The Shifting Natural Wealth of Nations: The Role of Market Orientation

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Abstract

This paper explores the effect of market orientation on (known) natural wealth using a novel dataset of world-wide major hydrocarbon and mineral discoveries. Consistent with the predictions of a two-region model, our empirical estimates based on a large panel of countries show that increased market orientation causes a significant increase in discoveries. In a thought experiment whereby economies in Latin America and sub-Saharan Africa remained closed, they would have only achieved one quarter of the actual increase in discoveries they have experienced since the early 1990s. Our results call into question the commonly held view that resource endowment is exogenous.

JEL Classification : E00, F3, F4.

Keywords: natural resources, discoveries, market orientation, liberalization, institutions, endogenous reserves

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I. INTRODUCTION

The literature on economic development often assumes that natural resource endowment is exogenous. The consensus in that literature is that resource endowment alongside institutions or legal origin, and geography play a crucial role in determining economic and social outcomes.[1] In contrast, the resource economics literature has emphasized that the resource base is endogenous to investment in exploration and extraction.[2] That literature has however overlooked the role that market orientation and institutions play in driving investment in the resource sector. The present paper bridges the gap and explores the effect of market orientation on (known) natural wealth.

Countries with weak rule of law, high political or default risk, underdeveloped financial markets, or high transaction cost and deficiencies in governance may attract only limited investment flows even if they offer high rates of return (Shleifer and Wolfenzon, 2002).[3] Specifically for the resource sector, empirical evidence suggest that a stable political environment, a low risk of expropriation, and a favourable investment climate boost investment (Bohn and Deacon, 2000; Stroebel and van Benthem, 2014).[4] [5] The present paper presents systematic evidence that policies geared toward economic liberalization and increased market orientation lead to major natural resource discoveries that eventually boost extractive activities in those countries. Increased market orientation in developing countries has thus become a determinant of (known) resource wealth.

The experience of the United States during the nineteenth and early twentieth century provides a historical account of the role of market orientation in driving natural wealth. Although the United States at the time of independence was considered to be a country of "abundance of land but virtually no mining potential" (O'Toole, 1977), by 1913 it was the world's dominant

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[1] See Acemoglu, Johnson and Robinson (2002), Easterly and Levine (2002), Glaeser and Shleifer (2002), Hall and Jones (1999), and Rodrik, Subramanian and Trebbi (2002).

[2] See Pindyck (1978), Arrow and Chang (1982), and Devarajan and Fisher (1982).

[3] The literature linking institutions and international capital flows relates to the so-called "Lucas' paradox" (Lucas, 1990). Policies and institutional factors have been shown to play an important role in explaining the magnitude and nature of capital flows to developing and emerging economies (Alfaro, Kalemli-Ozcan and Volosovych, 2008).

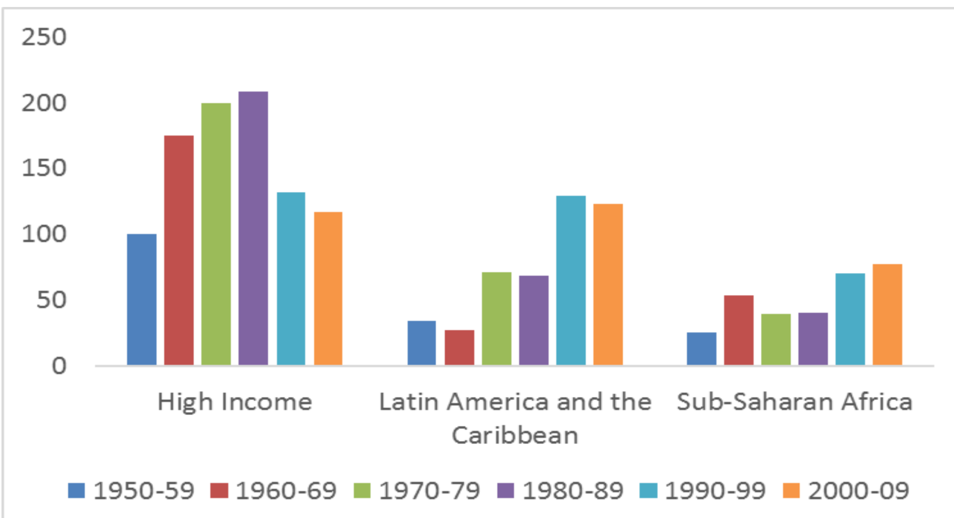
[4] Irreversible investments in the resource sector involve sunk costs and are subject to holdup and the political risk of expropriation (Long, 1975).

[5] Exploiting variations in market orientation and oil deposits sitting on either side of the border, empirical evidence suggests that institutions substantially affect oil and gas exploration (Cust and Harding, 2015).

producer of virtually every major industrial mineral (David and Wright, 1997). Rather than being driven by a comparative advantage in geological endowments, this resource-based development of the United States was driven among other things by an open market orientation and an accommodating legal environment with the government claiming no ultimate title on mineral rents (e.g., Wright and Czelusta, 2004).[6]

In stock terms, proven reserves of natural resources are today significantly higher in advanced countries than in developing countries (World Bank, 2006). In flow terms, however, we observe a shift in resource discoveries from developed to developing countries over the past decades that coincides with increased market orientation in developing countries. The trend towards more market orientation seems to have led to a shift in the geographic distribution of discoveries. As a consequence, the share of worldwide resource discoveries in Latin America and the Caribbean and Sub-Saharan Africa has doubled over the past decades (see Figure 1).

Figure 1: Number of Natural Resource Discoveries by Region and Decade



Note: Based on data from MinEX for natural resource discoveries and Mike Horn for hydrocarbon discoveries. High income countries include OECD members as well as Bahrain, Brunei, Cyprus, Equatorial Guinea, Kuwait, Oman, Qatar, Saudi Arabia, Trinidad and Tobago, and the United Arab Emirates.

[6] Economic historians argue that natural resources may be under-produced due to a lack of effective property rights (e.g. Anderson and Libecap, 2011) and that private mineral rights became more explicit as mine values increased (Demsetz, 1967; Libecap, 1976). With increased competition for valuable resources, informal rules were insufficient to reduce risk and support long-term investment to develop the mines. Making property rights more formal boosted mining investment.

Anecdotal evidence suggests a causal link between increased market orientation and discoveries across continents and types of natural resources (see Table 1). The increase in discoveries after countries open up to the global economy tends to be quite stark. In Peru, for example, discoveries more than quadrupled, in Chile they tripled, and in Mexico they doubled. In Ghana, discoveries only occurred after the opening of the economy.

Table 1: Number of discoveries before and after opening – Country Examples

Country	Chile	Ghana	Peru	Indonesia	Mexico
Date of Opening	1976	1985	1991	1970	1986
Number of Discoveries 10 years before opening	5	0	5	3	12
Number of Discoveries 10 years after opening	15	6	23	15	21

Source: Based on data from MinEX for natural resource discoveries and Mike Horn for hydrocarbon discoveries. Dates of opening are from Wacziarg and Welch (2008).

To motivate the empirical analysis, we develop a simple two-region model of endogenous reserves based on Pindyck (1978) where multinational corporations are faced with an implicit tax which decreases in market orientation, and seek the lowest cost location. The model explores the interplay between market orientation and other channels such as the increase in the marginal cost of discoveries and (demand driven) natural resource price shocks. In turn, key model predictions of the model are then taken to the data.

For our empirical analysis we build a unique dataset of the universe of world-wide major natural resource discoveries since 1950, covering 128 countries, 33 types of natural resources and over 60 years. Our main explanatory variable is a generic measure of market orientation. To account for the endogeneity of such a variable, we use an instrumental variable approach based on Buera et al (2011) – a country's choice to liberalize its economy depends on the policies of neighbouring countries in general, but also on how successful other countries with liberalized and closed economies, respectively, performed. We include country as well as year-by-resource fixed effects in our panel estimates to control for time-varying resource-specific factors such as technological progress in extractions of the different types of minerals and hydrocarbons, as well as time-invariant country characteristics such as geographic location to capture that different areas have different resource endowments.

Consistent with the model's predictions, our empirical analysis shows that market orientation causes a statistically and economically significant increase in resource discoveries. Our point estimates indicate that going from a closed to an open market orientation increases discoveries by over 100 percent. We verify the mechanism through which this occurs by showing that exploration spending (a key determinant of discoveries) also significantly increases following changes in market orientation (also by over 100 percent). In a thought experiment whereby economies in Latin America and sub-Saharan Africa remained closed, they would have only achieved one quarter of the actual increase in discoveries they have experienced since the early 1990s. Our results are robust to a wide array of checks including the use of alternative dependent variables (discoveries per capita or a simple dummy variable), separating out mineral and hydrocarbon resources, including additional controls, the use of an alternative estimator and the use of an alternative measure of market orientation.

Our paper is related to the theoretical and empirical literature on exhaustible resource exploitation and exploration. Resource exploration and discoveries have been investigated either as a deterministic or a stochastic process (e.g. Pindyck, 1978; Arrow and Chang, 1982; Devarajan and Fisher, 1982). The canonical model is the exploration model developed by Pindyck (1978) where a social planner maximizes the present value of the social net benefits from consumption of oil and the reserve base can be replenished through exploration and discovery of new fields.[7] We extend this to a two-region model to explore the relationship between exploration investment and discoveries where multinational corporations are faced with explicit taxes and implicit taxes (as proxy for lack of market orientation) on their investment in the South and but none in the North and arbitrage between different locations.

This paper is also related to the literature on the so-called "resource curse".[8] In particular, empirical evidence suggests that the curse in terms of the effect of natural resources on growth is less negative and can even turn positive if the quality of institutions is beyond a certain threshold (e.g., Mehlum, Moene and Torvik, 2006; Boschini, Pettersson and Roine, 2007). While this literature has long focused on the direction of causality running from resource

[7] We use the depletion and exploration investment rates as decision variables. This is a metaphor, since not the depletion rate but the investment in rigs follows a Hotelling rule (Anderson, Kellogg and Salant, 2016).
[8] See Frankel (2012), Venables (2016), Ross (2012), and van der Ploeg (2011) for recent surveys.

endowment and institutions to growth and conflicts, our results suggest that causality running from policies and market orientation to resource endowment is also important. Our focus is "upstream" rather than "downstream". As such we are concerned with "external" policies and institutions that are geared toward foreign investors who conduct exploration activities. Our results do not contradict the fact that subsequent to a discovery, countries with poor "internal" institutions (e.g. weak state capacity) may experience poor economic performance or civil strife.

