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ABSTRACT

Trade Liberalization, Democratization and Technology Adoption*

We study the role of trade liberalization, democratization and their interaction for technology adoption. A general equilibrium theory with heterogeneous skills predicts a complementarity between trade and political regimes. Openness should accelerate technology adoption if coupled with democratization but may lead to a slow down if these regime changes are imbalanced. We use panel data on technology adoption at the sectoral level for the period 1980-2000 by exploiting within country variation and the heterogenous timing of openness and democratization. The results document the existence of robust positive interactions between these institutional changes for technology adoption and productivity growth.

JEL Classification: F16, J24, O14, P51, F59

Keywords: trade openness, democratization, political economy theory, technology adoption, sector level panel data, cross-country analysis

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Trade liberalization and democratization will bring 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. However, the effects of these regime changes for technological improvements are not straightforward. This paper presents a theoretical and empirical investigation of the role of trade liberalization, democratization, and their interactions, for technological adoption.

The available literature, discussed in Section 2, suggests that trade liberalization and democratization may favor technological progress and increased productivity mainly indirectly. Trade liberalization can increase 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 can 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 erodes their political power. In a positive perspective, improving institutions in one dimension, but not in the other, may actually be harmful by creating an unbalanced shift in economic and political power. When considered jointly, these arguments suggest the existence of a complementarity between trade liberalization and democratization for the incentives of adopting technologies.

To investigate the theoretical role of the interactions between trade and political regime and derive testable predictions, we set up a simple general equilibrium occupational choice model. In the model, production takes place in two sectors, one using skills (the modern sector) and one using manual labor and natural resources (the traditional sector) the rents of which are extracted by a minority elite. Heterogenous workers optimally relocate between the two sectors with endogenously determined wages. The framework is used to characterize 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. The model does not predict that openness

to trade should favor technology adoption *per se* since the political rulers may react to the reduction in rents by hampering (or slowing down) the diffusion of new technologies. A process of democratization in autarky may trigger the defense of vested interests against technological improvements that result from a "Luddism" effect associated to the reduction of the wages of the newly enfranchised unskilled workers. Consequently, the model predicts that democratization, *per se*, does not necessarily lead to productivity improvements in autarky. It instead predicts the existence of a positive complementarity between the trade and the political regime for the adoption of more productive technologies.

The role of the interaction between changes in the trade and political regimes in the adoption of better technologies has not been empirically explored. To test the predictions we exploit information on the adoption of a large number of technologies for over a hundred countries from the CHAT database. We exploit within-country variation in panel regressions with country, time (and technology) fixed effects for the period 1980-2000. The baseline specification investigates the effects of both institutional changes separately and jointly by exploiting a difference-in-difference design. The explanatory variables of main interest are the timing of trade liberalization and the timing of democratization. This methodology essentially compares country that liberalized (or democratized) in a certain year to countries that did not experience institutional changes in that year.

The results provide support to the common wisdom that both trade openness and democracy have positive effects on the level of technology in pooled OLS regressions. Nonetheless, the average (treatment) effect of either trade liberalization or democratization is negative when country fixed effects are explicitly accounted for. In line with the theoretical predictions the results reveal large positive, and highly statistically significant, interaction between trade liberalization and democratization. Only countries going through both transitions tend to experience significant improvements in technology. The findings are very different for those countries experiencing unbalanced regime changes. Democratization in autarky does not appear to make any significant difference while trade liberalization within autocracies can even slow down technological change and the dynamics of productivity. The evi-

dence documents that the average effects of trade liberalization or democratization hide relevant heterogeneity and suggest that studying their role in linear regressions frameworks can be misleading.

To assess the robustness of the results, and to investigate the empirical relevance of some side predictions, we perform an extensive set of checks including the use of alternative data, samples and controls. In the empirical analysis we implement a set of strategies to deal with the two main concerns that have been raised in the literature studying the effects of trade liberalization and democratization on macroeconomic outcomes, namely the existence of biases from omitted variables and reverse causality. The analysis controls for omitted information at the country level (e.g. culture of innovation), time (e.g. technological waves) and technology (e.g. trends of adoption and dismissal in some specific technological sectors) by including fixed effects on each of these dimensions.

The finding of a negative main effect coupled with a significant positive interaction of trade and political regime changes on the technology at the sector level appear unlikely to be imputed to reverse causality since changes in technologies disaggregated at the sector level (the dependent variable) are unlikely to consistently affect the timing of trade openness and democratization at the country level. Also it is not obvious which type of reverse causality can deliver consistently opposite statistical biases when opening to trade takes place under different political regimes. We nonetheless implement a set of specific checks to explore the robustness of the findings also in that respect. The results are not driven by some specific type of technology and hold when restricting attention to countries that only change one regime thereby iteratively ruling out reverse causality by construction in trade and political transitions. A further counterfactual exercise involves exploiting the time structure of the panel data (e.g. using the leads of regime changes rather than the lags). Finally, further tests show that the results are qualitatively and quantitatively very stable when including initial conditions in each technological sector and for alternative lag structure of the data.

The paper is organized as follows. Section 1 discusses the related theoretical and empirical literature. Section 2 presents the theoretical framework. Section 3

introduces the data, the estimation strategy and the empirical results while Section 4 concludes. Proofs, further results and information on data sources are reported in the Online Appendix (attached to this file).

1 Background Literature

The role of trade liberalization and democratization on the dynamics of technological change (and workers' productivity) have been studied, mainly independently, by trade theorists and political economists. Wood (1995) was among the firsts in highlighting the possible effects of trade openness on the "incentives" for technology (defensive) adoption. He made the point that, in the face of a more intense competition from international markets, firms that may have had little incentive to adopt prior to liberalization may improve their technologies (by either doing R&D or taking advantage of existing technologies). Acemoglu (2003) highlights that, besides affecting domestic relative prices, trade liberalization increases the possibility to adopt superior technologies. He also notices, however, that not all countries appear to have equally profited from this opportunity and concludes that it would be important to further investigate the incentives for endogenous technology adoption. Following Melitz (2003) and Melitz and Ottaviano (2008), a number of recent contributions in international trade predict aggregate industry productivity to grow with trade liberalization through a selection effect, produced by the reallocation of resources towards more productive firms. This self-selection mechanism, which is supported by a large and increasing empirical evidence, 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).[1] The mechanism is also in line with the view that oligarchies raise 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

[1]See also Melitz and Redding (2012) for a comprehensive overview. Aidt and Gassebner (2010) provide evidence that oligarchic rulers are more free to extract resources in countries protected by trade barriers by, e.g. exploiting trade taxes.

the population at large, see Acemoglu (2006).[2] Indeed, Berman and Machin (2000) argue that the differential skill upgrading observed in the LDC's may reflect differences in these countries' choices of whether to adopt skill-biased technologies.[3] As discussed in more details below, the simple political economy theory that we propose looks at the incentives for technology adoption by part of the political rulers.

We contribute to the literature a simple theoretical investigation of the preferences of the group in power on policies that facilitate or block the adoption of new technologies under different trade regimes. To illustrate the hypothesis and derive testable predictions, we study a theoretical framework where workers with heterogeneous productivity, modeled along the lines of Yeaple (2005), self-select into different sectors. Increases in productivity move the production possibility frontier outwards but, crucially, they do so non-neutrally: technological improvements change the allocation of workers between the two sectors (thereby affecting output, wages, and prices) and benefit differentially agents with heterogenous skills. 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 in power controls the state (and its rents), and democracy, where the policies are selected by majority voting with universal franchise.[4]

Empirically, the typical finding in a cross-sectional perspective is a positive role of either trade or political regimes for income growth.[5] The effects of trade liberal-

[2]Olson (1982) and, in particular, Mokyr (1998) provide extensive discussions on how policies implemented by the political rulers may facilitate, or slow down, technological dynamics and technology adoption.

[3]See Goldberg and Pavcnik (2007) for a comprehensive survey.

[4]Despite the different theoretical set up, we share the focus with some theoretical analysis that have modeled the role of the strength (or efficiency) of political institutions for the effect of openness to trade on aggregate outcomes like the public funding of education in Falkinger and Grossman (2005), redistributive policies in Segura-Cayuela (2006), contract enforcement in Do and Levchenko (2009) and property rights protection in Stefanadis (2010). Complementary to the theoretical insights of these papers, the theory predicts that opening to trade may deteriorate the incentives for technology adoption under weak political institutions.

[5]There is vast literature studying the determinants of income growth at the cross-country level.

ization or democratization accounting for country specific unobserved heterogeneity has not been easy to identify, however. Two main problems related to the conceptualization and measurement of trade openness and democracy and the lack of exogenous variation. These problems have been recently addressed by a careful coding of these regime changes that have been used to identify the effects of trade liberalization and democratization by exploiting the heterogenous timing of these transitions in difference-in-difference frameworks. Most notable, Rodrik and Wacziarg (2005), Papaioannou and Siouraounis (2008), and Persson and Tabellini (2009) document a positive and significant causal effects of democratization on income growth while Slaughter (2001) documents a positive effect of trade liberalization on per capita income convergence across countries.[6] Giavazzi and Tabellini (2005) extend the scope of the analysis to explore the dynamic feedbacks between economic and political liberalization for investment and income growth. Their findings suggest that studying the effects of each reform separately can be misleading.

We are not aware of any empirical study that investigates the interactions between trade liberalization and democratization for technology adoption (and labor productivity) in a cross-country perspective.[7] Limited data availability has until recently prevented the possibility addressing this empirical question. The cross-country panel data on technology adoption at the sector level that has been recently made available (in the CHAT database) by Comin, Hobijn and Rovito (2006) is nicely suited to for our purposes.[8] The interactions between changes in trade and

Przeworksi and Limongi (1993), Barro (1996), Tavares and Wacziarg (2001) and Persson (2004) study the effect of democracy while Greenaway, Morgan, and Wright (2002), Dollar and Kraay (2003), Edwards (2008), and Wacziarg and Welch (2008) concentrate, in particular, attention to the effect of trade liberalization.

[6] Aghion, Alesina and Trebbi (2007) show that democracy fosters value added per worker in the more advanced sectors of an economy by reducing the protection of vested interests and granting freedom of entry in markets.

[7] To our knowledge, the widespread perception on the positive role of openness and democracy across countries was not documented (using for instance data on technology adoption) but was rather indirectly inferred from the fact that, everything else equal, open economies and democratic countries tends to be richer than closed economies and autocracies.

