
	Internet users
	Personal computers
Health	Appendectomies
	Beds: in-patient acute care
	Beds: in-patient long-term care
	Bone marrow transplants
	Breast conservation surgeries
	Caesarean sections
	Cardiac catheterisations
	Cataract surgeries
	Cholecystectomies
	Cholecystectomies, laparoscopic
	Computed tomography (CAT) scanners
	Coronary bypass procedures, in-patient
	Coronary bypasses
	Coronary stenting procedures
	Dialysis patients
	Dialysis patients, home
	Heart transplants
	Hernia procedures, inguinal and femoral
	Hip replacement surgeries
	Hysterectomies (vaginal only)
	Kidney transplants
	Knee replacement surgeries
	Lithotriptors
	Liver transplants
	Lung transplants

Table 10 – continued from previous page

Category	Variable Description
	Mammographs
	Mastectomies
	MRI units
	Pacemaker surgical procedures
	Percent immunized for DPT, children déc-23 months
	Percent immunized for measles, children déc-23 months
	Prostatectomies (excluding transurethral)
	Prostatectomies (transurethral)
	Radiation therapy equipment
	Tonsillectomies
	Varicose vein procedures
Steel	Stainless steel production
	Steel production by other methods
	Steel production by the basic bessemer method
	Steel production in blast oxygen furnaces
	Steel production in electric arc furnaces
	Steel production in open hearth furnances
Telecommunications	Cable television subscribers
	Cell phones
	Mail items
	Newspaper circulation (daily)
	Radios
	Telegrams
	Telephones
	TVs
Tourism	Hotel and other visitor beds
	Hotel and other visitor rooms
Transportation	Aviation passenger kilometers
	Aviation ton-km of cargo
	Railroads: freight ton-kilometers
	Railroads: length of line open
	Railroads: passenger-journey kilometers
	Ships: motor
	Ships: sail
	Ships: steam
	Ships: steam and motor
	Tonnage of motor ships
	Tonnage of sail ships
	Tonnage of steam and motor ships
	Tonnage of steam ships
	Vehicles: commercial
	Vehicles: passenger cars

Data on Technology Adoption

Table 11: Cumulative number of technologies in the sample of autocratic countries

Country	Closed Autocracy					Opened Autocracy				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Albania	14	14								
Algeria	26	28	31	20	15					
Angola	15	14	17	14	13					
Argentina	30									
Azerbaijan									19	14
Bangladesh	20	24	25							
Belarus					15					
Benin	19	19								
Bolivia	22									
Brazil	29									
Bulgaria	22	21								
Burkina Faso	15	15	14	12						10
Burma	14	17	20	18	17					
Burundi	13	17	18							15
Cameroon	18	19	21						18	16
Central African Republic	17	18	16							
Chad		19	18	14	13					
Chile						28	28			
China	25	29	33	27	24					
Croatia				21						
Democratic Republic of the Congo	22	23	22							
Egypt	27	28	28						24	17
El Salvador	21									
Ethiopia	21	22	1							
Gabon	15	17	17	15	12					
Gambia									18	12
Ghana							23	24	20	
Guatemala	20	18								
Guinea	15	16						16	14	12
Guinea-Bissau	7	9						13		
Haiti	13	13			10					
Hungary	31	34								
Indonesia						24	27	28	19	
Iran	25	26	28	24						
Iraq	22	22	19	14	13					
Jordan						19	19	21	23	18