The remainder of the paper is organized as follows. Section II develops a simple two-region model of depletion and discoveries. Section III presents the data used in the empirical analysis while section IV lays out the empirical strategy. Section V presents the main results and key robustness checks. Section VI concludes.

II. A TWO-REGION MODEL OF RESOURCE DISCOVERIES

We present a simple two-region, three-period model of endogenous reserves and resource discoveries. The North has free access for international resource companies (IRCs) and the South is less open for IRCs. IRCs decide *where* to explore reserves depending on local extraction costs which depend on market orientation and availability of subsoil resources. They relocate activities until costs of resource exploration across the globe are equalized.

IRCs in the North decide on exploration investment in periods 0 and 1, I_0 and I_1. This gives initial reserves, $S_1(I_0),$ and discovery of new reserves, $D(I_1) = A\ln(I_1).$ At the start of period 2, reserves in the North are $S_2 = S_1(I_0) + D(I_1) - R_1,$ where R_1 denotes current depletion. Future depletion cannot exceed remaining reserves. The resource is sold on the world market at prices p_1 and p_2. This market is competitive, so IRCs take prices as given. The cost of extraction falls with remaining proven reserves: $G(S_t) = \gamma / S_t$ with $\gamma > 0.$ IRCs can freely borrow at the given world interest rate *r*. Variables, cost and exploration functions for the South are denoted by an asterisk. North and South may differ in extraction costs and initial reserves.

Furthermore, the South has access restrictions captured by taxes $T_0^* > 0$ and $T_1^* > 0$ on exploration investment. Global IRCs thus maximize their net worth in the two markets:

(1)
$$\underset{I_t, I_t^*, R_t, R_t^*}{\text{Max}} \sum_{t=1}^{2} \Big((1+r)^{-t} \left[p_t - G(S_t) \right] R_t - (1+r)^{t-1} I_{t-1} \Big) + \sum_{t=1}^{2} \Big((1+r)^{-t} \left[p_t - G^*(S_t^*) \right] R_t - (1+r)^{t-1} (1+T_{t-1}^*) I_{t-1} \Big),$$

subject to $R_2 \le S_2 = S_1(I_0) + D(I_1) - R_1$ and $R_2^* \le S_2^* = S_1^*(I_0^*) + D^*(I_1^*) - R_1^*$. This gives the Hotelling rules governing extraction speeds for the North and South:

(2)
$$p_2 - G(S_2) + G'(S_2) R_2 = (1+r)\left[p_1 - G(S_1) \right],$$
$$p_2 - G^*(S_2^*) + G^*{}'(S_2^*) R_2^* = (1+r)\left[p_1 - G^*(S_1^*) \right].$$

Future rents minus the marginal increase in future extraction cost from extracting an extra unit today must equal current rents plus interest. Maximizing net worth also requires that the marginal rent from discovery investment equals the cost including taxes in each region:

(3) $\left[p_1 - G\big(S_1(I_0) \big) \right] D'(I_1) = 1$ and $\left[p_1 - G^*\big(S_1^*(I_0^*) \big) \right] D^*{}'(I_1^*) = 1 + T_1^*$.

This gives discoveries $D = A \ln\big((p_1 - \gamma / S_1) A \big)$ and $D^* = A^* \ln\big((p_1 - \gamma^* / S_1^*) A^* / (1+T_1^*) \big)$. Discoveries thus rise with the global resource price. The North has more discoveries if geological conditions are better ($A > A^*$), it has a higher or more easily accessible stock of reserves that depresses extraction costs ($\gamma < \gamma^*$ or $S_1 > S_1^*$), and there are less taxes and easier access for IRCs in the North ($T_1^* > 0$). Global IRCs relocate exploration across the globe so that total marginal cost of extracting and discovering a unit of resource is equalized across the globe as can be seen from the global arbitrage condition $p_1 = \dfrac{\gamma}{S_1} + \dfrac{I_1}{A} = \dfrac{\gamma^*}{S_1^*} + (1+T_1^*) \dfrac{I_1^*}{A^*}$.

Maximizing net worth also gives the efficiency conditions that yield initial reserves and exploration in much the same way as discoveries follow from (3) (see Appendix A). The main difference is that initial exploration investment benefits from making future extraction cheaper by ensuring higher proved reserves. We thus get the following comparative statics results for discoveries (those for exploration investment and reserves are in Appendix A):

(4) $$D = D(\overset{+}{p_1}, \overset{+}{R_1}, \overset{+}{A}, \overset{-}{\gamma}) \quad \text{and} \quad D^* = D^*(\overset{+}{p_1}, \overset{+}{R_1^*}, \overset{-}{T_0^*}, \overset{-}{T_1^*}, \overset{+}{A^*}, \overset{-}{\gamma^*}).$$

A gradual opening of the South to natural resource exploration as indicated by a fall in the future tax ($T_1^* < T_0^*$) shifts more effort to additional future discoveries rather than exploration today. Resource discoveries in the South are thus held back by the lack of openness to IRCs.[9]

Finally, to explain world resource prices one needs to introduce global resource demand. Due to tax shifting, equilibrium world resource prices increase with resource exploration taxes in the South. Resource producers are more successful in shifting the burden to consumers if demand for resources is relatively inelastic and supply of resources is not. Taxes and restrictive access in the South thus lead to a shifting of exploration activities and discoveries from the South to the North once account is taken of the endogenous nature of world resource prices (see Appendix A). As the South liberalizes and gets more open to IRCs, exploration activities and discoveries shift from the North to the South. Other (not mutually exclusive) forces include the rise in global resource demand (e.g., from China and India) that led to more exploration efforts and discoveries and increases in the marginal cost of exploration. In the empirical analysis, we allow discoveries to depend not only on ease of access for IRCs but also on global resource demand shocks and changes in marginal costs of discoveries due to depletion forces.

III. DATA AND STYLIZED FACTS

Here we discuss the various datasets that we use. We focus on the novel data on major hydrocarbon and mineral deposits as well as the data on market orientation (see Appendix B for a more comprehensive list of data and sources as well as additional summary tables).

Discoveries

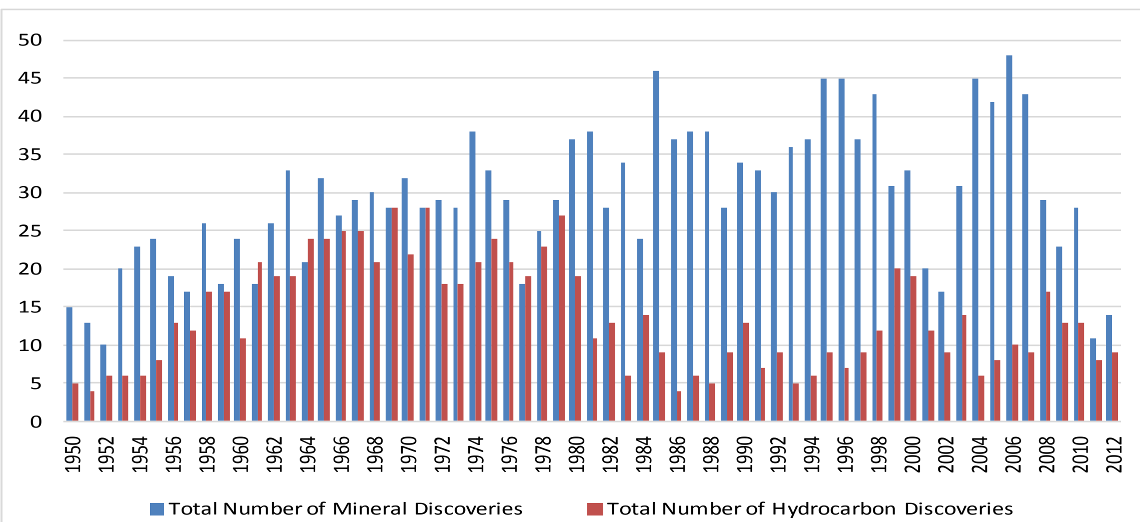
The oil and gas discovery dataset is from Horn (2014). Horn reports discoveries of giant oil (including condensate) and gas fields which we refer to jointly as hydrocarbon or simply oil discoveries. A giant oil discovery is defined as a discovery of an oil and/or gas field that

[9] Furthermore, resource extraction in the South increases if it more attractive for IRCs to discover new reserves and is postponed if the market expects easier access for IRCs in the future.

contains at least a total of 500 million barrels of ultimately recoverable oil equivalent.[10] Ultimately recoverable reserves refer to the amount that is technically recoverable given existing technology.

The data on mineral deposits discoveries is from MinEx. The list of minerals included in the dataset is comprehensive and includes precious metals and rare earths. The dataset excludes iron ore and bauxite, given that exploration is less important for them. They are more abundant than other metals and exploitation decisions tend to be based more on proximity to port facilities for the former and substantial energy availability for the latter. As in the case of hydrocarbons, we only capture discoveries above a certain threshold, corresponding roughly to a mineral deposit which has the capacity to generate an annual revenue stream of at least USD 50 million after accounting for fluctuations in commodity prices.[11] Figure 2 plots the total number of worldwide discoveries (split between minerals and hydrocarbons) by year. Since the early 1980s the average number of discoveries has been fairly stable at the global level. In our empirical work we use discoveries disaggregated by 128 countries and 33 types of resources.

Figure 2: Number of Natural Resource Discoveries by Year



Note: Based on data from MinEX for natural resource discoveries and Mike Horn for hydrocarbon discoveries.

[10] In other words, smaller discoveries are not included in our dataset.
[11] See Appendix B for the exact definition of the threshold by mineral.

Exploration

To measure exploration effort, we use disaggregated data on exploration expenditures from Rystad for oil and gas and from SNL Metals and Mining for selected minerals including copper, nickel, zinc, diamonds, uranium, and platinum. The SNL Metals and Mining dataset only starts in 1994 and thus limits the sample period for this part of our empirical analysis. Similar to the data on discoveries, data on exploration spending are broken down by country, type of natural resource and year.