[8] Comin and Hobijn (2004) that collected data for the pre and post WWII era across 25 major

political regimes are investigated accounting for country specific unobserved heterogeneity and waves of technological change using a difference-in-difference framework with country and time fixed effects. As benchmark we use the data on trade openness from Wacziarg and Welch (2008) and the data on democratization from the Polity IV database. The empirical strategy therefore exploits variation overtime within the different technological sector by accounting for country specific unobserved heterogeneity and common time effects.

2 Theoretical Analysis

2.1 Set-Up

Preferences and Production. Consider an economy, where individuals have preferences over a manufacturing good X and a traditional good Z,

$$u = x^{\beta} z^{1-\beta}, \tag{1}$$

where x and z are the individual consumption of goods X and Z. We set the price of good Z to unity as numeraire and denote by p the (relative) price of the manufacturing good.

There are two factors of production: Labor, denoted by L and a fix factor of production, N, that stands for e.g. natural resources. The population is divided into two groups: a unit mass of workers, who are endowed with a skill level θ distributed according to a cumulative distribution function $G(\theta)$ with density $g(\theta)$ where $\theta \in [1, \infty]$, and a smaller (minority) group of size $\sigma < 1$ referred to as the "elite" who do not supply labor but are the residual claimants of the income produced in the economy net of the remuneration of workers.[9] As discussed below, only individuals belonging to the elite have political power (e.g. can vote) in oligarchies while all individuals are politically represented in a democracy.

technologies in 23 countries over a period of 200 years and document that openness to trade increases the speed at which countries adopts technology.

[9]That the elite do not supply labor is only for simplicity. The results only require that these individuals are able to extract resources on top of the returns from supplying labor.

Production of the two goods takes place in two perfectly competitive sectors: (i) a resource-based traditional sector, which uses manual labor, L, and N to produce good Z; (ii) a productivity-based manufacturing (modern) sector, which uses skilled labor to produce good X. Workers can freely supply their labor to any of the two sectors.

The good Z is produced using an aggregate production function with constant return to scale,

$$Z(L,N) = L^{\eta}N^{1-\eta}. \tag{2}$$

The effective labor supplied by any individual working in the Z sector is independent from his skill level θ and is normalized to 1. On the contrary, the amount of effective labor supplied in sector X depends on the skill level θ and is equal to $l(\theta, A) = \theta^A$, where $A \geq 1$ represents the productivity of available technologies. Production in the modern sector is therefore given by the total number of goods produced by all workers employed in that sector,

$$X(G(\theta), A) = \int_{\theta} l(\theta, A)\, dG(\theta), \tag{3}$$

that depends both on the amount of workers and their productivity.[10]

Factor Income. Denote by y the individual factor income. For a given price of the manufacturing good p, an individual supplying $l(\theta, A)$ units of effective labor to the X sector earns,

$$y_X = \theta^A p. \tag{4}$$

The wage earned by a worker in the Z sector equals his marginal productivity and is independent from his skill level (as no skills are used in production of the traditional good). The individual factor income of an unskilled worker is therefore given by,[11]

$$y_Z = w(L,N) = \frac{\partial Z(L,N)}{\partial L}. \tag{5}$$

[10] This modeling of the production function of the manufacturing sector essentially follows Yeaple (2005).

[11] Recall that the price of the Z good is normalized to one.

The elite are the residual claimants of the production in the traditional sector, that is, they appropriate (and distribute evenly among their group of size σ) all income produced in that sector net of the wages paid to workers,

$$y_E = [Z(L, N) - w(L, N)L](1/\sigma). \tag{6}$$

Notice that since the production function (2) is constant returns to scale, this is equivalent to assuming that the elite control all rents accruing to the natural resources N. For our purposes we do not need to specify the means by which the (oligarchic) elite extract resources in the traditional sector. Empirically the economic and political ruling groups in developing economies extract rents by various means including the control and ownership of natural resources (like oil or land) which are priced on regulated markets, by controlling the state apparatus (which involves public patronage, corruption, fiscal transfers and directed benefits), or by controlling the state monopolies, to name some.[12]

Two main features of the model drive the theoretical predictions. The first is that more advanced sectors of production are skill (or human capital) intensive and more able to absorb technological improvements, while traditional sectors rely more on the use of unskilled labor. The second is that the economic interests of the (oligarchic) elites in terms of extractable rents predominantly rely on the returns produced with a relative higher intensity of low skills and natural resources rather than human capital. This set-up aims at modeling these two features in the simplest way.[13]

Trade and Political Regimes. We consider a dichotomous representation of the trade regime. The economy can either be closed (in autarky) with no possibility to trade, or open, where all goods can be traded at zero cost.[14] In autarky the entire

[12]See Acemoglu (2006) for an extensive discussion of these issues.

[13]For instance, the assumption that an increase in A only affects the production of good X is only to simplify illustration. The results only require that productivity in the modern sector is relatively more elastic to technological improvements than in the traditional sector.

[14]This representation is in line with the use of dichotomous measures of openness that, following the empirical literature, is exploited in the empirical Section 4.

demand must be covered through internal production and the relative prices, p may differ from the one prevailing in international markets, p^*. In an open economy the internal demand is unrelated to internal production and domestic relative prices coincides with the world relative price: $p = p^*$.

We consider two extreme political regimes. In an autocracy, the elite control the state and extract all rents (net of wages) produced in the traditional sector. Only the elite are politically represented since they are the only ones allowed, *de jure*, to vote (due to the existence of constraints on the political franchise) or can *de facto* control public policies by influencing or controlling elections and thereby setting policies in their own self-interest. In a democratic regime all individuals can vote and policies mirror the preferences of the majority of the population which, by assumption, is made up by workers.[15] The key assumption is that a process of democratization reduces the ability of the elite to defend their economic interest by exploiting their political power.

2.2 Equilibrium

Labor market equilibrium. Individuals face the choice between working in the Z sector supplying one unit of (unskilled) labor, or in the X sector supplying their individual skill that amounts to θ.

Workers take earnings, prices of goods and the technology of production as given when making optimal choices, which essentially amounts to comparing the expected income that can be earned in each sector, (5) and (4), given their individual skill level θ. A worker with productivity $\underline{\theta}$ is indifferent between working in either sector if, and only if,

$$\underline{\theta}^A p = w\left(L, N\right), \tag{7}$$

while any worker with strictly higher skills, $\theta > \underline{\theta}$, optimally chooses to work in the

[15] As discussed in the Section 3, in line with literature the empirical coding of the political regime is also dichotomous and makes use of information on the extension of the political franchise (whether it is restricted or universal), the presence of free and contested elections, and by considering the extent of substantive political and civil liberties (which are measured by the Freedom House and the Polity Projects).

X sector since from (7),

$$\theta^A p = (\theta/\underline{\theta})^A w(L,N) > w(L,N),$$

where $(\theta/\underline{\theta})^A$ is the wage premium enjoyed by a worker with skills θ given A. Any worker with $\theta < \underline{\theta}$ optimally chooses to work in the traditional sector and earns $w(L,N)$.

The equilibrium in an open economy only requires that the labor market is in equilibrium because the prices of goods are unaffected by the allocation of labor across sectors (as free trade implies convergence of relative prices to the international levels) and total consumption of each good needs not equal the total production. Hence we have,

Lemma 1 [Equilibrium in an Open Economy] *For any $\{A, G(\theta), N\}$, in an open economy there exists a unique threshold level of skills, which is denoted by $\underline{\theta}^o(A)$ and characterized by (7) evaluated at $p = p^*$, for which the economy is in equilibrium.*[16]

Product market equilibrium. In a closed economy, the production of each good must equal its total demand. The characterization of the macroeconomic equilibrium therefore requires that both the labor and the product markets clear.

Given the utility function (1), the demand (in terms of aggregate expenditure) of each good is proportional to nominal income. Since in a closed economy the aggregate demand of each good must equal its total production we have that product market clears if, and only if,

$$(1-\beta)pX(G(\theta),A) = \beta Z(L,N). \tag{8}$$

The economy is in equilibrium if the product and the labor markets both clear, that is, when (7) and (8) jointly hold. Given the production functions (2) and (3), this is the case if, and only if,

$$\beta G(\underline{\theta})\underline{\theta}^A = \eta(1-\beta)\int_{\underline{\theta}}^{\infty} \theta^A dG(\theta). \tag{9}$$

[16]The analysis and the results can be extended to a set up with multiple manufacturing sectors, as in Yeaple (2005), each characterized by a different A. In particular, it would remain true that the most productive workers will employ the most productive technologies with the only difference that the equilibrium would involve multiple (and not a unique) thresholds for θ.

We therefore have,

Lemma 2 [Equilibrium in a Closed Economy] *For any* $\{A, G(\theta), N\}$*, in a closed economy there exists a unique threshold level of skills denoted by* $\underline{\theta}^c(A)$ *for which (9) holds so that both the product and the labor markets are in equilibrium.*

Proof: See Appendix.

2.3 The Effects of Technological Improvements

To characterize the conflict of interests regarding technological improvements across different groups, consider the possibility of a costless increase in the productivity of skilled labor in the modern sector, A. This can be interpreted, for instance, to be a consequence of the 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, or the reduction of barriers to entry in modern business through better property rights protection, etc. The assumption that technological improvement is costless allows to focus on the conflict of interest about its economic effects by abstracting from redistributive issues related to the financing of these policies.

Let us consider first the effect of a rise in productivity, A, in a closed economy.

Lemma 3 [Technological Improvements in a Closed Economy] *In a closed economy, a larger* A *increases the equilibrium threshold skill level of the indifferent worker, denoted by* $\underline{\theta}^c(A)$ *(thereby decreasing the share of workers in sector* X*). The total production of both sectors,* X *and* Z *increases, the relative price of the manufacturing goods,* p*, decreases and:*
(i) wages in the traditional sector, w *decrease;*
(ii) the skill premium of workers in the manufacturing sector, $(\theta/\underline{\theta}^c(A))^A$*, increases only for workers with* $\theta > \overline{\theta}(A) > \underline{\theta}^c(A)$ *so that in the* X *sector only workers with a high enough skill level can experience an increase in nominal earnings,* $w(L(\underline{\theta}^c), N)(\theta/\underline{\theta}^c)^A$
.

Proof: See Appendix.

In a closed economy improvements in the productivity in the X sector lead to a shift of workers away from this sector. The seemingly counter-intuitive effect is due to the fact that in a closed economy the internal demand and supply of each good must equalize in general equilibrium. A higher A expands the economy production possibility frontier thereby increasing total income, so that the equilibrium demand and accordingly the production of all goods increase. Since the larger demand can only be satisfied by domestic production it requires more workers in the traditional sector (that does not experience an increase in productivity). The larger demand for X is satisfied by an increase in production using fewer, but more productive, workers.