Table 11 – continued from previous page

Country	Closed Autocracy					Opened Autocracy				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Kazakhstan				19	18					
Kenya	22	23	23						23	14
Kyrgyzstan									15	16
Lesotho	12	15	13							
Liberia	12	13								
Madagascar	22	24	22							
Malawi	20	20	18							
Mali	18	20						20		
Mauritania	15	18	17						14	13
Mexico	29	30								
Morocco	23						25	26	19	15
Mozambique	16	18	15							
Nepal	13	15								
Nicaragua		15								
Niger	16	18	18							
Nigeria		23	23	18						
Pakistan	27	28			17					
Panama	20	20								
Paraguay	19	19								
Philippines	25	25								
Poland	34	33								
Republic of the Congo	21	21	20		12					
Romania	19	21								
Rwanda	12	14	17	11	10					
Senegal	20	21	23	22						
Sierra Leone	15	15	15	14						
Singapore						20	19	19	18	14
Somalia	15	17	17							
South Korea						27	25			
Swaziland	14	16	16	17	16					
Syria	24	24	20	19	19					
Taiwan						19	18	18		
Tajikistan				15						15
Tanzania	22	22	21						16	
Togo	19	21	22	19	14					
Tunisia	22	25						25	20	16
Turkey	32									
Turkmenistan				14	13					
Uganda								19	23	14
Uruguay	27									
Uzbekistan				16	17					
Yemen								17	16	16
Zambia	20	21	21							
Zimbabwe			23	21	18					

Table 12: Cumulative number of technologies in the sample of democratic countries

Country	Closed Democracy					Opened Democracy				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Albania			15						18	16
Argentina		28	29						23	19
Armenia									16	16
Australia						34	38	45	57	51
Austria						30	37	42	36	51
Bangladesh				19						15
Belarus				16						
Belgium						30	32	47	47	36
Benin								20	15	14
Bolivia							20	21	18	16
Botswana						17	17	19	18	15
Brazil		30	30						27	16
Bulgaria			21						20	22
Burundi				18						
Canada						27	33	48	50	43
Central African Republic				16	12					
Chad	17									
Chile								30	23	17
Colombia	28	28						24	24	17
Costa Rica	19	19						19	18	14
Croatia					19					
Czech Republic									39	40
Democratic Republic of the Congo				15	13					
Denmark						37	40	52	46	54
Dominican Republic	16	15	17						19	14
Ecuador	25	25	25						24	17
El Salvador		21						18	17	15
Estonia				20	24					
Finland						32	38	59	56	52
France						38	39	52	42	58
Gambia	12						13	14		
Georgia				16						17
Germany						36	43	52		
Ghana	24									16
Greece						31	31	41	38	26

Table 12 – continued from previous page

Country	Closed Democracy					Opened Democracy				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Guatemala								19	19	15
Guinea-Bissau									12	9
Haiti			15	11						
Honduras	20	20	21						17	16
Hungary								38	35	48
India	26	29	30	24	20					
Indonesia										15
Iran					17					
Ireland						33	36	38	48	45
Israel	26						26	28	25	18
Italy						34	38	46	34	51
Japan						31	34	41	31	29
Latvia									22	25
Lesotho				13	11					
Liberia			14	11	9					
Lithuania									21	22
Macedonia									18	15
Madagascar				17						14
Malawi				13	13					
Malaysia						25	26	24	16	14
Mali									19	15
Mauritius						17	18	21	18	16
Mexico								33	45	46
Moldova									21	18
Mozambique									11	11
Nepal			15						16	13
Netherlands						32	35	45	41	42
New Zealand	27	24						30	28	47
Nicaragua	17		17						19	14
Niger									13	14
Nigeria	23				13					
Norway						32	35	36	31	37
Pakistan				22						
Panama			19	20						15
Papua New Guinea	14	13	14	13	11					
Paraguay								19	16	14
Peru	26	26	25						21	
Philippines								24	21	18
Poland								37	35	28
Portugal						30	29	35	51	48
Republic of the Congo				18						

Table 12 – continued from previous page

Country	Closed Democracy					Opened Democracy				
	1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Romania			21						23	23
Russia				23	23					
Senegal					15					
Sierra Leone					13					
Slovak Republic									34	39
Slovenia									23	23
Somalia				12	8					
South Africa	21	28	29						23	18
South Korea								30	23	17
Spain						31	35	45	44	37
Sri Lanka	25	25	26						22	17
Sweden						33	39	52	41	43
Switzerland						27	30	42	33	34
Taiwan									9	5
Tanzania										13
Thailand						27	28	28	22	18
Turkey		33						40	37	30
Uganda	19	19								
Ukraine				22	21					
United Kingdom						30	31	45	46	38
United States						38	40	54	48	46
Uruguay		24						22	24	18
Venezuela	24	26	28	24						19
Zambia									18	14
Zimbabwe	24	24								