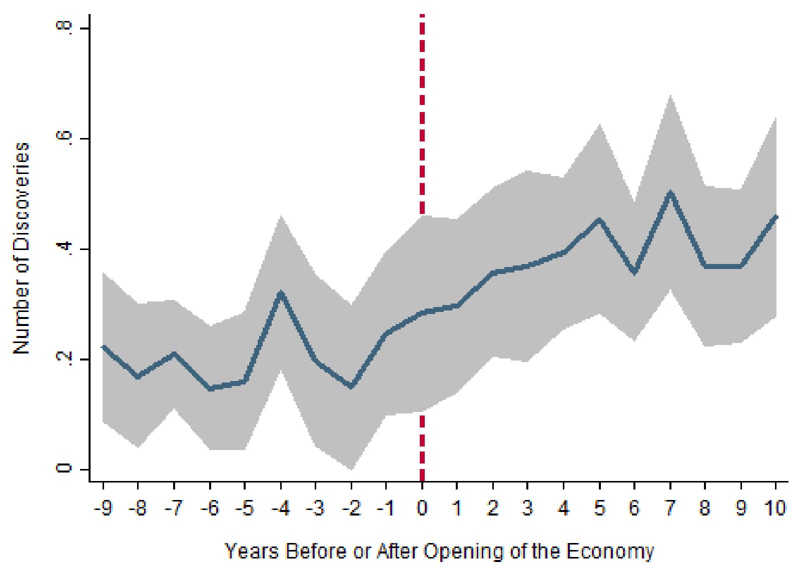
Measure of market orientation

To measure market orientation or openness, we use data on the timing of economic liberalization for a large number of countries (133 countries) and years (1950 to 2004) originally constructed by Sachs and Warner (1995) (SW thereafter) and revised and extended by Wacziarg and Welch (2008). Following SW, the following criteria are used to classify a country as open: (i) the average tariff rate on imports is below 40%; (ii) non-tariff barriers cover less than 40% of imports; (iii) the country is not a socialist economy (according to the definition of Kornai (1992)); (iv) the state does not hold a monopoly of the major exports; and (v) the black market premium is below 20%. The resulting indicator is a dichotomous variable. If in a given year a country satisfies all of these above criteria, SW call it open and set the indicator to 1. Otherwise, the indicator takes the value of 0.

While this indicator was originally designed to capture openness to trade, we follow Rodriguez and Rodrik (2001) and Buera et al. (2011) by viewing the SW indicator as proxy for broader economic openness and market orientation. Trade liberalisation is usually just one part of a government's overall reform plan for integrating an economy with the world system. Other aspects of such a program almost always include price liberalization, budget restructuring, privatization, deregulation, and the installation of a social safety net (Sachs and Warner, 1995). For our purposes, we capture a broad measure of market orientation which policy implications often reverberate on the "openness" of the resource sector. Indeed, investment in exploration is worthwhile only if there are prospects for further extractive activities. Such a generic measure of market orientation allows us to capture a combination of factors such as favourable business climate including fiscal terms, political risks and access to relevant equipment and financing.[12] We thus use the indicator as proxy for country's degree of market orientation. If the SW indicator is equal to 1, the country is deemed market oriented. If the indicator is equal to 0, the country is not.

As a first look at the data we conduct an event-study type of analysis where we calculate the average number of discoveries prior and after liberalization for all such episodes in the updated Wacziarg and Welch dataset.[13] Figure 3 shows that the number of discoveries significantly increases after economic liberalization leads to a market-oriented economy. The average number of discoveries per year and country rises from 0.2 prior to liberalization to 0.36 afterwards.

Figure 3: Average number of discoveries before and after liberalization



Note: The blue line shows the point estimates of a regression of the number of countries per country and year on a set of period fixed effects (while controlling for event fixed effects). The grey area shows the 90 percent confidence interval. There are a total of 82 events (countries switching from closed to open economies) in the dataset.

[12] We prefer this to resource-specific measure of market orientation, because generic measures typically capture de facto conditions and/or multilateral commitments (e.g., to the World Trade Organization) which are more difficult to reverse and thus more credible than say sectoral regulations that govern rather narrower aspects of a bilateral relationship between firms and national authorities.

[13] In practice, we regress the number of discoveries on a set of period fixed effects while controlling for event fixed effects. We then retrieve the coefficients of the period fixed effects and plot them.

The pattern linking liberalization and discoveries seems to hold across geographical regions and time periods. Looking at all episodes of opening in our dataset (82 cases), we observe that in 54 percent of cases countries discovered more natural resources in the 10 years following a shift to a market-oriented economy than in the ten years before, in 24 percent of cases there was no difference and in 22 percent of cases they discovered less.

The event analysis does not include any controls and does not address endogeneity issues or other statistical confounding influences. Nevertheless, it provides us with a window into what the data have to offer and motivates our main hypothesis that economic opening and market orientations increases the number of resource discoveries.

IV. EMPIRICAL STRATEGY

We are interested in estimating the impact of market orientation on resource discoveries. Let $Y_{i,t,k}$ be the number of discoveries for country i at time t of resource k. Our baseline empirical model estimates

$$\text{(I)} \qquad Y_{i,t,k} = \gamma OPEN_{i,t-1} + \beta Z_{i,t-1,k} + \alpha_i + \theta_{j,k} + \varepsilon_{i.t,k}$$

where $OPEN_{i,t-1}$ is an indicator for whether country i is open at time $t-1$, $Z_{i,t-1,k}$ is a set of controls which depending on the case vary at country-year, country-resource or country-resource-year level. α_i is a country fixed effect, $\theta_{j,k}$ is a year-resource fixed effect and $\varepsilon_{i.t,k}$ is an error term.[14] The country fixed effects control for time-invariant country-specific characteristics such as geographic location. The year-resource fixed effects control for time-varying resource-specific factors such as international prices and technological progress. The additional controls included in $Z_{i,t-1,k}$ are a measure of the previous stock of discoveries of resource k in country i as well as the square of this stock measure. This allows us to capture the country specific dynamics related to the clustering of discoveries over time and depletion

[14] The model is essentially a difference-in-difference specification where the coefficient of interest is γ.

of geological reserves after large numbers of discoveries.[15] While the combination of country and year-by-resource fixed effects is our favoured specification, we also estimate regressions with year and country-resource fixed effects instead since this allows us to explicitly include resource prices (which we believe to yield a coefficient of interest in its own right) as a variable in $Z_{i,t-1,k}$. We cluster standard errors at the country-resource level but significance is unchanged if we cluster at the year-resource level (see Supplementary Appendix).

Identification

As discussed at length in the literature, resource discoveries can impact policies and institutions. For instance, discoveries may trigger conflicts over resources and erode political institutions (Ross 2001, 2012). As a first step to avoiding reverse causality, all explanatory variables are included with a lag.[16] Nevertheless, a naïve OLS estimation of (I) is likely to face serious concerns. To try and isolate variation in openness which is exogenous to resource discoveries, and in the absence of a large-scale natural experiment, we require an instrument. Since both cross-sectional and time variation are crucial in our setting, we furthermore need the instrument to be time varying. This is not easy, since most previous instruments used for comparable variables in the literature tend to rely exclusively on cross-sectional variation. Our solution, which rests on a number of assumptions to be discussed below, is to construct an instrument for openness based on the idea that neighbours' market orientation, and in particular the relative success of neighbours who choose to be open or not, are strong drivers for the choice of own market orientation. Intuitively, the instrument tries to capture the fact that average openness in other countries ($j \neq i$) as well as the relative success of open and closed economies (i.e., those with and without market orientation) should not be influenced by future resource discoveries in country i and should only influence discoveries in country i via their impact on openness in country i and not directly. We closely follow the reduced-form specification in Buera et al. (2011) for this exercise.[17] Specifically, we take from Buera the

[15] In those specifications where we include the past stock of discoveries (essentially the sum of lagged dependent variables) Nickel bias might be a concern. However, given that it tends to $1/T$ and we have roughly 50 years of annual data, this bias is likely to be small.
[16] The reverse causality generally discussed in the literature would tend to bias our results downwards – resource-rich countries are often shown to do worse on a number of institutional measures.
[17] Buera et al. (2011) include the lagged market orientation index in their reduced form specification which we exclude given the endogeneity concern. Their aim is not to construct an instrument, but to motivate a structural

idea that the liberalization decision of country i in period t ($OPEN_{i,t}$) depends positively on a distance-weighted measure of other countries policies ($\overline{OPEN}_{i,t-1}$) and negatively on the distance-weighted average growth rate over the previous 3 years of other countries which remain closed ($\hat{E}_{i,t-1}[z|OPEN = 0]$)[18],

$$\text{(II)} \quad E\left[OPEN_{i,t}\middle|..\right] = \varphi_1 \overline{OPEN}_{i,t-1} + \varphi_2 \hat{E}_{i,t-1}[z|OPEN = 0],$$

hence our hypothesis is that $\varphi_1 > 0$ and $\varphi_2 < 0$. For the instruments to be valid, they need to be strongly correlated with openness of markets in country i but uncorrelated with resource discoveries, conditional on openness of markets in country i. The instruments satisfy the inclusion condition as we will show below. One concern with the exclusion restriction might be that discoveries in a neighbour (after that neighbour opens up) make exploration in country i more attractive, independent of country i also opening up (e.g., because of additional geological information). While this effect certainly cannot be ruled out, it is likely to be at most a local effect. Information gained from a successful discovery only applies to a very limited geographical area, usually not more than several square kilometres. Nevertheless, we directly control for a distance-weighted measure of discoveries in other countries in the past year in a robustness exercise and find that results are unchanged.

If both (regional) opening of markets and discoveries are driven by a (third) outside factor, omitted variables might also pose a threat to our identification. We try to address this in several ways. First, directly controlling for a lagged, distance-weighted measure of discoveries in other countries (as just discussed) addresses not only the regional spill over problem but also the omitted variable problem related to an unknown deep driver (such as US foreign policy perhaps or the fall of the Soviet Union) to some degree. Secondly, we show that the results are a general phenomenon, which holds for different time periods and regions – no one region or time period (which might have been affected by a specific omitted variable) is responsible for the results.

estimation. Furthermore, Buera et al. also include the distance-weighted growth rate of open countries, $\hat{E}_{i,t-1}[z|OPEN = 1]$,as a complement to $\hat{E}_{i,t-1}[z|OPEN = 0]$. Including it does not change any results. But since the coefficient on $\hat{E}_{i,t-1}[z|OPEN = 1]$ is never significant in the first stage we exclude it to have the most parsimonious instrument possible.

[18] The weights are based on distance data obtained from the CEPII: http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=6

More generally, the rich fixed-effects structure we use, in particular the year-by-resource effects, rule out a number of alternative stories such as one in which by coincidence the arrival of a new technology for discoveries of a particular resource happens concurrently with a wave of opening up of markets. The robustness section discusses all of these in more detail.