As labor becomes more abundant, the equilibrium wage in the traditional sector w is reduced. An increase in the threshold $\underline{\theta}^c$ also reduces the skill premium of the least skilled workers in the manufacturing sector.[17] Only workers with sufficiently high skills $\theta > \overline{\theta}(A)$ can experience a strict net gain in their skill premium from technology adoption. More productive technologies therefore increase competition between workers in a closed economy and force the low-skill worker to accept a reduction in their baseline wage. As a result, rents extracted by the elite from the traditional sector increase at the expense of the lower wages of the low skilled workers.

The effect of increasing productivity in an open economy is summarized in,

Lemma 4 [Technology Adoption in an Open Economy] *In an open economy a larger A decreases the equilibrium threshold skill level of the indifferent worker, $\underline{\theta}^o(A)$ (thereby increasing the share of workers in sector X). The production of X increases, while that of Z decreases. Prices remain unchanged at $p = p^*$ and:*
(i) wages in the traditional sector, w increase;
(ii) the skill premium of all workers in the manufacturing sector, $(\theta/\underline{\theta}^o)^A$, and hence their nominal earnings, $w(L(\underline{\theta}^o), N)(\theta/\underline{\theta}^o)^A$, increase.

Proof: See Appendix.

[17] A higher $\underline{\theta}(A)$ 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.

In an open economy improvements in the productivity in the modern sector attracts more workers thereby increasing the production of X. The local production of the traditional goods decreases and the larger demand is met by imports. In the traditional sector, where labor gets more scarce and marginally more productive, the indifference wage required by workers increases.[18] Once the economy has liberalized to trade, a rise in productivity, A, increases the skill premium both directly (for any skill level) and by reducing the minimum skill level $\underline{\theta}^o$ required to work in that sector. Consequently, in an open economy the adoption of a better technology reduces the rents that the elite can extract.

2.4 Trade Liberalization, Democratization and Technology Adoption.

The goal is to study the change in incentives for technological improvements (higher A) in response to a change in the trade and/or the political regimes. To this end we next characterize who gains and who looses from an increase in A in each trade regime.

In this simple set-up with homothetic preferences the equilibrium individual levels of consumption for each good, denoted by $x(A)$ and $z(A)$, are proportional to individual income. This implies that, as derived in the Appendix, the indirect utility of each individual is given by,

$$u(x(A), z(A)) = \widetilde{\beta} \frac{y(A)}{p(A)^{\beta}}, \tag{10}$$

where $\widetilde{\beta} \equiv \beta^{\beta} (1-\beta)^{1-\beta}$ and $y(A)$ and $p(A)$ denote the equilibrium individual income and relative price for any given A. The individual indirect utility (10)

[18] Analyzing the effects of a change in A on the skill premium in the X sector is instrumental to study changes in incentives for technology adoption after openness to trade. Notice however that, in line with the literature, trade openness can also have a direct effect on wages (and the skill premia) through the (one shot) adjustment of relative prices p. Specifically, from (7), a reduction in manufacturing prices (associated for instance to lowering import tariff) leads to a reduction in the wage premium of skills in that sector (by increasing the threshold $\underline{\theta}^o(A)$ for any A). The evidence by Attanasio, Goldberg and Pavcnik (2004) and Goldberg and Pavcnik (2005) of a reduction of the wage premium in sectors that were more exposed to trade in Colombia, is in line with this effect.

therefore increases with the nominal income and decreases with $p(A)$. The effects of increasing productivity A on the income of different individuals and prices in closed and open economies is studied in Lemma 3 and 4.

Let us consider an economy initially characterized by an autarkic trade regime and ruled by the autocratic elite, that is, being a closed autocracy. We investigate the change in the incentives for technology adoption after trade liberalization, democratization, and a transition that involves both. In line with empirical evidence discussed in more details in Section 3, the historical transitions from closed autocracies to open democracies involved as intermediate step: either a transition to an open autocracy or a transition to a closed democracy.[19]

Let us first study how the incentives of the ruling autocratic elites towards technological improvements changes in the face of opening to trade. From Lemma 3, in a closed economy a larger A leads to a reduction in the price p, which increases the indirect utility of all individuals in the economy by making manufacturing goods cheaper. The oligarchic elites, who are the residual claimants of the production in the traditional sector, gain from the reduction in baseline wages, w, which is associated with a higher skill premium in the manufacturing sector and tougher competition, reducing the wage of unskilled workers. Both effects unambiguously increase the real income and, therefore, the indirect utility of the autocratic elites. In an open economy technology adoption does not deliver advantages in terms of relative prices (since they are set in international markets). Also from Lemma 4, the autocratic elites face a reduction in the ability to reap the benefits of more productive technologies in an open economy since wages increase following the shift of workers towards the manufacturing sector. They are therefore worse off if productivity A increases.

A process of trade liberalization alone is therefore expected to reduce the incentives for technological improvements by part of the ruling oligarchic elites. Said the other way around, opening the economy increases the vested interests of the autocratic elites which leads them into using their political power to slow down or

[19] As discussed in more detail in Section 3, not all countries experience a transition in both regimes during the observation period (1980-2000) and no country experience a contemporaneous change in both trade and political regime.

block technological improvements.

Proposition 1 [Trade Liberalization] *For any* $\{A, G(\theta), N\}$*, n a closed autocracy the incentives of the ruling political group for fostering technological improvements are reduced after opening to trade.*

Proof: See Appendix.

Consider now the effect of a process of democratization in a closed economy. An increase in the political power of the workers reduces the political ability of the (former) autocratic elites to defend their economic interest. In view of Lemma 3, technology adoption can have different effects on the well-being of different workers, however. Although for different reasons than those for the (former) oligarchic elites, the skilled workers of the manufacturing sector unambiguously gain from higher productivity (their wage increases and they enjoy lower prices). A transition to democracy should therefore leave incentives for technological improvements essentially unchanged if these workers become political pivotal (if they are, for instance, the new median voter). In turn, the unskilled workers enjoy a net gain only if the reduction in equilibrium prices more than offsets the reduction in their wages. If this is not the case and the low skill workers outnumber the skilled workers then the process of democratization may even lead to a reduction of incentives to facilitate technological improvements.[20]

Depending on the actual gains or losses of the unskilled workers in terms of their real wages and their political power in democracy we should therefore expect that a process of democratization in a closed economy should either have no effect or a negative effect on the incentives to promote technological improvements.

Proposition 2 [Democratization] *Consider a closed autocracy. For any* $\{A, G(\theta), N\}$ *the incentives of the ruling political group for fostering technological improvements are either unchanged or are reduced after democratization.*

Proof: See Appendix.

[20] This appears the most likely scenario in less developed countries, where the low income workers tend to be politically pivotal, see Tavares (2008).

From Lemma 4, technological improvements unambiguously benefit all workers in an open economy. Experiencing a joint transition in the trade and the political regime therefore raises incentives to adopt new technologies. In view of Proposition 2, the increase in such incentives is smaller (or absent) if trade liberalization takes place in a country that has already experienced a transition to a democracy, where the skilled workers benefitting from a higher A are politically pivotal.

Proposition 3 [Trade Liberalization and Democratization] *Consider a transition to an open democracy. For any* $\{A, G(\theta), N\}$*, the incentives of the ruling political group for fostering technological improvements:*
i) strictly increase after democratization of an open autocracy;
ii) increase, or are left unchanged, after opening of a closed democracy.

Proof: See Appendix.

In order to devise an empirical strategy to investigate the relevance of the theoretical insights it is useful to highlight that Propositions 1, 2 and 3, characterize changes in incentives to adopt new technologies after trade liberalization and democratization. Strictly speaking, the theory does not deliver any prediction the level of technology in closed and open countries or in autocracies and democracies *per se*. Furthermore, the level of technology may be different across countries and it may be affected by country specific observable and unobservable characteristics.

3 Empirical Evidence

The theoretical framework deliver several testable predictions. The level of technological adoption is expected to depend on a country's trade and political regimes. Specifically, in a close autocracy the effect of changes of trade and/or political regimes on the technology adoption are as follows: 1) negative after trade liberalization; 2) negative or insignificant after democratization; 3) positive after a joint transition in both regimes (following trade liberalization *and* democratization). In this section we investigate the empirical relevance of these predictions and conduct a series of sensitivity exercises to test the robustness of the baseline findings.

3.1 Data

In the absence of a more direct measure of technology adoption or productivity, the early empirical literature has concentrated attention to the Solow residual. A main limitation of this strategy is that the Solow residual captures (by construction) the effect of all other factors beyond technology that affect total productivity such as, e.g., the variation of capacity utilization, labor hoarding, the inefficiencies of the economy related to formal and informal institutions to name a few. To address this problem Comin and Hobjin (2004) and Comin, Hobjin and Rovito (2006, 2008) have assembled the Cross-Country Historical Adoption of Technology (CHAT) dataset which represents a natural benchmark to investigate the theoretical predictions of the model. The CHAT provides information on technologies by measuring the number of units of capital that embody the new technology or the amount of output produced with the new technology. These data has the advantage to measure the *intensive margin* of technology adoption, which captures how many units of a good embodying a given technology are actually present in a given economy, and it is available for a wide range of technologies, countries and years.[21] Since technologies are measured in different units, we follow Comin and Hobjin (2009) and include a full set of time and technology specific effect in the estimations.[22] For robustness and as alternative variable of interest which can proxy for the level of labor productivity in the manufacturing sector, we also use information on value added per

[21] An alternative measure of technology adoption would be to use information on the share of firms adopting a particular technology. For the purposes of this paper this strategy, which requires firm-level information, is not viable since this information is not available (and would be hard to collect) for a large number of countries and a wide range of technologies. See also Comin, Hobjin and Rovito (2008) for a discussion on this point.

[22] For many technologies the data report information on the number of capital goods per capita (like, e.g. the number of computers per capita). For some technologies the information refer to the output produced (e.g. the amount of steel produced in electric arc furnaces) while for some the information is about the technology level of diffusion (e.g. the number of credit and debit card transactions per capita). We refer to Comin and Hobjin (2009) for an exhaustive description of the data.

worker from the CEPII *"TradeProd"* database.[23] We investigate the effect of trade liberalization and democratization for technology adoption in the period 1980 to 2000 which encompasses most of the third wave of democratization and the 1990's which witness many episodes of trade liberalization.