V. MAIN EMPIRICAL RESULTS

A. Benchmark Results

We now turn to our benchmark results. Table 2 shows the first-stage of the 2SLS estimates. The coefficients on distance-weighted average openness and on distance-weighted growth of closed economies have the expected sign. The former is always highly significant and positive while the latter is only significant in columns (1) and (5) which allow for longer timer series. Overall, the high F-statistics (of the excluded instruments) indicate that the instruments are highly correlated with the endogenous variable.

Table 3 shows the second stage of the baseline 2SLS estimates. Column 1 only includes year and country-by-resource fixed effects, as well as our basic variable of interest. In columns 2, 3 and 4 we add as additional controls the level of prices as well as the stock of past discoveries and its square. In column (5) we us country and year-by-resource fixed effects (and consequently we have to drop the price variable).[19] Given that price data is only available since the mid-1960s for many resources (and even later for some) we lose a fairly large number of observations in columns (2)–(4). This, combined with the demanding nature of the year-by-resource fixed effects makes column (5) our preferred specification.

Across all specifications, regression results consistently show that the coefficient on our measure of market orientation is positive and statistically significantly associated with more discoveries. More open countries are thus more likely to discover new resources. More open institutions allow for easier transfer of capital and technology and thus exploration is more attractive in those regions, as predicted by the model in section II. Comparing the magnitude

[19] For some resources, price data have limited time series information. Appendix B provides detailed information on available price data by natural resource.

of the IV and OLS coefficients shows that the IV estimates are larger by a magnitude of about 3-4.[20] The OLS estimates are biased downwards in accordance with the general reverse causality story where resource discoveries lead to rent seeking and potentially even conflict.

Table 2: The Impact of Liberalization on Resource Discoveries (First stage of 2SLS)

VARIABLES	(1) SW/Wacziarg Openness	(2) SW/Wacziarg Openness	(3) SW/Wacziarg Openness	(4) SW/Wacziarg Openness	(5) SW/Wacziarg Openness
Distance-Weighted Average Openness, lagged	0.928***	0.831***	0.836***	0.833***	0.928***
	(0.053)	(0.012)	(0.012)	(0.012)	(0.069)
Distance-Weighted Growth Closed Economies, lagged	-0.169***	-0.098	-0.113	-0.116	-0.172***
	(0.053)	(0.086)	(0.086)	(0.086)	(0.052)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Controls		(log) Price lagged	(log) Price lagged, Discoveries Stock lagged	(log) Price, Discoveries Stock lagged, Discoveries Stock	Discoveries Stock lagged, Discoveries Stock Squared lagged
Observations	157,284	57,976	57,976	57,976	157,284
F-Stat (2, 1801) Excluded Instruments	9192	2508	2560	2484	9388
Anderson-Rubin Wald Test (p-value)	0	0	0	0	0
R-squared	0.6589	0.7157	0.7163	0.7165	0.6591
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the first stage of a 2SLS estimation where distance weighted average openness and distance weighted growth of closed economies are used as excluded instruments for a country's SW/Wacziarg Openness indicator. The number of observations in columns (1) and (5) are larger than in the other columns because columns (2) – (4) include natural resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country-resource fixed effects employed in columns (1) – (4). The Anderson-Rubin Wald statistics allows for a test of the joint significance of the excluded instruments in a reduced-form estimation, where the null hypothesis is that the coefficients of the excluded instruments are jointly equal to zero. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

While significance is not affected, the main coefficient of interest is significantly smaller in columns (1) and (5) than in columns (2) - (4), presumably due to the different time periods being covered. Taking column (5) of table 3 as a lower bound for the impact of market orientation on discoveries indicates that liberalization and opening up of markets increases discoveries per country-year-resource by 0.014. The average number of discoveries per country-year-resource in our full dataset is 0.01. Simply as a means of gauging the magnitude of the estimated coefficient, we thus note that it indicates an increase of roughly 140% of the average number of discoveries. With 2392 discoveries (from 1950 to 2004) distributed over

[20] Table S1 in the Supplementary Appendix presents the OLS estimates for comparison.

roughly 30 resources and 60 years, one country opening up is thus estimated to increase annual average discoveries worldwide by over 1% (ceteris paribus).

Table 3: The Impact of Liberalization on Resource Discoveries (2SLS)

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries
SW/Wacziarg Openness, lagged	0.0209***	0.0756***	0.0760***	0.0641***	0.0140***
	(0.00432)	(0.0161)	(0.0152)	(0.0147)	(0.00410)
(log) Price, lagged		0.0146**	0.0149***	0.0103**	
		(0.00678)	(0.00532)	(0.00448)	
Stock of Discoveries, lagged			-0.000541	0.0257*	0.0382***
			(0.00500)	(0.0141)	(0.00499)
Stock of Discoveries squared, lagged				-0.000441**	-0.000284***
				(0.000175)	(8.24e-05)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	157,284	57,976	57,976	57,976	157,284
R-squared	0.279	0.323	0.323	0.335	0.227
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the estimates of the second stage of a 2SLS regression for the number of natural resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of control variables. Distance weighted average openness and distance weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. The number of observations in columns (1) and (5) are larger than in the other columns, because columns (2) – (4) include natural resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country- resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Considering that in 1980 only 1 out of 26 countries in our sample in sub-Saharan Africa were open and in 2000 this was 15 out of 26 (for Latin America and the Caribbean – 2 out of 16 in 1980 versus 15 out of 16 in 2000), the aggregate impact is large indeed. To further quantify the importance of market orientation, we calculate the predicted number of discoveries per country, year and resource based on the assumption that openness in all countries did not change since 1950 and we compare it to the predicted number of discoveries using data for economic opening such as it occurred. We find that in the counter-factual world without a shift towards market orientation, the increase in discoveries in sub-Saharan Africa and Latin

America in the 1990s and 2000s would have been only one quarter as large as the increase with economic opening.[21]

As analytically illustrated in section II, a more open market orientation (a lower implicit 'tax'), but also higher prices and the stock of previous discoveries impact the number of new discoveries. Empirically, we find that increases in prices are significantly associated with more discoveries. The result is intuitive, since higher prices make additional exploration activity profitable. The coefficient associated with the stock of discoveries is positive and statistically significant. That result suggests that in locations where discoveries have occurred in the past, more discoveries are more likely (an informational probing effect).[22] The coefficient associated with the square term in the stock of cumulative discoveries is negative suggesting that the effect is non-linear. In other words, bigger stocks of cumulative discoveries eventually turn out to be associated with a lower likelihood of discovery as the easiest available deposits have been discovered (depletion effect). We interpret this as a trade-off between the initially reduced costs of exploring close to a known deposit with the eventually increased cost due to geological depletion.

B. Verifying the Mechanism: Exploration Efforts

So far, we have focused on the relationship between market orientation and major discoveries. To examine the underlying mechanism, we explore whether exploration efforts rise following shifts in market orientation. Our hypothesis is that more market-oriented or open economies are able to attract more exploration investment and thus have more resource discoveries. Oil and gas exploration, as well as mineral exploration, are capital intensive and thus costly. Nowadays, over a hundred billion dollars are spent on resource exploration annually according to Rystad and SNL Metals and Mining. And while exploration is a very risky activity[23], in

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[21] Recall Figure 1 which illustrated the actual increase in discoveries in sub-Saharan Africa and Latin America and the Caribbean.

[22] Cavalcanti et al (2016) used well-level data on oil drilling for Brazil to show that, after a first wild-cat discovery, follow-up exploration activity and additional discoveries increase significantly in following years.

[23] An oil exploration well (wildcat well – a well drilled a mile or more from an area of existing oil production) can have a probability as low as 10% of yielding viable oil, while a rank wildcat (a well drilled in an area where there is no existing production) has an even smaller chance of finding oil. Elf was drilling in 1971 for offshore oil in Norway and found nothing. Recently, it found a huge new field just 3 metres away from the original drilling. Drilling outcomes are therefore highly uncertain.

which "luck is obviously a major factor" (Harbaugh, Davis, and Wendebourg, 1995), exploration efforts ought to be a key determinant of discoveries. To verify that proposition for our data, we first estimate the following equation

$$\text{(III)} \qquad y_{itk} = B(L)s_{itk} + \alpha_i + \theta_t + \sigma_k + \varepsilon_{itk},$$

where y_{itk} and s_{itk} are the number of discoveries and the logarithm of exploration spending in millions of constant (2010) U.S. dollars[24], respectively, of resource *k* in country *i* at time *t* and α_i, θ_t and σ_k are country, year and resource fixed effects. $B(L)$ is a *p*-th order lag operator. We estimate the equation for $p \in \{1,2,3\}$ using OLS and then test whether $H_0 : \sum_0^p b_h = 0$. Table 4 reports the results of this exercise. We can always strongly reject the null hypothesis of no impact of exploration spending on discoveries at the 1% significance level.

Table 4: The Impact of Exploration Spending on Natural Resource Discoveries

	P Value of Wald Test (H0: Effect is 0)		
Dependent variable	1 Lag	2 Lags	3 Lags
Number of Discoveries	0	0	0

	Point Estimate (Sum of coefficients)		
Dependent variable	1 Lag	2 Lags	3 Lags
Number of Discoveries	0.013	0.013	0.013

Having thus established that exploration spending increases the likelihood of discoveries we test whether openness increases exploration spending to complete the causal chain. To do so we estimate a regression analogous to equation (I). Table 5 gives the 2SLS estimates where we instrument openness as above.

[24] Exploration expenditures data are deflated using the US GDP deflator. Using alternative deflators gives similar results.

Table 5: The Impact of Liberalization on Exploration Spending (2SLS)

VARIABLES	(1) (log) Real Exploration Spending	(2) (log) Real Exploration Spending	(3) (log) Real Exploration Spending	(4) (log) Real Exploration Spending	(5) (log) Real Exploration Spending
SW/Wacziarg Openness, lagged	1.230***	0.903**	1.074**	1.079***	1.804***
	(0.424)	(0.365)	(0.407)	(0.405)	(0.641)
(log) Price, lagged		0.930***	0.968***	0.966***	
		(0.193)	(0.192)	(0.192)	
Stock of Discoveries, lagged			0.0424***	0.0641***	0.223***
			(0.0119)	(0.0169)	(0.00724)
Stock of Discoveries squared, lagged				-0.000325**	-0.00237***
				(0.000136)	(9.36e-05)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	3,706	3,467	3,467	3,467	3,747
R-squared	0.931	0.941	0.940	0.940	0.755
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing the logarithm of real exploration spending (expressed in millions of 2010 US Dollars) by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of control variables. Data on exploration spending is available starting in 1994. Distance weighted average openness and distance weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. Column (5) uses country as well as year-natural resource fixed effects instead of the year and country-natural resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Unfortunately, the period of analysis when using exploration spending is relatively short due to exploration data only being available starting in 1994 (to the best of our knowledge it is nevertheless the best available data). Still, we find a strong positive impact of openness on exploration spending. The point estimates suggest an increase in exploration spending of close to 150% after opening markets when using the lowest point estimate (column 2).[25] This fits well with the above quantification of the impact of market orientation on the number of discoveries. Opening up the economy thus leads to a large and significant increase in

[25]This can be calculated as $100 * [e^{\gamma} - 1]$ which with $\gamma = 0.903$ gives 147%.

exploration spending that in turn results in additional discoveries of new reserves according to table 4. The level of prices is also found to be strongly positively associated with exploration spending, with an estimated elasticity of about one. Furthermore, the stock of cumulative discoveries first has a positive 'information' effect and eventually a negative 'depletion' effect as also found empirically for the effects on discoveries reported in table 3.

C. Robustness

We have examined robustness by exploring a wide array of alternative specifications, additional controls, alternative definitions of the dependent variable, countries and periods excluded from our sample, splitting up the sample between hydrocarbon and mineral discoveries, using an alternative estimator which specifically takes into account the large number of zeros in the discovery data, and collapsing our data to a two-way, country-year panel (see tables S2-S13 in the Supplementary Appendix).

As discussed in section IV, in theory it might be true that the exclusion restriction for the distance-weighted instrument is not satisfied as openness of neighbours' economies increases discoveries there and then discoveries in the home country as the neighbours' discoveries provide additional geological information about the home country. By controlling directly for neighbours' distance-weighted discoveries, this concern is addressed (see table S2). We find that the point estimate on market orientation is virtually unchanged relative to the baseline regression, but the estimate for the impact of neighbours' discoveries is always positive albeit not always significant.

The significance of our core results in table 3 is unaffected if standard errors are clustered at the country-resource level instead of at the year-resource level (see table S3). If the human capital index and GDP from the Penn World Tables as are added as controls, the results are broadly the same even though the point estimates of the effect of openness on discoveries are somewhat smaller (see table S4).

To allow for a more even comparison between countries (even though the fixed effects included in all regressions already address issues such as differing size of countries), we also estimated with discoveries *per capita* as the dependent variable (see tables S5 and S6). The point estimate on openness remains positive and highly significant. Instead of using a count variable (the number of discoveries), we have also used a simple dummy variable as the dependent variable, again confirming the significance of market orientation for natural resource discoveries (see table S7).

Our core empirical results are remarkable stable to excluding any of the individual country groups (see table S8) or excluding any particular decade (see table S9). Across all regressions the coefficient on market orientation remains positive and significant. This is important since it suggests that our results are not driven by one region or one specific time period only.

Given our rich data set for discoveries, we can estimate equation (I) individually for different natural resources $k \in \{Gold, Oil, Gas, Copper, Nicker, Uranium, Zinc, Silver\}$. This list covers over 90% of all discoveries over our period of analysis, 1950-2004, corresponding to 2171 out of a total of 2392 discoveries. The estimates for the impact of openness on discoveries range from virtually no impact for uranium, to a (statistically significant) increase of close to 3% for nickel, and oil and an increase of over 5% for silver, albeit that the latter is not precisely estimated (see table S10).[26] Averaging across these coefficients gives a total impact of 2.2% on total worldwide discoveries, more than double the impact of slightly more than 1% obtained from the aggregate regressions. This might be due to not all of the coefficients in the individual regressions being statistically significant and taking all of them at face value thus overestimates the total impact.

Given that our dependent variable is count data with a very large fraction of zeros, we have also employed the zero-augmented Poisson estimator (ZIP) as an alternative to model this feature of the data directly (see table S11). In particular, ZIP fits a logit model to predict the excess zeros and separately models the count data by fitting a Poisson model.[27] To predict

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[26] These numbers are obtained by taking the estimated coefficients γ_k for each resource *k* and dividing them by the average yearly number of discoveries of resource k.

[27] Let $\text{prob}(y_{itk}) = e^{-\lambda_{jtk}} \lambda_{jtk}^{N_{itk}} / y_{itk} j!$, where y_{itk} denotes the number of resource discoveries in country *i* at time *t* and for a specific resource *k*. (Silva and Tenreyro, 2006). y_{itk} is assumed to follow a Poisson distribution as follows. Specifying λ_{jtk} as a linear function of explanatory variables X_{jtk}, gives the expectation of y_{jtk} conditional on X_{jtk} : $L_{jtk} \equiv E\left[y_{jtk} \middle| X_{jtk} \right] = e^{X_{jtk} \cdot B_{jk}}$, where X_{jtk} is the row vector of explanatory variables. Taking logs gives the model $\log E\left[y_{itk} \middle| X_{itk} \right] = B_{jk} X_{itk}$.

excess zeros we use the lag of the previous stock of discoveries.[28] The coefficient for the effect of openness on discoveries is positive and significant. The interpretation of the point estimate is now different. For example, opening up increases the expected log count of discoveries by 0.486 (from the coefficient in column 4 of table S11) so that discoveries increase by a factor of $e^{0.525}\sim 1.7$ after a country opens up. This is somewhat larger than the quantitative effect obtained from our 2SLS estimates in table 3.

As an additional exercise, we have collapsed our three-way panel (country, year, resource) to a two-way panel (country, year) since the obtained regression coefficients are particularly easy to interpret and can be immediately compared to the preliminary event-study analysis conducted in section III. Opening of the economy increases discoveries by 0.47 per year and country (column 1 of table S12). Recall that a cursory look at the data as shown in figure 4 suggested an increase of 0.16, severely underestimating the positive impact. One could argue that there are important differences in the role market orientation plays in fostering mineral versus hydrocarbon discoveries. In particular, minerals might be seen as more appropriable than hydrocarbons because mining output does not move through pipelines and takes place exclusively onshore. Instead our results suggest that in fact the effect of market orientation is driven as much by hydrocarbon as mineral discoveries (columns 2 and 3 of table S12).[29]

Last, we have tested robustness of our core results using the International Country Risk Guide (ICRG) Political Risk Rating rather than market orientation as the explanatory variable (see table S13). The risk rating assesses political stability based on a number of factors, including socioeconomic conditions, government stability, investment profile, internal conflict, external conflict, corruption, military involvement in government, religious tensions, ethnic tensions, law and order, democratic accountability, and bureaucratic quality. The risk rating ranges from 100 (least risk) to 0 (most risk). While that risk rating is not per say a measure of market orientation, it provides relevant insights in to the attractiveness of the economy to foreign investors.[30] Despite that relative to our baseline regressions the time period is shortened (as the

[28] The drawbacks of ZIP are that we do not employ an IV strategy and for computational reasons we cannot include a fixed-effects structure which is as rich as in the least squares estimations.
[29] We lose some power when splitting the sample, hence the reduced significance levels.
[30] The results using ICRG indicators which are presented in this section should be presented as associations rather than causations.

ICRG data is available only since 1984), political risk appears as an important determinant of resource discoveries, corroborating the importance of institutional factors for investment decisions and ultimately natural resource discoveries. Again, the point estimates are positive and economically and statistically significant. In terms of quantification, using the point estimates from the ZIP regressions indicates that a 1 standard deviation improvement in the political risk rating (which corresponds to a move from, for example, Mali to South Africa, South Africa to Chile, or Chile to Canada) would lead to 20% more natural resource discoveries in those countries (column 3 or 4 of table S13). To provide a further sense of the relevant magnitude, a thought experiment is conducted in which Latin America's and sub-Saharan Africa's political risk rating suddenly jumps to the levels of the most advanced economies in each of these regions, which are, respectively, Chile and Botswana. This experiment yields close to a 15 percent increase in the number of deposits discovered worldwide, all else equal. The figure increases to 22 percent if instead Latin America and sub-Saharan Africa were to suddenly adopt the same level of property rights as in the United States, again all else equal.[31] Notwithstanding the dramatic improvement in institutions implied by this thought experiment, the magnitudes unveiled again suggest that market orientation plays an important role in driving exploration spending and ultimately discoveries of natural resources.

VI. CONCLUSION

We have examined the effect of changes in market orientation on (known) natural wealth. Consistent with the predictions of a two-region model, we presented empirical estimates based on a large panel of countries that show that increased market orientation causes a significant increase in discoveries. In a thought experiment whereby economies in Latin America and sub-Saharan Africa remained closed, they would have only achieved one quarter of the actual

[31] The difference between the median political risk ratings is Latin America and the US in 2012 was 17 points. Therefore, if Latin America was suddenly like the US, discoveries should increase by a factor of $e^{17*0.02} = 1.4$. For SSA, the difference is 25.5 points, and therefore discoveries should increase by a factor of 1.66. If we then take the number of discoveries for Latin America and SSA in the decade 2000-2009 (123 and 77, respectively) and apply this factor, we get that Latin America and SSA would discover another 49 and 51 deposits, respectively, per decade. Given that the total number of deposits discovered over 2000-2009 was 448, this would be an increase in world-wide discoveries of roughly 22%.

increase in discoveries they have experienced since the early 1990s. These results help explain the worldwide shift in the geographic distribution of natural resource discoveries, with the economic opening in Sub-Saharan Africa and Latin America contributing to a large increase in the share of worldwide discoveries in these two regions.

Our results provide novel evidence in support of the primacy of outward market orientation by calling into question the view that resource endowments are an exogenous feature of an economy. And while we find that market orientation increases discoveries, the resulting resource boom may lead to aggressive rent seeking and conflicts, potentially worsening welfare for citizens. Our results thus suggest that the relationship between resource endowments and institutions (in the larger sense) is complex. Further research should attempt to "unbundle institutions" and revisit some of the key empirical findings including in the resource curse literature on the mediating role of institutions for resource endowments.