In line with the theory and the empirical literature, we consider a dichotomic representation of trade and political regimes. The indicator for trade liberalization has been taken from Wacziarg and Welch (2008) which update the Sachs and Warner (1995) openness indicators and trade liberalization dates. The liberalization date is the year 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 (2008), and zero otherwise. This coding involves permanent trade regime changes.

As baseline information for democratization we use data on political regimes from the Polity IV database. The polity variable measures the quality of democratic institution and varies from +10 (strongly democratic) to -10 (strongly autocratic). As a benchmark we follow the literature and code a country to be democratic if the polity score index is positive and autocratic if it is negative. This conceptualization of democracy follows Munck and Verkuilen (2002) and Przeworski et al. (2000). To check the robustness of the results, we nonetheless also replicate the analysis using alternative coding of political regimes. In particular, as discussed in further detail below, we consider information on free and contested elections from Golder (2005) and the refined coding by Papaioannou and Siourounis (2008) which further im-

[23]This variable, which can be interpreted as a measure of labor productivity in the manufacturing sector, can be taken for an indirect proxy for technology adoption since, besides being influenced also by other factors like for instance workers' human capital, should be highly related to the technologies operated by these workers. The information builds on data from the OECD and UNIDO. We refer to Mayer, Paillacar and Zignago (2008) for a more detailed description of the data.

poses a stability conditions thereby restricting attention to the subset of permanent democratic transitions. A summary of the country classification in terms of trade and political regimes (and their changes overtime) is reported in the supplementary appendix.[24]

3.2 Empirical Strategy

Testing the main hypothesis requires estimating the effect on the level of technology adoption of switches in either trade regime or political regime and, crucially, jointly in both regimes. The main explanatory variables of interest are $Open_{jt}$, a dummy variable that takes the value of one in the years after the trade regime has changed and 0 otherwise, and $Demo_{jt}$, which takes the value of one once the country has democratized and zero otherwise. To study the possible complementarities between the trade regimes and the political regimes affect the adoption we consider the interaction between the trade regime variable, $Open_{jt} \times Demo_{jt}$ which takes value one if the country is open *and* democratic and zero otherwise.

The empirical strategy involves estimating the effects of trade liberalization, democratization and their interaction on the future level of technology adoption using the following model:

$$\begin{aligned} ln\left(TechA_{ijt}\right) &= \lambda_0 + \lambda_1 Open_{jt_{-1}} + \lambda_2 Demo_{jt_{-1}} + \lambda_3 \left(Open_{jt_{-1}} \times Demo_{jt_{-1}}\right) \\ &+ \nu_j + \nu_{it} + \varepsilon_{ijt} \end{aligned} \tag{11}$$

Specification (11) controls for time invariant country specific unobserved characteristics by including country fixed effects ν_j. Following Comin and Hobjin (2009), the model also includes a full set of time and technology fixed effects, denoted by ν_{it} since, as discussed above, the technologies are measured in different units. This also allows to control for the possibility that different technologies follow different adoption paths overtime. The standard errors are allowed to be adjusted for clustering

[24] A full list of the countries included in the sample classified by trade and political regime in each year and reporting the their average number of technologies under each of their trade and/or political regimes is available upon request.

at the country-level to account for heteroskedasticity and non-independence across the repeated observations within countries.[25]

The dichotomic representation of the regime changes and the inclusion of country and technology×year fixed effects allows to interpret the effects as resulting from a difference-in-difference estimator that exploits a change (in a regime) in a given year as treatment (first difference) and compares it to countries that do not change regime in the same year (second difference). This strategy therefore allows to exploit within country variations overtime to study the effect of trade liberalization and democratization rather than using cross country variability to find the effect of trade openness and democracy.

3.3 Results

Preliminaries. The baseline sample contains data on the adoption of 83 technologies for 129 developed and developing countries for the period 1980-2000. The baseline sample is composed of 46 democracies, 26 autocracies and 57 countries that have switched their political regimes during the sample period. There are 12 closed economies, 34 open countries and 60 countries that have switched their trade regimes during the sample period.[26]

As a preliminary step, Table 1 reports the results of regressions *without* country fixed effects to study the relationship between the level of technology and the trade or political regimes (and their interaction) overtime across countries. The results in column (1) document a larger level of technology adoption in open economies than in closed economies. Column (2) shows a similar differential between democracies and autocracies. These results are therefore in line with the common wisdom that more open or more democratic economies, taken alone, are characterized with higher technology adoption. Column (3) confirms these first findings by including

[25]This level of clustering is chosen as benchmark since the information on trade and political regimes is at the country level. For robustness we have nonetheless also considered clustering of the errors at the technology-country level and at the technology level.

[26]Tables 8 and 9 in Appendix 5.2 report the summary statistics and a correlation matrix between the technology adoption variable and the political and trade regimes.

information on both trade and political regimes. These results confirm the common wisdom that open countries and democracies are characterized by a higher level of technology.

Table 1: Preliminary Analysis: Impact of Trade and Political Regimes on Technology

Dependent Variable	Technology Adoption				
	(1)	(2)	(3)	(4)	(5)
Openness	1.445***		0.965***	0.544	0.592
	(5.849)		(4.019)	(1.575)	(1.622)
Democracy		1.472***	1.002***	0.724**	0.747**
		(6.324)	(4.386)	(2.267)	(2.277)
Openness × Democracy				0.679	0.678
				(1.501)	(1.480)
Technology FE	Yes	Yes	Yes	Yes	No
Tech.×Years FE	No	No	No	No	Yes
Country FE	No	No	No	No	No
Sample	Full	Full	Full	Full	Full
Observations	56,959	56,959	56,959	56,959	56,959
Number of countries	129	129	129	129	129
Adjusted R^2	0.870	0.870	0.874	0.875	0.877

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively.

The empirical specification is extended, in column (4), to the inclusion of the interaction between the trade and the political regimes to check whether there is any significant interplay between these regimes and technology. To interpret the results recall that the base category is the set of closed autocracies. This implies that, for instance, the estimate of the variable 'democracy' in Column (4) compares the level of available (adopted) technology between closed autocracies and closed democracies, while the coefficient of the variable openness reflect the difference between closed and open autocracies. The results suggest that the technology in open autocracies does not significantly differ from closed autocracies. Closed democracies are technologically more advanced than closed autocracies and open democracies are the countries with the largest technological level.[27] Column (5) shows that these findings are virtually unchanged when further including a full set of time and technology specific effects to control, as suggested by Comin and Hobjin (2009), for

[27]The latter obtains from adding the three coefficients which turns out to be significant.

the difference in measurement units of the dependent variable. Overall, the specifications explain from about 87.5% of the variation of the log level of technology adoption as suggested by the adjusted R^2.

Baseline results. The findings reported in Table 1 do not represent, strictly speaking, a test of the theoretical hypothesis, however. The theoretical model provides testable predictions on the effects a variation in trade and/or political regimes on the incentives to adopt new technologies (rather than on different levels of technology in the different regimes). Also the differences in technological level across countries are likely to be related to omitted country specific characteristics which, not being accounted for in Table 1, can be picked up by the trade and political regimes.

To deal with these issues we move one step forward and the test the empirical model (11) that includes both technology×year and countries fixed effects thereby making it possible to exploit within country variability overtime. The results can be interpreted as referring to the deviation of the adoption level of each technology in country j at time t from the average adoption level in that period in the non-treated countries. By including country fixed effects, the empirical model exploits *within-country* impact of trade and/or political regime changes overtime. This empirical strategy represents a closer test of the hypothesis since the empirical identification relies on the changes on trade and political regime (rather than the mere status of openness and democracy at each point in time) and controls for time invariant country specific unobserved heterogeneity (that may jointly affect both the technological level, the trade and the political regime) and omitted variables such as geography or social norms that may differently affect technology adoption in different countries.

The results of the estimation of the empirical model (11) are reported in Table 2. Columns (1) and (2) investigate the effect of trade liberalization and democratization on technology adoption, respectively. The results for each regime change needs to be interpreted with reference to the baseline omitted category which in Table 2 is the set of countries that, at each point in time, do not change the respective (trade or political) regime. The baseline results are based on the full sample which includes

countries that change trade or political regimes and countries that do not change (either one or both) regimes during the observation period. This implies that, for instance, the (difference-in-difference) effect of democratization needs to be compared with reference to all countries that do not democratize in that period.[28] The results are strikingly different from the equivalent specifications reported in Table 1. Once country fixed effects are included neither opening to trade nor democratization have robust significant effects on technology adoption. In fact, if anything, both opening to trade and democratizing tend to have a negative effect on technology adoption. Column (3) shows that these findings do not depend on the fact that each regime change is studied in isolation.

Table 2: Trade Liberalization and Democratization on Technology Adoption

Dependent Variable	Technology Adoption				
	(1)	(2)	(3)	(4)	(5)
Openness	-0.063		-0.048	-0.182***	-0.176***
	(-1.212)		(-0.980)	(-3.009)	(-2.766)
Democracy		-0.084	-0.075	-0.132**	-0.145***
		(-1.580)	(-1.490)	(-2.592)	(-2.800)
Openness × Democracy				0.198***	0.193***
				(3.049)	(2.858)
Tech.×Years FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Full	Full	No Soc.
Observations	56,959	56,959	56,959	56,959	54,361
Number of countries	129	129	129	129	114
Adjusted R^2	0.951	0.951	0.951	0.951	0.952

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively. In column (5), we exclude former socialist countries.

According to the theoretical predictions the average effect of a change in either trade or political regimes might hide relevant heterogeneities, however. The theoretical prediction of the existence of relevant complementarity between these regime

[28]For robustness we have replicated the analysis of Table 2 also excluding the countries that are always democracies during the observation period thereby restricting attention to countries that start autocracies and either remain autocracies or democratize during the observation period. The results (available upon request) are confirmed and the effect of joint regime changes discussed below are even quantitatively stronger.

changes is studied in column (4), that is, by estimating the empirical model (11). The results suggest that the insignificant effect of either trade liberalization and democratization is due to the fact a change in each of these regimes alone has a negative effect on technology adoption. Recalling that the baseline (omitted category) is the set of closed autocracies, the results in column (4) imply that the level of technology adoption drops if a closed autocracy opens up to trade or democratizes, respectively. On the contrary, the coefficient of the interaction term is positive and highly significant, suggesting that technological dynamics are positively affected when a country liberalizes both economically (openness to trade) and politically (democratization). The findings are in line with the theoretical predictions in Propositions 1-3. In addition, trade liberalization in a democracy increases the level of technological adoption by 2 percent while democratization in an open country increases this level by about 7 percent.[29] This confirms the prediction in Proposition 3 that the effect of a transition to an open democracy should be expected to be stronger when it initiates from an open autocracy rather than a closed democracy.

To check whether the results are driven by the "*former socialist*" countries that have, undergone the transition to market economies in the 1990s, column (5) excludes these countries from the sample. The results are very similar to those of column (4).[30] Overall, the specifications explain from about 95% of the variation of the log level of technology adoption as suggested by the adjusted R^2.[31]

One relevant issue that has been raised in the political economy literature is

[29]The effect of trade liberalization in a democracy is the difference between the coefficients interaction term and the openness variable: 0.198-0.182. The effect of democratization in an open country is computed as the difference between the coefficients of the interaction term and the democracy variable: 0.198-0.132.

[30]There are fifteen former socialist countries in the sample: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. In column (5), we exclude these countries from the regression. The results hold also excluding India, a former mixed-socialist country that undertook market reforms in the early 1990's.

[31]The results are robust to the inclusion of further covariates like GDP and per capita GDP. The main difference is that the point estimate of the direct effect of democracy gets even smaller and generally not statistically significant. We abstain to report these results (available upon request) since the potentially endogeneity of these further covariates might bias the estimates.

about the identification of the date of democratization and the fact that the change in political regime may not be permanent.[32] To check the role of the definition of political regime changes we have replicated the baseline analysis using the available alternative coding of democratization from Golder (2005), which follows Przeworski et al. (2000) and identifies democratization by considering the existence of free and contested elections and from Papaioannou and Siourounis (2008) which involves a joint consideration of available sources (including both Freedom House and Polity IV scores and information on contested elections) and further restricts attention to regime changes leading to stable democracies. The results of these robustness test confirm the baseline findings and, in fact, document even more heterogenous effects with the point estimate of the interaction effect being larger and even more significant.[33]

Further Analysis. A relevant concern that has been raised in the literature studying the effects of trade liberalization and democratization on macroeconomic outcomes is the existence of biases due to reverse causality. As the literature points out, the estimates of the effect of political or trade regimes can be affected by reverse causality if the variable of interest, for instance income growth or the level of foreign direct investments, consistently affects the probability that a country undergoes trade liberalization or a transition to democracy.[34] Specifically to the case of interest for this paper, reverse causality should bias the estimates of the effect of either trade openness and democratization upwards delivering 'false' positive

[32]While opening to trade is permanent, some countries in the sample have experienced episodes of political regime reversals.

[33]The results are reported in Tables 10 and 11 and in the Appendix. We refer to Golder (2005) and Papaioannou and Siourounis (2008) for a very detailed and extensive discussion of the alternative codings of democratization. Another alternative (but admittedly crude) method to check the robustness of the results to the role of political instability is to drop all observations which correspond to a period of political instability. Marshall and Jaggers (2009) provide information on the number of years since the most recent political regime change or since the end of a transition period. The results of these further checks (available upon request) also confirm the baseline findings.

[34]We refer to Bertrand *et al.* (2004) and Giavazzi and Tabellini (2005) for extensive discussions of this issue.

effects if improvements in technology adoption facilitate opening to trade and/or democratization. The (average) effect of trade liberalization and democratization on technology adoption are negative (although marginally insignificant), however, as documented in Columns (1), (2) and (3) of Table 2. The negative direct effects of a trade liberalization and democratization actually get stronger once one includes the interaction between these regimes, as in Column (4). In turn, the joint effect of a change in both regimes is positive, large and highly significant. It is not obvious which type of reverse causality could deliver consistently opposite statistical biases when opening to trade takes place under different political regimes.[35] The main results of Table 2, about the existence of heterogenous effects of trade liberalization and democratization (and their positive interactions), therefore appear unlikely to be driven by reverse causality. To assess the robustness of the results, and to investigate the empirical relevance of some side predictions, we perform some robustness checks which should also be informative about the possible existence of reverse causality. Before concluding, we finally discuss the results of some further tests.

Different Technologies. An important difference compared to studies on macroeconomic outcomes is that the analysis does not investigate the evolution of aggregate (or indirect) measures of productivity at the country level but the change in technology adoption in a large number of different sectors within each country. Compared to use of indirect productivity measures, exploiting disaggregated data at the sector level should reduce the likelihood of reverse causality since technology adoption in each single sector should be unlikely to affect the (timing of) regime changes. One could argue, however, that some specific technologies might be relevant in affecting the trade and political regimes. For instance telecommunications and transportation technologies might matter for both processes of trade liberalization and democratization. Also, as argued by Bekaert et al. (2005), financial development can facilitate

[35] Also, the empirical specification (11) essentially exploits the differential timing of the regime transitions across countries (rather then the regime change *per se*). The identification of the causal effect of the regime changes therefore requires that the timing of the transitions are not consistently affected by the change in technology adoption.

trade liberalization (at least for countries joining a free market area). One way to investigate this possibility is to check whether the results are driven by one specific technological sector. Column (1) of Table 3 replicates the baseline analysis by excluding technological adoption in the communication, transportation and financial development sectors. Despite the large reduction in sample size (and the lower degree of precision of the estimates) the results confirm the baseline findings. The remaining columns report the results of sub-samples obtained by dropping iteratively each category of technologies (in Agriculture, General, Health, Steel production and Tourism sectors, respectively). The results confirm the baseline findings.[36]

Table 3: Robustness: Excluding each of the Technological Sectors

Dep. Variable	Technology Adoption					
	(1)	(2)	(3)	(4)	(5)	(6)
Openness	-0.151**	-0.225***	-0.115*	-0.247***	-0.160***	-0.194***
	(-2.100)	(-3.270)	(-1.977)	(-3.630)	(-2.658)	(-3.144)
Democracy	-0.061	-0.161***	-0.100**	-0.173***	-0.129**	-0.147***
	(-1.176)	(-2.626)	(-2.047)	(-3.130)	(-2.558)	(-2.858)
Open. × Demo	0.177**	0.218***	0.136**	0.271***	0.177***	0.209***
	(2.415)	(3.019)	(2.127)	(3.769)	(2.669)	(3.179)
Tech.×Years FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Excl. Sector:	Communic. Trans. & Financ.	Agric.	General	Health	Steel	Tourism
Observations	33,699	43,892	52,940	46,800	54,329	53,135
Countries	129	129	129	129	129	129
Adjusted R^2	0.960	0.957	0.935	0.950	0.953	0.952

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively.

Sub-samples of countries that switch only one regime. Recall that the baseline sample includes countries that may have switched one or both regimes. One crude way to investigate whether the results are driven by reverse causality in either openness or democratization is to replicate the analysis on the sub-samples of countries

[36]The most notable difference is that the negative effect of democratization is statistically insignificant in column (1) which jointly excludes communication, transportation and financial development. The results obtained by dropping iteratively each one of these three sectors confirm the findings and are unreported (but available upon request) to avoid duplication.

that only change one of the two regimes. The estimation framework again identifies the differential impact of trade liberalization by exploiting within countries variability overtime by including both country and technology×year fixed-effects. The results are reported in Table 4.

Table 4: Robustness: Countries that do not change Political *or* Trade Regime.

Dependent Variable	Technology Adoption					
	Change Trade Regime			Change Political Regime		
	(1)	(2)	(3)	(4)	(5)	(6)
Openness	-0.124***	-0.252***	-0.200**			
	(-2.936)	(-2.930)	(-2.240)			
Democracy				0.006	-0.087	-0.095
				(0.089)	(-1.041)	(-1.075)
Openness × Demo.		0.200*	0.194*		0.409**	0.413**
		(2.052)	(1.881)		(2.753)	(2.765)
Technology×Years FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sample			No Soc.			No Soc.
Observations	9,601	9,601	8,571	8,316	8,316	8,174
Number of countries	26	26	20	23	23	22
Adjusted R^2	0.962	0.962	0.966	0.956	0.956	0.956

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively. In column (2) we exclude years of political instability. Columns (1) to (3) consider the sub-sample of countries that do not change their political regime (but only their trade regime). Columns (4) to (6) consider the subsample of countries that do not change their trade regime (but only their political regime). In column (3) and (6), we exclude former socialist countries.

Columns (1) to (3) of Table 4 replicates the baseline analysis restricting attention to the sub-sample of countries that did not change their political regime. The sample is composed of countries that stay either autocratic or democratic but that have liberalized their trade during the sample period.[37] In other words, this exercise exploits the change in the trade regime in autocracies and democracies. The prob-

[37]Notice that estimation sample is substantially reduced since, due to the inclusion of country fixed effects, the estimates only exploit information on countries that change their trade regime (but not their political regime) in the observation period. This sample includes Burkina Faso, Cameroon, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Georgia, Guinea, Honduras, Israel, Kenya, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Mauritania, Moldova, Morocco, New Zealand, South Africa, Sri Lanka, Tajikistan, Tanzania, Tunisia and Venezuela.

lem of reverse-causality from technology adoption to a change in political regime is therefore ruled out by construction.

Column (1), documents that, also in the sub-sample of countries that only change trade regime, the average effect of trade openness on technology adoption is negative. Column (2) allows for a heterogenous effect of trade openness on technology adoption conditional on the political regime. The point estimate of the openness variable (in autocracies) is negative and significant. To interpret the result, recall that the coefficient of the openness variable informs on the effect on the level of technology adoption when trade liberalization takes place in autocratic countries. The effect of liberalization in democratic countries is therefore found by adding the coefficient *openness* and *openness* $\times$ *democracy* variables. In accordance with Proposition 1, trade liberalization reduces the level of technology adoption in autocratic countries. We do not detect a significant impact on countries that are already democratic.[38] Columns (3) excludes the former socialist countries. The openness variable continues to be negative but estimated with a lower degree of precision, while there is no significantly positive effect of opening to trade in democratic countries.

The columns (4) to (6) of Table 4 perform the complementary exercise by considering the effect of democratization on technology adoption in the sub-sample of countries that do not change their trade regime in the observation period.[39] In this case reverse causality from technology to openness is ruled out by construction. The results also confirm the previous findings. The average effect of democratization in a closed country, reported in column (4) is insignificant. This is also in line with the ambiguous effect of such political transition in Proposition 2. In turn, democ-

[38] In order to quantify the impact of liberalization in democratic countries, we compute the difference between both coefficients and its statistical significance: 0.200-0.252=-0.052, t-statistics=-0.91. Despite the very different sample this result is fairly in line with the baseline findings reported in Table 2.