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APPENDIX A: EQUILIBRIUM DISCOVERIES

Maximizing net worth also gives efficiency conditions for initial reserves and exploration:

$$(3') \quad \begin{aligned} \left[p_1 - G\left(S_1(I_0)\right) - G'\left(S_1(I_0)\right) R_1 \right] S_1'(I_0) = 1 + r \quad \text{and} \\ \left[p_1 - G^*\left(S_1^*(I_0^*)\right) - G'\left(S_1^*(I_0^*)\right) R_1^* \right] S_1^{*\prime}(I_0^*) = (1+r)(1+T_0^*). \end{aligned}$$

This is used together with (3) to obtain the comparative statics properties (4) and

$$(\text{A1}) \quad I_0 = I_0(\overset{+}{p_1}, \overset{+}{R_1}), \quad S_1 = S_1(\overset{+}{p_1}, \overset{+}{R_1}), \quad I_0^* = I_0^*(\overset{+}{p_1}, \overset{+}{R_1^*}, \overset{-}{T_0^*}), \quad S_1^* = S_1^*(\overset{+}{p_1}, \overset{+}{R_1^*}, \overset{-}{T_0^*}).$$

Let world demand for oil in period *t* be iso-elastic and given by $\Gamma_t p_t^{-\varepsilon}, t = 1, 2,$ where $\varepsilon > 0$ is the price elasticity of demand and $\Gamma_t > 0$ an exogenous shift to oil demand in period *t*. Market equilibrium on the world oil markets requires

$$(\text{A2}) \quad R_1 + R_1^* = \Gamma_1 p_1^{-\varepsilon} \quad \text{and} \quad R_2 + R_2^* = \Gamma_2 p_2^{-\varepsilon}.$$

Using initial exploration and discoveries as given in (4), the depletion equations become

$$(\text{A3}) \quad \begin{aligned} R_1 + R_2 = S_1(p_1, R_1) + D(p_1, R_1, A, \gamma) \quad \text{and} \\ R_1^* + R_2^* = S_1^* = S_1^*(p_1, R_1^*, T_0^*) + D^*(p_1, R_1^*, T_0^*, T_1^*, A^*, \gamma^*). \end{aligned}$$

The extraction rates follow from the Hotelling rules (2) or

$$(\text{A4}) \quad \begin{aligned} p_1 - G\left(S_1(p_1, R_1)\right) = \frac{1}{1+r}\left[p_2 - G(R_2) + G'(R_2) R_2 \right] \quad \text{and} \\ p_1 - G^*(S_1^*) = \frac{1}{1+r}\left[p_2 - G^*(R_2^*) + G^{*\prime}(R_2^*) R_2^* \right]. \end{aligned}$$

Equations (A2)-(A4) can be solved for extraction rate and prices $\left\{R_1, R_1^*, R_2, R_2^*, p_1, p_2\right\}$ and thus also for initial and future oil discoveries $\left\{S_1, S_1^*, D, D^*\right\}$ in terms of the ease of access for IOCs in the South $\left\{T_0^*, T_1^*\right\}$, the extraction cost parameters and geological conditions in the North and the South $\left\{\gamma, \gamma^*\right\}$ and $\left\{A, A^*\right\}$, and the global oil demand shocks $\left\{\Gamma_1, \Gamma_2\right\}$. One could also extend the analysis to allow for discoveries to depend on how much has been explored initially and thereby on geological conditions. One can capture this by making *A* a function of I_0 and A^* a function of I_0^*, but our main conclusions regarding the shifting frontier of natural resources will not be materially affected.

APPENDIX B: DATA

Table B.I: Data Definition and Sources

Variable	Source
Number of natural resource discoveries per year, country and natural resource	Horn (2014), MinEx (2014)
Sachs and Warner Openness Indicator	Sachs and Warner (1995), Wacziarg and Welch (2008)
Exploration spending	Rystad (2014) and SNL Metals and Minerals (2014)
Commodities prices [We use the longest available series, taken either from UNCTAD, Datastream, Bloomberg or the IMF, depending on the natural resource. UNCTAD is used for Manganese, Tungsten and Phosphate.]	IMF, Primary Commodity Price System; Thomson Reuters Datastream, Bloomberg, L.P.; and UNCTADstat.
Population	Summers and Heston
Real GDP and GDP growth	Summers and Heston
Human Capital Index	Summers and Heston
Geographic distance between countries	CEPII
Political Risk Rating	International Country Risk Guide (2015)
Polity 2 Score	Marshall and Jaggers (2009)

Table B. II. Summary statistics

	Mean	Std. Dev.	10%	50%	90%	Observations
1950-1959						
Number of Discoveries (by country, year, natural resource)	0.006	0.095	0	0	0	43,860
SW/Wacziarg Opennes	0.292	0.454	0	0	1	20,026
Real GDP Growth	0.049	0.059	-0.015	0.046	0.137	15,912
Growth in Natural Resource Price (by year and resource)	-0.017	0.14	-0.21	-0.013	0.186	1,548
1960-1969						
Number of Discoveries (by country, year, natural resource)	0.011	0.137	0	0	0	43,860
SW/Wacziarg Opennes	0.3	0.458	0	0	1	28,424
Real GDP Growth	0.534	0.061	-0.007	0.05	0.145	26,146
Growth in Natural Resource Price (by year and resource)	0.029	0.158	-0.137	0	0.406	11,997
1970-1979						
Number of Discoveries (by country, year, natural resource)	0.116	0.147	0	0	0	43,860
SW/Wacziarg Opennes	0.313	0.463	0	0	1	30,226
Real GDP Growth	0.051	0.075	-0.025	0.048	0.127	28,390
Growth in Natural Resource Price (by year and resource)	0.143	0.321	-0.179	0.087	0.687	14,190
1980-1989						
Number of Discoveries (by country, year, natural resource)	0.01	0.161	0	0	0	43,860
SW/Wacziarg Opennes	0.36	0.48	0	0	1	30,940
Real GDP Growth	0.281	0.072	-0.045	0.029	0.104	28,560
Growth in Natural Resource Price (by year and resource)	-0.029	0.277	-0.284	-0.032	0.238	1,612
1990-1999						
Number of Discoveries (by country, year, natural resource)	0.017	0.135	0	0	0	43,860
SW/Wacziarg Opennes	0.671	0.469	0	1	1	34,204
Real GDP Growth	0.292	0.089	-0.065	0.369	0.101	32,572
Growth in Natural Resource Price (by year and resource)	-0.173	0.215	-0.253	-0.276	0.244	21,543
2000-2009						
Number of Discoveries (by country, year, natural resource)	0.01	0.132	0	0	0	43,860
SW/Wacziarg Opennes	0.808	0.394	0	1	1	17,340
Real GDP Growth	0.05	0.083	-0.022	0.039	0.12	32,980
Growth in Natural Resource Price (by year and resource)	0.102	0.343	-0.299	0.076	0.479	27,219

Natural resources

The following natural resources are included in the dataset (numbers in bracket indicate first year for which we have price data if that year is later than 1960): Antimony (2005), Boron (2004), Chromium (1990), Copper, Diamonds (2005), Fluorite (no price data), Natural Gas (1985), Gold, Graphite (no price data), Lead, Lithium (1997), Magnesium (2003), Manganese, Mineral sands (no price data), Molybdenum (2012), Nickel, Niobium (2013), Oil, Palladium (1992), PGE (no price data), Phosphate, Platinum (1992), Potash (no price data), Rare earths (no price data), Silver (1968), Soda ash (2007), Tantalum (2009), Tellurium (2013), Tin, Tungsten, Uranium (1980), Vanadium (1987), Zinc, Zircon (1997).

Discoveries of Gold, Oil, Natural Gas, Copper, Nickel, Uranium, Zinc and Silver account for over 90 percent of all discoveries (followed by Diamonds and Molybdenum which account for 1-2 percent each).

Definition of minimum size of included discoveries by resource: Oil and Gas (> 500 million barrels of ultimately recoverable oil equivalent). Gold (>1 Moz Au-equivalent). Silver (>50 Moz Ag). PGE (>1 Moz Au-equivalent). Copper (>1 Mt Cu-equivalent). Nickel (>100 kt Ni). Zinc (> 2.5 Mt Zn+Pb). Lead (> 2.5 Mt Zn+Pb). Cobalt (>1 Mt Cu-equivalent). Molybdenum (>1 Mt Cu-equivalent). Tungsten (>1 Mt Cu-equivalent). Uranium Oxide (>25 kt U_3O_8).

Countries

The following countries are included in our sample: Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cyprus, Cambodia, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Republic of Congo, Democratic Republic of the Congo, Costa Rica, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Honduras, Hungary, Israel, India, Indonesia, Iran, Iraq, Ireland, Italy, Côte d'Ivoire, Japan, Jordan, Kazakhstan, Korea (South), Kuwait, Kyrgyz Republic, Lao P.D.R., Lesotho, Liberia, Libya, FYR Macedonia, Madagascar, Malaysia, Mali, Mauritania, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Serbia, Sierra Leone, Slovak Republic, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Syria, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, United Arab Emirates, Ukraine, United Kingdom, United States, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

Market orientation

The following countries opened their economies between 1950 and 2004 (numbers in bracket indicate year of opening): Canada (1952), Costa Rica (1952), Morocco (1956), Bolivia (1956), Germany (1959), Italy (1959), France (1959), Spain (1959), Denmark (1959), Greece (1959), Netherlands (1959), Finland (1960), Sweden (1960), Austria (1960), Australia (1964), Japan (1964), Jordan (1965), Ireland (1966), South Korea (1968), Indonesia (1970), Chile (1976), Sri Lanka (1977), Botswana (1979), Morocco (1984), Bolivia (1985), Israel (1985), Ghana (1985), Guinea (1986), Costa Rica (1986), Mexico (1986), New Zealand (1986), Colombia (1986), Philippines (1988), Guatemala (1988), Mali (1988), Venezuela (1989), Tunisia (1989), El Salvador (1989), Turkey (1989), Poland (1990), Uruguay (1990), Hungary (1990), Brazil (1991), South Africa (1991), Sri Lanka (1991), Nicaragua (1991), Honduras (1991), Ecuador (1991), Bulgaria (1991), Argentina (1991), Peru (1991), Trinidad and Tobago (1992), Dominican Republic (1992), Romania (1992), Albania (1992), Cameroon (1993), Zambia (1993), Ivory Coast (1994), Niger (1994), Kyrgyzstan (1994), Macedonia (1994), Armenia (1995), Mauritania (1995), Tanzania (1995), Egypt (1995), Mozambique (1995), Azerbaijan (1995), Venezuela (1996), Bangladesh (1996), Tajikistan (1996), Madagascar (1996), Ethiopia (1997), India (1997), Burkina Faso (1998), Papua New Guinea (1999), Congo (DRC) (2001), Sierra Leone (2001), Kazakhstan (2001), Pakistan (2001), Nigeria (2002), Congo (Brazzaville) (2002), Ethiopia (2004)

The following countries closed their economies between 1950 and 2004 (numbers in bracket indicate year of closing): Turkey (1954), Sri Lanka (1957), Venezuela (1960), Nicaragua (1961), Guatemala (1962), El Salvador (1962), Costa Rica (1962), Honduras (1962), Morocco (1965), Syria (1966), Peru (1968), Bolivia (1980), Ecuador (1983), Sri Lanka (1984), Venezuela (1994), Colombia (2000), Ethiopia (2001), Venezuela (2003)

SUPPLEMENTARY APPENDIX

Table S1 gives the OLS estimates corresponding to the 2SLS estimates given in table 3. These estimates are a factor 3-4 smaller than the 2SLS estimates. This downward bias of the OLS estimates is consistent with reverse causality, where resource discoveries lead to rent seeking and potentially even conflict.