[39] Again the sample is substantially reduced since the estimates only exploit information on the countries that change their political regime (but not their trade-regime) in the observation period. This sub-sample include Angola, Belarus, Central African Republic, Chad, Chile, Democratic Republic of the Congo, Republic of the Congo, Croatia, Haiti, Indonesia, Iran Islamic Republic, Lesotho, Liberia, Malawi, Nigeria, Pakistan, Senegal, Sierra Leone, Somalia, South Korea, Taiwan, China, Thailand and Zimbabwe.

ratization in a open country leads to a sizable positive and significant increase in technology adoption as expected from Proposition 3.

Despite the large reduction in sample size (and the change in the omitted group) which makes the results not directly comparable to the baseline findings, the results obtained in the two sub-samples by and large confirm the findings that trade liberalization have a negative effect on technology adoption if it takes place in an autocracy, democratization taking place in closed countries is insignificant while a joint process of trade liberalization and democratization accelerates technology adoption.

Leads of the Regime Changes. As a further falsification test, we extend the baseline model to the consideration of the leads, rather than the lags, of these regime changes. This exercise might be informative on the existence of reverse causality from technological adoption to changes in the trade and political regimes since a statistically significant coefficients of the leads of the regime changes would point out a potential problem of reverse causality in the regressions. Table 5 reports the results of extending the baseline specification to the inclusion of the (three or five-year) leads of the trade and political regimes.

The leads of the regime changes are always insignificant while the point estimates of the (lags) of the political and trade regime changes (and their interaction) are only marginally affected when compared to the respective results of Table 2 and the inclusion of the leads do not involve any notable change the explanatory power as measured by the Adjusted R-squared.[40]

Initial Technological Levels and Persistence of the Effect. The consideration of data from different technological sectors within each country allows to control for initial conditions in the form of the initial level of technology.[41] Although the inclusion of technology×year fixed effects already accounts for sector specific trends

[40]Notice that the results are essentially directly comparable to the baseline findings reported in Table 2 since including three years leads of regime change, we do not loose any observation (as the trade and political regimes variable are available until 2004) while including five years leads involves only a small reduction in sample size.

[41]The inclusion of country fixed effect would preclude the possibility to control for initial conditions if the variable of interest is at the country level like, for instance, proxies for aggregate measures of productivity.

Table 5: Robustness: Counterfactuals using time Leads of Regime Changes

Dependent Variable	Technology Adoption					
	(1)	(2)	(3)	(4)	(5)	(6)
Openness	-0.042		-0.160***	-0.063		-0.191***
	(-0.964)		(-2.942)	(-1.396)		(-3.419)
Democracy		-0.085*	-0.129***		-0.083*	-0.134***
		(-1.826)	(-2.944)		(-1.693)	(-2.849)
Openness × Democracy			0.175***			0.193***
			(2.776)			(3.082)
Three years leads:						
Openness	-0.050		-0.056			
	(-1.325)		(-1.086)			
Democracy		0.001	-0.010			
		(0.026)	(-0.234)			
Openness × Democracy			0.052			
			(0.844)			
Five years leads						
Openness				-0.028		-0.046
				(-0.719)		(-0.935)
Democracy					0.005	-0.019
					(0.148)	(-0.461)
Openness × Democracy						0.078
						(1.388)
Tech.×Years FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Full	Full	Full	Full
Observations	56,959	56,959	56,959	54,313	54,313	54,313
Number of countries	129	129	129	129	129	129
Adjusted R^2	0.951	0.951	0.951	0.951	0.951	0.951

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively.

overtime, controlling for the initial level of technology in each sector and countries appears a natural, and potentially very demanding, robustness check. Column (2) of Table 6 extends the baseline results of Column (1) to the consideration of the initial level of technology in each sector. The results document that the heterogenous effects of regime changes is not imputed to the omission of initial conditions. The remaining columns of Table 6 replicate the analysis considering three and five years lags of the change in trade and political regimes. The result uncover very similar patterns and suggest that regime changes have persistent effects in particular for the positive complementarity between trade openness and democratization.

Manufacturing Labor Productivity. As a final check we consider manufacturing

Table 6: Robustness: Lagged Effects and Initial Conditions

Dep. Variable	Technology Adoption					
	One Year Lag		Three Years Lag		Five Years Lag	
	(1)	(2)	(3)	(4)	(5)	(6)
Openness	-0.182***	-0.131***	-0.154**	-0.108*	-0.113*	-0.073
	(-3.009)	(-2.647)	(-2.423)	(-1.897)	(-1.702)	(-1.106)
Democracy	-0.132**	-0.067**	-0.123**	-0.069**	-0.091*	-0.049
	(-2.592)	(-2.033)	(-2.338)	(-2.053)	(-1.826)	(-1.484)
Open. × Demo.	0.198***	0.125**	0.220***	0.141**	0.222***	0.135*
	(3.049)	(2.418)	(3.228)	(2.298)	(3.128)	(1.912)
Tech.×Years FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Tech. Initial Con.	No	Yes	No	Yes	No	Yes
Sample	Full	Full	Full	Full	Full	Full
Observations	56,959	56,959	56,959	56,959	56,959	56,959
N. of countries	129	129	129	129	129	129
Adjusted R^2	0.950	0.985	0.950	0.985	0.950	0.985

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively. Columns (1) and (2) consider the effect of regime changes with one year lag (baseline). Columns (3) and (4) consider the effect of regime changes lagged by three years while columns (5) and (6) consider regime changes lagged five years. Columns (2), (4) and (6) include the initial level of technology in the respective sector and country.

value added per worker as dependent variable of interest.[42] The results should be interpreted as purely suggestive test of the theoretical predictions since they are based on the more indirect (and potentially more noisy) measure of labor productivity which is related to the level of technology but it is also likely to be affected by other relevant country specific features (like the availability of human capital, the country specific institutions, etc.). The empirical model includes two ways (time and country) fixed effects, thereby exploiting within country variability overtime to account for country specific unobserved heterogeneity and global trends in labor productivity.[43]

[42]The estimation sample reduces to 98 countries. We have also used this smaller sample using the technology adoption as a dependent variable to check whether the results were sensitive to a change in sample size. The results confirm the baseline findings and are available upon request.

[43]As for the empirical model (11), the results can be interpreted as a difference-in-difference estimator. The main difference between the two models is that we cannot control for technology-year fixed effects (since we do not consider different technologies) but we include time fixed effects.

Table 7: Robustness: Trade Liberation, Democratization and Labor Productivity

Dependent Variable	Manufacturing Value Added per Worker				
	(1)	(2)	(3)	(4)	(5)
Openness	-0.218**		-0.197**	-0.447***	-0.446***
	(-2.415)		(-2.143)	(-4.301)	(-4.300)
Democracy		-0.147	-0.105	-0.204*	-0.204*
		(-1.507)	(-1.035)	(-1.847)	(-1.840)
Openness × Democracy				0.348***	0.347***
				(2.961)	(2.963)
Years Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Full	Full	No Soc.
Observations	1365	1365	1365	1365	1344
Number of countries	98	98	98	98	93
Adjusted R^2	0.868	0.870	0.870	0.872	0.869

Dependent variable, value added per worker, $\ln(LP_{jt})$. OLS Regressions. Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively. In column (5), we exclude former socialist countries.

The results, reported in Table 7 uncover patterns that are qualitatively identical to the baseline specification for technology adoption. The estimations consistently confirm, in particular, that the interaction between the trade liberalization and democratization leads to significant increases in labor productivity.[44]

4 Concluding Remarks

This paper provides a theoretical and empirical analysis of the interplay 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

The estimation specification is therefore,

$$\begin{aligned} ln\left(LP_{jt}\right) &= \beta_0 + \beta_1 Open_{jt_{-1}} + \beta_2 Demo_{jt_{-1}} + \beta_3 \left(Open_{jt_{-1}} \times Demo_{jt_{-1}}\right) \\ &+ \mu_j + \mu_t + \zeta_{jt} \end{aligned} \tag{12}$$

where 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 while ζ_{jt} is the error term.

[44]Similar to the baseline results of Table 1, unreported regressions without country fixed effect confirm the common wisdom that open countries and democracies have higher labor productivity but that this pattern vanishes once country fixed are included.

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 tested exploiting within country variation overtime in trade openness, democracy and technology adoption at the sector level for a large set of countries. 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 the common wisdom and have relevant policy implications.

The theoretical predictions linking changes in trade and political regimes to technology adoption are tested in reduced form by exploiting cross-country panel data. The channel proposed in the theory hinges on general equilibrium effects which affect the ability of the ruling elites to extract resources from the economy and the interests of the different groups in the population. Lack of data on rent extraction, employment and wages at the sector level for a large enough panel of countries currently prevents a deeper investigation of the possible channels behind the documented heterogenous effects. Extending the analysis of the effects of openness and democratization to the considerations of further effects beyond technology adoption appears a fruitful direction for further analysis.

References

Acemoglu, D. (2003): "Patterns of Skill Premia," *The Review of Economic Studies*, 70, 199–230.

——— (2006): "Oligarchic versus Democratic Societies.," *Journal of European Economic Association*, 6, 1–44.

Aghion, P., A. Alesina, and F. Trebbi (2007): "Endogenous Political Institutions," *NBER Working Paper*, (13180).

Aidt, T., and M. Gassebner (2010): "Do Autocratic States Trade Less?," *The World Bank Economic Reivew*, 24, 38–76.

Attanasio, O., P. Goldberg, and N. Pavcnik (2004): "Trade Reforms and Wage Inequality in Colombia," *Journal of Development Economics*, 74, 331–3666.

Barro, R. J. (1996): "Democracy and Growth," *Journal of Economic Growth*, 1(1), 1–27.

Bekaert, G., C. R. Harvey, and C. Lundblad (2005): "Does financial liberalization spur growth?," *Journal of Financial Economics*, 77(1), 3–55.

Berman, E., and S. Machin (2000): "Skill-Based Technology Transfer around the World," *Oxford Review of Economic Policy*, 16(3), 12–22.

Bertrand, M., E. Duflo, and S. Mullainathan (2004): "How much should we trust differences-in-differences estimates?," *Quarterly Journal of Economics*, 119(3), 249–275.

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

——— (2009): "Lobbies and Technology Diffusion," *The Review of Economics and Statistics*, 91, 229–244.

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

——— (2008): "A New Approach to Measuring Technology with an Application to the Shape of the Diffusion Curves," *Journal of Technology Transfer*, 33, 187–207.

Do, Q.-T., and A. Levchenko (2009): "Trade, Inequality, and the Political Economy of Institutions," *Journal of Economic Theory*, 144(1), 1489–1520.

Dollar, D., and A. Kraay (2003): "Institutions, Trade, and Growth," *Journal of Monetary Economics*, 50(1), 133–162.

Edwards, S. (1998): "Openness, Productivity and Growth: What Do We Really Know?," *Economic Journal*, 108.

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

Giavazzi, F., and G. Tabellini (2005): "Economic and Political Liberalizations," *Journal of Monetary Economics*, 52(6), 1297–1330.

Goldberg, P., and N. Pavcnik (2005): "Trade, wages, and the Political Economy of Trade Protection: Evidence from the Colombian Trade Reforms," *Journal of International Economics*, 75, 75–105.

——— (2007): "Distributional Effects of Globalization in Developing Countries," *Journal of Economic Literature*, 45(1).

Golder, M. (2005): "Democratic Electoral Systems around the World," *Electoral Studies*, 24, 103–121.

Greenaway, D., W. Morgan, and P. Wright (2002): "Trade liberalization and Growth in Developing Countries," *Journal of Development Economics*, 67, 229–244.

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

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

Melitz, M. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71, 1695–1725.

Melitz, M., and G. Ottaviano (2008): "Market size, trade, and productivity," *Review of economic studies*, 75(1), 295–316.

Melitz, M., and S. J. Redding (2012): *Heterogeneous Firms and Trade*. Handbook of International Economics, Forthcoming.

Mokyr, J. (1998): *The Political Economy of Technological Change: Resistance and Innovation in Economic History*. Cheltenham: Edward Elgar.

Munck, G., and J. Verkuilen (2002): "Conceptualizing and Measuring Democracy: Evaluating Alternative Indices," *Comparative Political Studies*, 35(1), 5–34.

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

Papaioannou, E., and G. Siourounis (2008): "Democratization and Growth," *Economic Journal*, 118, 1520–1551.

Persson, T. (2004): "Consequences of Constitutions. 2003 presidential address at the Annual EEA Congress," *Journal of European Economic Association*, 2(2-3), 139–161.

Persson, T., and G. Tabellini (2009): "Democratic Capital: The Nexus of Political and Economic Change," *American Economic Journal Macroeconomics*, 1, 88–126.

Przeworski, A., M. Alvarez, J. A. Cheibub, and F. Limongi (2000): *Democracy and Development: Political Institutions and Well-Being in the World, 1950-1990*. Cambridge University Press, New York.

Przeworski, A., and F. Limongi (1993): "Political Regimes and Economic Growth," *Journal of Economic Perspectives*, 7(1), 51–69.

Sachs, J., and K. Warner (1995): "Economic Reform and the Process of Global Integration," *Brooking Papers on Economic Activity*, 1, 1–95.

Segura-Cayuela, R. (2006): "Inefficient Policies, Inefficient Institutions and Trade," *Documentos de Trabajo del Banco de España*, (633), 669–685.

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

Stefanadis, C. (2001): "Appropriation, Property Rights Institutions and International Trade," *American Economic Journal: Economic Policy*, 2, 148.

Tavares, J. (2008): "Trade, Factor Proportions, and Political Rights," *Review of Economics and Statistics*, 90, 163–168.

Tavares, J., and R. Wacziarg (2001): "How Democracy Affects Growth," *European Economic Review*, 45(8), 1341–1378.

Wacziarg, R., and K. H. Welch (2008): "Trade Liberalization and Growth: New Evidence," *World Bank Economic Review*, 22(2), 187–231.

Wood, A. (1995): "How Trade Hurt Unskilled Workers," *The Journal of Economic Perspectives*, 9(3), 57–80.

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

5 Online Appendix

5.1 Analytical Derivations and Proofs

Proof of Lemma 2. The assumption that individual preferences (1) are homothetic implies the standard result that the individual optimal total expenditure in each type of good is a fixed proportion of his total expenditure (and therefore income). This also implies that the aggregate demand for each good is given by,

$$pX = \beta E \text{ and } Z = (1-\beta)E, \tag{13}$$

where E denotes the total expenditure in the economy (that equals total income produced and distributed to owners of factors of production in the economy).

In a closed economy the total demand for each good, implicitly characterized in (13), must be covered by internal production. Given the production function for each sector (2) and (3), and for allocation of workers in the two sectors, summarized by the productivity of the indifferent worker $\underline{\theta}$ the previous conditions can be expressed as be expressed as,

$$p\int_{\underline{\theta}}^{\infty}\theta^{A}dG(\theta) = \beta E, \tag{14}$$

and

$$Z(L(\underline{\theta}), N) = (1-\beta)\,E, \tag{15}$$

The product market clears when (14) and (15) jointly hold that is if, and only if,

$$p = \frac{\beta}{1-\beta}\frac{Z(L(\underline{\theta}), N)}{\int_{\underline{\theta}}^{\infty}\theta^{A}dG(\theta)}. \tag{16}$$

Recall that the labor market is in equilibrium at $\underline{\theta}$ if (5) and (4) jointly hold which implies

$$p = \frac{w(L(\underline{\theta}), N)}{\underline{\theta}^{A}}. \tag{17}$$

The product and the labor markets therefore clear at $\underline{\theta}$ if, and only if, (16) and (17) hold simultaneously which implies

$$Y(L_Y(\underline{\theta})) = \frac{1-\beta}{\beta}\frac{w(L_Y(\underline{\theta}))}{\underline{\theta}^{A}}\int_{\underline{\theta}}^{\infty}\theta^{A}dG(\theta). \tag{18}$$

Recall that, for any given $\underline{\theta}$, the share of workers in the traditional sector is

$$L\left(\underline{\theta}, N\right) = \int_1^{\underline{\theta}} g(\theta) d\theta = G(\underline{\theta}). \tag{19}$$

The production function (2) is constant returns to scale. Assuming a Cobb-Douglas functional form we have that the total income distributed to the workers in the traditional sector is a fixed proportion of total production in that sector so that,

$$w(L(\underline{\theta}), N) L(\underline{\theta}) = \eta Y(L(\underline{\theta}), N). \tag{20}$$

Using (19) and (20), the equilibrium condition (18) can be finally expressed as,

$$G(\underline{\theta})\underline{\theta}^A = \eta \frac{1-\beta}{\beta} \int_{\underline{\theta}}^{\infty} \theta^A dG(\theta). \tag{21}$$

The equilibrium in a closed economy is unique since the left hand side of (21) is strictly increasing in $\underline{\theta}$ while the right hand side is strictly decreasing in $\underline{\theta}$.

Proof of Lemma 3. Denoting by $\underline{\theta}^c$ the equilibrium threshold in a closed economy and rewriting the equilibrium condition (21), define

$$F(\underline{\theta}^c, A) = G(\underline{\theta}^c)k - \frac{\int_{\theta^c}^{\infty} \theta^A dG(\theta)}{\underline{\theta}^{cA}} = 0$$

where $k = \frac{1}{\eta}\frac{\beta}{1-\beta}$. To see the effect of an increase in A on $\underline{\theta}^c$ we use the implicit function theorem to get

$$\frac{\partial \underline{\theta}^c(A)}{\partial A} = -\frac{\delta F(.)/\delta A}{\delta F(.)/\delta \underline{\theta}^c} = -\frac{-\int_{\theta^c}^{\infty} \theta^A \left(\ln\theta - \ln\underline{\theta}^c\right) dG(\theta)/\underline{\theta}^{cA}}{G'(\theta^c)k - \frac{\underline{\theta}^{cA}\left(-\underline{\theta}^{cA}\right) - A\underline{\theta}^{cA-1}\int_{\theta^c}^{\infty}\theta^A dG(\theta)}{[\underline{\theta}^{cA}]^2}} > 0. \tag{22}$$

since by Leibniz rule

$$\frac{\partial \int_{\theta^c}^{\infty} \theta^A dG(\theta)}{\partial \underline{\theta}^c} = -\underline{\theta}^{cA} < 0$$

and since $\partial L\left(\underline{\theta}^c\right)/\partial \underline{\theta}^c > 0$.

The last observation also directly implies a reduction in the wage w in the traditional sector following an increase in A. The effect of an increase in A on the skill premium is given by

$$\frac{\partial\left(\theta^A/\underline{\theta}^c(A)^A\right)}{\partial A} = \left(\theta^A/\underline{\theta}^c(A)^A\right)\left[\ln\theta - \ln\underline{\theta}^c(A)\frac{\partial \underline{\theta}^c(A)}{\partial A}\right] \tag{23}$$

From (22) $\partial \underline{\theta}^c(A)/\partial A > 0$ and since $\ln \theta$ is strictly monotonic in θ there exists a unique $\overline{\theta}(A)$ such that (23) equal zero.

The increase in the labor occupied in the traditional sector, Z implies an increase in the total production in that sector. In principle the equilibrium production in the X sector may increase (due to A) or decrease (due to higher $\underline{\theta}^c$) depending on the sign of $d\left(\int_{\theta^c}^{\infty} \theta^A dG(\theta)\right)/dA$. But the equilibrium condition requires that the positive direct effect of a better technology A dominates and always increases total output also in the X sector. This can be seen by considering again the condition for the equilibrium in a closed economy,

$$G(\underline{\theta}^c)\underline{\theta}^{cA} = \eta \frac{1-\beta}{\beta} \int_{\theta^c}^{\infty} \theta^A dG(\theta). \tag{24}$$

As shown above, a higher A increases $\underline{\theta}^c$, so the left hand side of (24) is increasing in A so that also the right hand side must increase which requires an increase in total production in the X sector: $d\left(\int_{\theta^c}^{\infty} \theta^A dG(\theta)\right)/dA > 0$. Finally notice that, from (17), the reduction in equilibrium wages w and the increase in the threshold level of skill $\underline{\theta}^c$ implies a reduction in p.

Proof of Lemma 4. The equilibrium in an open economy is implicitly characterized by (17) evaluated at the international prices $p = p^*$. That $\frac{\partial \underline{\theta}^o(A)}{\partial A} < 0$ and, therefore, that the labor supply L and total production in Z decrease can be directly verified by applying the implicit function theorem to (17). All the remaining results directly follow as in the proof of Lemma 3.