Table S1: The Impact of Liberalization on Resource Discoveries (OLS)

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries
SW/Wacziarg Openness, lagged	0.00716***	0.0171***	0.0169***	0.0137***	0.00875***
	(0.00179)	(0.00442)	(0.00442)	(0.00392)	(0.00185)
(log) Price, lagged		0.0146**	0.0150***	0.0103**	
		(0.00677)	(0.00533)	(0.00449)	
Stock of Discoveries, lagged			-0.000839	0.0260*	0.0382***
			(0.00503)	(0.0141)	(0.00500)
Stock of Discoveries squared, lagged				-0.000451**	-0.000284***
				(0.000176)	(8.26e-05)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	161,160	57,976	57,976	57,976	161,160
R-squared	0.272	0.328	0.328	0.339	0.226
Estimation	OLS	OLS	OLS	OLS	OLS
Error Clustering	Country by Natural Resource	Country by Natural Resource	Country by Natural Resource	Country by Natural Resource	Country by Natural Resource

Note: The table reports results for regressions of the number of natural resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. The number of observations in columns (1) and (5) are larger than in the other columns because columns (2) – (4) include resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country-resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S.2 adds neighbours' distance-weighted discoveries as an additional control and finds that the point estimate on market orientation is virtually unchanged relative to the baseline regression whilst the estimate for the impact of neighbours' discoveries is always positive but not always significant.

Table S2: The Impact of Liberalization on Resource Discoveries (2SLS) – Controlling for neighbours' discoveries

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries
SW/Wacziarg Openness, lagged	0.0191***	0.0708***	0.0713***	0.0603***	0.0122***
	(0.00438)	(0.0165)	(0.0156)	(0.0153)	(0.00416)
Distance-Weighted Discoveries Neighbors, lagged	0.00648**	0.0108	0.0108	0.00853	0.00651**
	(0.00262)	(0.00661)	(0.00660)	(0.00635)	(0.00273)
(log) Price, lagged		0.0146***	0.0149***	0.0103***	
		(0.00461)	(0.00366)	(0.00314)	
Stock of Discoveries, lagged			-0.000568	0.0257***	0.0382***
			(0.00429)	(0.00832)	(0.00282)
Stock of Discoveries squared, lagged				-0.000442***	-0.000284***
				(0.000135)	(4.44e-05)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	157,284	57,976	57,976	57,976	157,284
R-squared	0.280	0.323	0.323	0.336	0.228
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. The number of observations in columns (1) and (5) are larger than in the other columns because columns (2) – (4) include resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country-resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S3 clusters standard errors at the country-resource level instead of at the year-resource level. It turns out that the significance of our core results in table 3 is unaffected.

Table S3: The Impact of Liberalization on Resource Discoveries (2SLS) – Clustering at the country-by-natural resource level

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries
SW/Wacziarg Openness, lagged	0.0209**	0.0756***	0.0760***	0.0641***	0.0140**
	(0.00880)	(0.0240)	(0.0240)	(0.0204)	(0.00700)
(log) Price, lagged		0.0146**	0.0149***	0.0103**	
		(0.00678)	(0.00532)	(0.00448)	
Stock of Discoveries, lagged			-0.000540	0.0257*	0.0382***
			(0.00500)	(0.0141)	(0.00500)
Stock of Discoveries squared, lagged				-0.000441**	-0.000284***
				(0.000175)	(8.24e-05)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	157,284	57,976	57,976	57,976	157,284
R-squared	0.279	0.323	0.323	0.335	0.227
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Country by Natural Resource	Country by Natural Resource	Country by Natural Resource	Country by Natural Resource	Country by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance weighted-growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. The number of observations in columns (1) and (5) are larger than in the other columns because columns (2) – (4) include resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country-resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S4 adds the human capital index and GDP from the Penn World Tables as controls. The results are broadly the same, but the point estimates of the effect of openness on discoveries are somewhat smaller.

Table S4: The Impact of Liberalization on Resource Discoveries (2SLS) – Additional Controls

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries
SW/Wacziarg Openness, lagged	0.00807**	0.00818**	0.00852**	0.00639*
	(0.00364)	(0.00370)	(0.00368)	(0.00368)
Stock of Discoveries, lagged	0.0357***	0.0360***	0.0360***	0.0361***
	(0.00296)	(0.00299)	(0.00299)	(0.00300)
Stock of Discoveries squared, lagged	-0.000260***	-0.000257***	-0.000258***	-0.000257***
	(4.51e-05)	(4.66e-05)	(4.66e-05)	(4.67e-05)
Human capital index, lagged	0.00104	0.00155	0.00160	0.00648**
	(0.00294)	(0.00297)	(0.00297)	(0.00319)
Revised Combined Polity Score , lagged		0.000198**	0.000159*	7.57e-05
		(8.21e-05)	(8.20e-05)	(8.13e-05)
Population (in millions), lagged			-4.64e-05***	7.43e-06
			(1.78e-05)	(1.72e-05)
Expenditure-side real GDP (in mil. 2011US$), lagged				-1.09e-08***
				(1.96e-09)
Country FE	YES	YES	YES	YES
Year FE	/	/	/	/
Natural Resource FE	/	/	/	/
Country by Natural Resource FE	/	/	/	/
Year by Natural Resource FE	YES	YES	YES	YES
Observations	146,234	139,468	139,468	139,468
R-squared	0.214	0.218	0.218	0.219
Estimation	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S5 tests the core results of table 3 by using discoveries *per capita* as the dependent variable. The point estimate on openness is again positive and highly significant.

Table S5: The Impact of Liberalization on Resource Discoveries (2SLS) – Discoveries per Capita as Dependent Variable I

VARIABLES	(1) Number of Discoveries per Capita	(2) Number of Discoveries per Capita	(3) Number of Discoveries per Capita	(4) Number of Discoveries per Capita	(5) Number of Discoveries per Capita
SW/Wacziarg Openness, lagged	0.00107***	0.00407***	0.00421***	0.00414***	0.000860***
	(0.000313)	(0.00108)	(0.00105)	(0.00106)	(0.000320)
(log) Price, lagged		0.00106***	0.00113***	0.00110***	
		(0.000392)	(0.000380)	(0.000378)	
Stock of Discoveries, lagged			-0.000140	2.73e-05	0.00126***
			(0.000156)	(0.000404)	(0.000111)
Stock of Discoveries squared, lagged				-2.83e-06	-1.23e-05***
				(6.11e-06)	(1.57e-06)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	150,484	56,369	56,369	56,369	150,484
R-squared	0.093	0.117	0.117	0.117	0.039
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries per capita by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. The number of observations in columns (1) and (5) are larger than in the other columns because columns (2) – (4) include resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country-resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S6 also uses discoveries per capita as dependent variable and adds more control variables, mirroring table S4. Again, the point estimate on openness is positive and highly significant.

Table S6: The Impact of Liberalization on Resource Discoveries (2SLS) – Discoveries per Capita as Dependent Variable II

VARIABLES	(1) Number of Discoveries per Capita	(2) Number of Discoveries per Capita	(3) Number of Discoveries per Capita	(4) Number of Discoveries per Capita
SW/Wacziarg Openness, lagged	0.000862***	0.000951***	0.000960***	0.000926***
	(0.000319)	(0.000324)	(0.000325)	(0.000322)
Stock of Discoveries, lagged	0.00128***	0.00127***	0.00127***	0.00127***
	(0.000113)	(0.000114)	(0.000114)	(0.000114)
Stock of Discoveries squared, lagged	-1.25e-05***	-1.21e-05***	-1.21e-05***	-1.21e-05***
	(1.58e-06)	(1.60e-06)	(1.60e-06)	(1.61e-06)
Human capital index, lagged	-0.00148**	-0.00144**	-0.00144**	-0.00137**
	(0.000662)	(0.000675)	(0.000676)	(0.000694)
Revised Combined Polity Score , lagged		1.69e-05	1.59e-05	1.47e-05
		(1.09e-05)	(1.11e-05)	(1.13e-05)
Population (in millions), lagged			-1.27e-06*	-4.79e-07
			(6.50e-07)	(3.92e-07)
Expenditure-side real GDP (in mil. 2011US$), lagged				-1.59e-10**
				(6.50e-11)
Country FE	YES	YES	YES	YES
Year FE	/	/	/	/
Natural Resource FE	/	/	/	/
Country by Natural Resource FE	/	/	/	/
Year by Natural Resource FE	YES	YES	YES	YES
Observations	146,234	139,468	139,468	139,468
R-squared	0.039	0.040	0.040	0.040
Estimation	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries per capita by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S7 tests the robustness of our core results using a simple dummy variable for discoveries. The effect of market orientation on natural resource discoveries remains positive and highly significant.

Table S7: The Impact of Liberalization on Resource Discoveries (2SLS) - Discovery Dummy as Dependent Variable

VARIABLES	(1) Discovery Dummy	(2) Discovery Dummy	(3) Discovery Dummy	(4) Discovery Dummy	(5) Discovery Dummy
SW/Wacziarg Openness, lagged	0.0118***	0.0446***	0.0446***	0.0441***	0.00781***
	(0.00270)	(0.0101)	(0.00987)	(0.00986)	(0.00262)
(log) Price, lagged		0.00788***	0.00788***	0.00771***	
		(0.00230)	(0.00195)	(0.00193)	
Stock of Discoveries, lagged			4.84e-06	0.000991	0.0225***
			(0.00135)	(0.00258)	(0.00113)
Stock of Discoveries squared, lagged				-1.66e-05	-0.000205***
				(3.66e-05)	(2.06e-05)
Country FE	/	/	/	/	YES
Year FE	YES	YES	YES	YES	/
Natural Resource FE	/	/	/	/	/
Country by Natural Resource FE	YES	YES	YES	YES	/
Year by Natural Resource FE	/	/	/	/	YES
Observations	157,284	57,976	57,976	57,976	157,284
R-squared	0.245	0.280	0.280	0.281	0.199
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports the second stage of a 2SLS estimation regressing a dummy variable which takes the value one if there was at least one resource discovery in a given country, year and resource type, on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. The number of observations in columns (1) and (5) are larger than in the other columns because columns (2) – (4) include resource prices as a control and price data are not available for certain years and resources. Column (5) uses country as well as year-resource fixed effects instead of the year and country-resource fixed effects employed in columns (1) – (4). *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S8 shows how remarkably stable our results are to excluding individual country groups as whatever group is removed from the sample the coefficient on openness remains positive and significant.