Characterization of indirect utility. As discussed above, individual maximization of utility requires that total expenditure in each good to be a fixed proportion of total individual expenditure,

$$x^i p = \beta y^i \text{ and } z^i = (1-\beta) y^i, \tag{25}$$

where x^i and z^i denote the optimal demand of each good by part of an individual with income y^i. The indirect utility of each individual i, which is given by,

$$v^i = \left(z^i\right)^{1-\beta} \left(x^i\right)^{\beta}. \tag{26}$$

can be rewritten using (25) as

$$v^i = \widetilde{\beta}\frac{y^i}{p^\beta}, \tag{27}$$

where $\widetilde{\beta} \equiv \beta^\beta (1-\beta)^{1-\beta}$. Since total expenditure of each agent equals his total income, equation (27) 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^β. Condition (27) can also be simply interpreted by saying that an individual is better off (after the improvement of technology A) if and only if his real income increases.

Proof of Proposition 1. We need to characterize the change in attitude towards technological improvements by part of the political rulers in an autocracy following a process of openness to trade. The total income of the elite, which is residual claimant of the income produced in the Z sector, is given by $Y^E = (1-\eta)Z$ and by dividing it by the size of Elite, denoted by σ, one gets the per-capita income of each member of the elite. From (27) each member of the elite strictly gains from an increase in the productivity A if, and only if, their real income increases. From Lemma 3 in a closed economy an increase in A increases the indirect utility of the elite since it increases Z and reduces the price p. From Lemma 4, however, Z decreases in response to higher A in an open economy (while $p = p^*$). A process of trade openness therefore reduces (respectively increases) the incentives of the elite to favor (respectively block) technology adoption.

Proof of Proposition 2. From Lemma 3 the earning of an unskilled worker, $w(L, N)$, decreases with a higher A in a closed economy. In an autarky, the unskilled workers can gain from technological improvements if, and only if, the reduction of price p more than compensate the reduction in their nominal income. In turn, from (4), the earnings of an individual with skill θ working in the modern sector are given by the base wage times the skill premium, $w(L, N)\,(\theta/\underline{\theta})^A$ that from Lemma 3 can be increasing only for the highly skill workers for which the increase in skill premium $(\theta/\underline{\theta})^A$ more than compensate the reduction in the base wage, w. Therefore, compared to a closed autocracy the process of democratization strictly reduces the

incentives for technology adoption if the new political ruler (the new pivotal voter) is a worker that looses from technology adoption (e.g. an unskilled worker) and is unchanged if the new political ruler gains from technology adoption (e.g. a highly skilled worker).

Proof of Proposition 3. Compared to an open autocracy the emergence of an open democracy strictly increases the incentives to increase A since, from Lemma 4, in an open economy all workers (the new political rulers) gain from higher A while the elite loose. Compared to a close democracy, openness to trade (weakly) increases the incentives for technology adoption since (again from Lemma 4) all workers gain from higher A while (from Lemma 3) in a closed democracy (only) the high skilled workers are (more) likely to gain from higher A.

5.2 Data Sources.

- **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 (2008). 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**: $Demo_{jt}$. The political regime are taken from the Polity IV database. The variable takes the value of one for positive polity scores, i.e. if the country is considered to be a democracy. The variable takes the value of zero for negative polity score, i.e. the country is considered to be an institutionalized autocracy.

- **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`.

5.3 Tables not included in main text.

- Table 8: Summary Statistics;
- Table 9: Correlation Table;
- Table 10: Robustness to alternative Codings of Political Regimes;
- Table 11: Robustness to controlling for the Stability of Democracy.

Table 8: Summary Statistics: Baseline sample

Variable	Label	Obs	Mean	Std. Dev.
Technology Adoption (log)	$TechA_{ijt}$	56959	8.13	5.77
Openness	$Lib_{it_{-1}}$	56959	0.57	0.49
Democracy	$Demo_{it_{-1}}$	56959	0.64	0.48
Openness × Democracy	$Int_{it_{-1}}$	56959	0.49	0.50

The baseline sample is composed by 129 countries over the years 1980 to 2000. See text for details.

Table 9: Correlation Table: Baseline sample

	$TechA_{ijt}$	$Lib_{it_{-1}}$	$Demo_{it_{-1}}$
$TechA_{ijt}$	1.000		
$Lib_{it_{-1}}$	0.107	1.000	
$Demo_{it_{-1}}$	0.110	0.539	1.000
$Int_{it_{-1}}$	0.118	0.850	0.745

The correlations are based on the sample composed by 129 countries over the years 1980 to 2000. The matrices for the individual years can only differ because of minor sample differences and they are virtually identical.

Table 10: Robustness of Baseline: Democratization (Free and Contested Elections)

Dependent Variable	Technology Adoption			
	(1)	(2)	(3)	(4)
Openness	0.573*	0.622*	-0.208***	-0.187***
	(1.692)	(1.731)	(-3.536)	(-3.042)
Democracy	0.940***	0.956***	-0.205***	-0.143***
	(2.744)	(2.742)	(-2.702)	(-2.736)
Openness × Democracy	0.593	0.596	0.289***	0.237***
	(1.288)	(1.280)	(3.854)	(3.842)
Technology FE	Yes	No	No	No
Tech.×Years FE	No	Yes	Yes	Yes
Country FE	No	No	Yes	Yes
Sample	Full	Full	Full	No Soc.
Observations	56,959	56,959	56,959	54,361
Number of countries	129	129	129	114
Adjusted R^2	0.879	0.880	0.950	0.951

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS Regressions. The coding of democratization relies on the data on the date of the first free and contested election from Golder (2005). Student ts are in parentheses. These are based on robust standard errors that have been adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively. Column (4) excludes former socialist countries.

Table 11: Robustness of Baseline: Stable Democratization

Dependent Variable	Technology Adoption			
	(1)	(2)	(3)	(4)
Openness	0.267	0.348	-0.322***	-0.329***
	(0.651)	(0.769)	(-2.900)	(-2.845)
Democracy	-0.175	-0.221	-0.243***	-0.246***
	(-0.414)	(-0.460)	(-3.082)	(-2.908)
Openness × Democracy	0.597	0.725	0.319***	0.319***
	(1.253)	(1.320)	(3.073)	(3.056)
Technology FE	Yes	No	No	No
Tech.×Years FE	No	Yes	Yes	Yes
Country FE	No	No	Yes	Yes
Sample	Full	Full	Full	No Soc.
Observations	15,175	15,175	15,175	14,549
Number of countries	32	32	32	29
Adjusted R^2	0.907	0.907	0.960	0.961

Dependent variable, technology adoption, $\ln(TechA_{ijt})$. OLS regressions. The coding of democratization involves change in polity score, free and contested election and restricts attention to stable democratization. The data are from Papaioannou and Siourounis (2008). Robust standard errors adjusted for clustering by country. ***, ** , * significantly different from 0 at 1%, 5% and 10% level, respectively. Column (4) excludes former socialist countries.

5.4 Summary Information on Trade and Political Regimes.

The dates denote the year at which a country switch regime. Countries that do not belong to the sample of value added per worker are marked with *. Column (2) report information on dates of changes of political regimes as well as information on the status of countries that do not switch political regime in the period 1980-2000. We denote by (a) the year from which the country becomes an autocracy. We denote by (d) the year from which the country becomes a democracy. We denote by (t) the transition period identified by a value of the polity IV index which is equal to zero. Columns 3 reports the years of liberalization as in Wacziarg and Welch (2008) as well as information on the status of countries that do not switch trade regime in the period 1980-2000. See main text for details.

Table 12: Country List (1980-2000)

Country	Political Regime	Trade Regime
Albania	1990 (d)	1992
Algeria	Autocracy	Closed
Angola*	1992 (t) 1993 (a)	Closed
Argentina	1983 (d)	1991
Armenia*	1996 (a) 1998 (d)	1995
Australia	Democracy	Open
Austria	Democracy	Open
Azerbaijan*	1992 (d) 1993 (a)	1995
Bangladesh	1991 (d)	1996
Belarus*	1995 (t) 1996 (a)	Closed
Belgium	Democracy	Open
Benin	1990 (t) 1991 (d)	1990
Bolivia*	1982 (d)	1985
Botswana	Democracy	Open
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	Open
Central African Republic	1993 (d)	Closed
Chad*	1984 (a)	Closed
Chile	1989 (d)	Open
China	Autocracy	Closed
Colombia	Democracy	1986
Costa Rica	Democracy	1986
Croatia	1999 (d)	Closed
Czech Republic	Democracy	Open
Demo. Republic of Congo*	1992 (t)	Closed

Table 12 – continued from previous page

Country	Political Regime	Trade Regime
Denmark	Democracy	Open
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	Open
France	Democracy	Open
Gabon	Autocracy	Closed
Gambia	1994 (a)	1985
Georgia	Democracy	1996
Germany	Democracy	Open
Ghana	1981 (a) 1996 (d)	1985
Greece	Democracy	Open
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)	Open
Iran*	1997 (d)	Closed
Iraq	Autocracy	Closed
Ireland	Democracy	Open
Israel	Democracy	1985
Italy	Democracy	Open
Japan	Democracy	Open
Jordan	Autocracy	Open
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	Open
Mali*	1991 (t) 1992 (d)	1988
Mauritania*	Autocracy	1995

Table 12 – continued from previous page

Country	Political Regime	Trade Regime
Mauritius	Democracy	Open
Mexico	1988 (t) 1994 (d)	1986
Moldova*	Democracy	1994
Morocco	Autocracy	1984
Mozambique*	1994 (d)	1995
Nepal	1990 (d)	1991
Netherlands	Democracy	Open
New Zealand	Democracy	1986
Nicaragua	1981 (a) 1990 (d)	1991
Niger	1991 (d)	1994
Nigeria	1984 (a) 1999 (d)	Closed
Norway	Democracy	Open
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	Open
Republic of the Congo*	1992 (d) 1997 (a)	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	Open
Slovak Republic*	Democracy	Open
Slovenia	Democracy	Open
Somalia	1991 (t)	Closed
South Africa	Democracy	1991
South Korea*	1987 (d)	Open
Spain	Democracy	Open
Sri Lanka	Democracy	1991
Swaziland	Autocracy	Closed
Sweden	Democracy	Open
Switzerland	Democracy	Open
Syria*	Autocracy	Closed
Taiwan	1992 (d)	Open
Tajikistan*	Autocracy	1996
Tanzania*	2000 (d)	1995
Thailand	1991 (a) 1992 (d)	Open

Table 12 – continued from previous page

Country	Political Regime	Trade Regime
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	Open
United States*	Democracy	Open
Uruguay	1985 (d)	1990
Uzbekistan*	Autocracy	Closed
Venezuela*	Democracy	1996
Yemen	Autocracy	Open
Zambia	1991 (d)	1993
Zimbabwe	1987 (a)	Closed