Table S8: The Impact of Liberalization on Resource Discoveries (2SLS) – Using subsamples of countries

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries	(6) Number of Discoveries	(7) Number of Discoveries	(8) Number of Discoveries
SW/Wacziarg Openness, lagged	0.0140***	0.00816**	0.0196**	0.0142***	0.0406***	0.0137***	0.0145***	0.0107***
	(0.00410)	(0.00341)	(0.00786)	(0.00422)	(0.0115)	(0.00391)	(0.00405)	(0.00404)
Stock of Discoveries, lagged	0.0388***	0.0354***	0.0395***	0.0382***	0.0359***	0.0405***	0.0383***	0.0398***
	(0.00289)	(0.00303)	(0.00262)	(0.00282)	(0.00312)	(0.00300)	(0.00283)	(0.00314)
Stock of Discoveries squared, lagged	-0.000294***	-0.000172***	-0.000399***	-0.000284***	-0.000249***	-0.000312***	-0.000286***	-0.000305***
	(4.43e-05)	(5.56e-05)	(4.97e-05)	(4.44e-05)	(4.79e-05)	(4.61e-05)	(4.46e-05)	(4.77e-05)
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	/	/	/	/	/	/	/	/
Natural Resource FE	/	/	/	/	/	/	/	/
Country by Natural Resource FE	/	/	/	/	/	/	/	/
Year by Natural Resource FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	147,628	143,990	115,090	154,292	128,452	142,154	150,722	118,660
R-squared	0.229	0.228	0.208	0.228	0.224	0.236	0.230	0.243
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource
Excluded Region	East Asia and Pacific	Europe and Central Asia	High-income OECD Countries	High-income non-OECD Countries	Latin America and the Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. Each column excludes one specific geographic area which is specified in the "Excluded Region" row. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S9 shows that the results are robust to excluding individual time periods. Again, across all regressions the coefficient on openness remains positive and significant.

Table S9: The Impact of Liberalization on Resource Discoveries (2SLS) – Using subsamples of time periods

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries	(6) Number of Discoveries
SW/Wacziarg Openness, lagged	0.0235***	0.0129***	0.0159***	0.0163***	0.00633*	0.0119***
	(0.00672)	(0.00449)	(0.00456)	(0.00443)	(0.00357)	(0.00429)
Stock of Discoveries, lagged	0.0379***	0.0349***	0.0352***	0.0369***	0.0418***	0.0435***
	(0.00283)	(0.00290)	(0.00319)	(0.00240)	(0.00362)	(0.00330)
Stock of Discoveries squared, lagged	-0.000277***	-0.000232***	-0.000250***	-0.000304***	-0.000286***	-0.000349***
	(4.46e-05)	(4.47e-05)	(4.74e-05)	(4.54e-05)	(5.85e-05)	(5.29e-05)
Country FE	YES	YES	YES	YES	YES	YES
Year FE	/	/	/	/	/	/
Natural Resource FE	/	/	/	/	/	/
Country by Natural Resource FE	/	/	/	/	/	/
Year by Natural Resource FE	YES	YES	YES	YES	YES	YES
Observations	143,242	129,710	127,160	126,378	123,454	136,476
R-squared	0.235	0.235	0.225	0.210	0.233	0.232
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource
Excluded Decade	1950s	1960s	1970s	1980s	1990s	2000s

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. Each column excludes one decade which is specified in the "Excluded Decade" row. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S10 gives the results of estimating equation (I) individually for different natural resources $k \in \{Gold, Oil, Gas, Copper, Nicker, Uranium, Zinc, Silver\}$.

Table S10: The Impact of Liberalization on Resource Discoveries (2SLS) – Results by natural resource

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries	(5) Number of Discoveries	(6) Number of Discoveries	(7) Number of Discoveries	(8) Number of Discoveries
SW/Wacziarg Openness, lagged	0.0960	0.106**	0.146***	0.0868	0.0781**	0.00327	0.0237	0.0311
	(0.0783)	(0.0403)	(0.0355)	(0.0545)	(0.0365)	(0.0139)	(0.0210)	(0.0194)
Stock of Discoveries, lagged	0.0702***	0.00278	0.0408***	0.0196*	-0.00771	-0.0731***	-0.0281**	-0.0189
	(0.0143)	(0.00719)	(0.0111)	(0.0110)	(0.0130)	(0.0219)	(0.0129)	(0.0199)
ldiscoveries_stock_squar	-0.000822***	-0.000608***	-0.000696***	-0.000541**	0.000346	0.00435**	-0.000178	0.00982***
	(0.000203)	(0.000184)	(0.000155)	(0.000257)	(0.000470)	(0.00189)	(0.000732)	(0.00263)
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Natural Resource FE	/	/	/	/	/	/	/	/
Country by Natural Resource FE	/	/	/	/	/	/	/	/
Year by Natural Resource FE	/	/	/	/	/	/	/	/
Observations	4,626	4,626	4,626	4,626	4,626	4,626	4,626	4,626
R-squared	0.415	0.286	0.328	0.274	0.188	0.160	0.158	0.276
Estimation	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Error Clustering	Year	Year	Year	Year	Year	Year	Year	Year
Natural Resource	Gold	Oil	Gas	Copper	Nickel	Uranium	Zinc	Silver

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country and year on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. Each column excludes shows results for one main type of natural resource. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S11 present estimates analogous to those in table 3 with the zero-augmented Poisson estimator (ZIP) to allow for count data with a very large fraction of zeros. To predict excess zeros we use the lag of the previous stock of discoveries. The coefficient for the effect of openness on discoveries is again positive and significant in all specifications.

Table S11: The Impact of Liberalization on Resource Discoveries (Zero-Inflated Poisson)

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries
SW/Wacziarg Openness, lagged	0.486***	0.418***	0.602***	0.525***
	(0.127)	(0.155)	(0.175)	(0.165)
(log) Price, lagged		0.375**	0.301**	0.267*
		(0.153)	(0.151)	(0.144)
Stock of Discoveries, lagged			0.0166***	0.0589***
			(0.00425)	(0.0124)
Stock of Discoveries squared, lagged				-0.000550***
				(0.000154)
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Natural Resource FE	YES	YES	YES	YES
Country by Natural Resource FE	/	/	/	/
Year by Natural Resource FE	/	/	/	/
Observations	161,160	58,078	58,078	58,078
Estimation	ZIP	ZIP	ZIP	ZIP
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports zero-inflated Poisson regressions of resource discoveries by country, year and resource on countries' SW/Wacziarg openness indicator as well as a number of controls. The number of observations in column (1) is larger than in the other columns because columns (2) – (4) include resource prices as a control and price data are not available for certain years and resources. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S12 collapses the three-way panel (country, year, resource) estimates of table 3 to a two-way panel (country, year). Opening of the economy increases discoveries by 0.47 per year and country (column 1). Splitting the analysis between hydrocarbon and mineral deposits shows that the effect of openness on discoveries remains positive and statistically significant (columns 2 and 3).

Table S12: The Impact of Liberalization on Resource Discoveries (2SLS) – Country-Year level regressions

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries
SW/Wacziarg Openness, lagged	0.471**	0.575**	0.588*
	(0.228)	(0.268)	(0.328)
Stock of Discoveries, lagged	0.0421***		
	(0.0108)		
Stock of Discoveries squared, lagged	-0.000205***		
	(4.74e-05)		
Stock of Hydrocarbon Discoveries, lagged		0.0456*	
		(0.0237)	
Stock of Hydrocarbon Discoveries squared, lagged		-0.000528***	
		(0.000141)	
Stock of Mineral Discoveries, lagged			0.0370***
			(0.0122)
Stock of Mineral Discoveries squared, lagged			-0.000204***
			(5.14e-05)
Country FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	4,626	4,626	4,626
R-squared	0.592	0.575	0.563
Estimation	2SLS	2SLS	2SLS
Error clustering	Country	Country	Country

Note: The table reports the second stage of a 2SLS estimation regressing the number of resource discoveries by country and on countries' SW/Wacziarg openness indicator as well as a number of controls. Distance-weighted average openness and distance-weighted growth of closed economies are used as excluded instruments for the SW/Wacziarg Openness indicator. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table S13 tests robustness of the core results presented in table 3 using the International Country Risk Guide (ICRG) Political Risk Rating rather than market orientation as the explanatory variable. Columns 1 and 2 show results from OLS regressions (mirroring table S1) while columns 3 and 4 show estimates using ZIP as the estimator (mirroring table S11). The ICRG variable has a positive and significant effect on discoveries for both types of estimates.

Table S13: The Impact of Political Risk on Resource Discoveries (OLS and ZIP) – Using ICRG index as explanatory variable

VARIABLES	(1) Number of Discoveries	(2) Number of Discoveries	(3) Number of Discoveries	(4) Number of Discoveries
ICRG Political Risk Rating, lagged	0.000162**	0.000202**	0.0197***	0.0206***
	(6.79e-05)	(8.83e-05)	(0.00630)	(0.00675)
(log) Price, lagged				0.469**
				(0.188)
Stock of Discoveries, lagged		0.0217***		0.0520***
		(0.00253)		(0.0167)
Stock of Discoveries squared, lagged		-9.84e-05***		-0.000397*
		(3.70e-05)		(0.000215)
Country FE	/	YES	YES	YES
Year FE	YES	/	YES	YES
Natural Resource FE	/	/	YES	YES
Country by Natural Resource FE	YES	/	/	/
Year by Natural Resource FE	/	YES	/	/
Observations	105,468	105,468	105,468	58,903
Estimation	OLS	OLS	ZIP	ZIP
Error Clustering	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource	Year by Natural Resource

Note: The table reports OLS and zero-inflated Poisson (ZIP) regression of resource discoveries by country, year and resource on countries' ICRG political risk rating indicator as well as a number of controls. The number of observations in columns (1) - (3) is larger than in the column (4) because the latter includes resource prices as a control and price data are not available for certain years and resources. Note that the magnitude of the coefficients in the OLS and ZIP regressions are not immediately comparable. *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.