CESifo, a Munich-based, globe-spanning economic research and policy advice institution

CESifo Area Conferences 2015

CESifo Conference Centre, Munich

CESifo Area Conference on Global Economy

22–23 May

From Mine to Coast: Transport Infrastructure and the Direction of Trade in Developing Countries

Roberto Bonfatti and Steven Poelhekke

CESifo GmbH · Poschingerstr. 5 · 81679 Munich, Germany
Tel.: +49 (0) 89 92 24 - 14 10 · Fax: +49 (0) 89 92 24 - 14 09
E-mail: office@CESifo.de · www.CESifo.org

From mine to coast: transport infrastructure and the direction of trade in developing countries

Roberto Bonfatti

University of Nottingham

Steven Poelhekke

*VU University Amsterdam, Tinbergen Institute, and De Nederlandsche Bank**

March 6, 2015

Abstract

Mine-related transport infrastructure typically connects mines directly to the coast. This is most clearly seen in former colonies, whose transport infrastructure was originally designed to facilitate the export of natural resources in colonial times. We provide the first econometric evidence that such infrastructure biases a country's structure of transport costs in favor of overseas trade, to the detriment of trade with neighbors and regional integration. Our main findings are that coastal destinations with more mine-to-coast infrastructure import relatively less fom neighbors, and this effect is stronger when the infrastructure overlaps with routes used to import from overseas. However this effect is reversed for

*Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank nor of the Eurosystem of central banks. We are also grateful to Kerem Cosar, Klaus Desmet, Brian Kovak, Torfinn Harding, Oliver Morrissey, Pierre-Louis Vezina, Tony Venables, seminar participants at the EBRD, the VU University Amsterdam, LSE, the Universities of Nottingham, Oxford, Birmingham, Trier, Manchester, as well as to conference participants at the 2011 CSAE Conference in Oxford, the 2012 Rocky Mountain Empirical Trade Conference in Vancouver, RCEF 2012 in Toronto, the 2012 EEA Meetings, and the 2012 ETSG.
Both authors are also affiliated with OxCarre and CESIfo.

landlocked destinations, where the mine-to-coast infrastructure will have to cut through at least one neighbor to reach the coast. The effect is specific to mines and not to oil and gas fields, arguably because pipelines cannot be used to trade other commodities. We discuss the welfare implications of our results, and relate these to the debate on the economic legacy of colonialism, and the recent surge of Chinese infrastructure investment in Africa.

JEL Codes: F14, F54, Q32, R4.

Keywords: Mineral Resources, Transport Infrastructure, Regional Trade Integration, Gravity Model, Economic Legacy of Colonialism.

1 Introduction

It has long been claimed that the transport infrastructure of developing countries, and that of former colonies and African countries in particular, has a suboptimal, *interior-to-coast* shape. The colonisers built rail and roads that facilitated the export of natural resources, but these were not suited for the needs of local and regional trade (e.g. Rodney, 1982, p. 209). Various observers have pointed out that colonial infrastructure has persisted over time, and that its interior-to-coast shape contributes to explaining the former colonies' limited regional integration and disappointing economic performance (e.g. Sachs *et al.*, 2004, p. 182).

A casual look at a map of African transport infrastructure immediately illustrates the logic of this argument. Figure 1 presents a map of West and East African railways at decolonisation (1960s). Colonial transport infrastructure mostly connected the interior to the coast, while there were very few links connecting neighboring countries. Furthermore, many of the latter links were designed primarily to connect the interior of a landlocked country to the coast. Colonial transport infrastructure has clearly persisted over time: Figure 2 describes the structure of African railways today, which appears to be very similar to that in the previous map.[1] While an interior-to-coast shape is not necessarily suboptimal, the conclusion that it is - particularly for its negative impact on regional trade - actually permeates the contemporary trade and development literature, and policy circles as well.[2]

[1] In the Online Appendix, we provide a case study of Ghana, a resource-rich country where the colonial transport infrastructure had a clear interior-to-coast pattern, and has persisted to these days.

[2] The trade literature has repeatedly documented that intra-African trade is "too small" compared to what

In this paper, we provide the first econometric evidence in support of the claim that interior-to-coast transport infrastructure penalises regional trade. In particular, we focus on *mines* and *mine-to-coast* infrastructure, and test the following hypothesis. Developing countries export most of their mineral resources overseas, requiring roads and railways to connect the mineral-rich regions of the interior to the coast. To the extent that such mine-to-coast infrastructure is also usable to import other goods, it will reduce the transport costs on imports, and more so on imports from overseas than on imports from neighbors. If mine-to-coast infrastructure has dominated national infrastructural investment - which according to the narrative above was the case in former colonies (and particularly in Africa) - more of this type of infrastructure should result in overall transport costs that are more biased in favor of overseas countries. Thus, countries with more mine-to-coast infrastructure should import relatively less from neighbors, and this should be more visible in former colonies (and particularly in Africa).

We build our empirical strategy on the following steps. We begin by estimating a gravity model of bilateral trade flows (controlling for importer and exporter fixed effects and a range of measures of trade costs) to show that countries with a larger number of mines - which, we argue, is a good proxy for both the quantity *and* quality of mine-to-coast infrastructure - import relatively less from neighbors. This qualifies the standard gravity result that neighboring countries trade more with each other, and may eliminate it or even overturn it for countries that have a sufficiently larger number of mines.[3] When we split the sample in destinations that are former colonies and those that are not, we find that this *trade re-direction effect* disappears for the first group of countries, while it is still there for the second group of countries. This is *prima-facie* evidence in favor of our hypothesis.

We then adopt three different strategies to establish that the trade-re-direction effect of mines is due to mine-to-coast infrastructure and its asymmetric impact on transport costs. Our first

gravity predicts, and that much of it can be attributed to the poor quality of transport infrastructure (e.g. Limao and Venables, 2001). Sachs *et al.* (2004, p. 182) explicitly blame this on interior-to-coast transport infrastructure inherited from colonial times, and highlight the urgent need to invest in cross-country connections within Africa. The African Development Bank has taken up this challenge in recent years, by launching an ambitious plan to improve the overland connections between Sub-Saharan African countries. This is estimated to have the potential to increase overland trade by as much as $250 billion over 15 years (Buys *et al.*, 2006).

[3]For example, we find that the positive neighbor effect on trade disappears altogether for the 40 most important mining countries.

strategy derives from the existence of landlocked countries in our sample. Developing landlocked countries will also tend to export most of their mineral resources overseas. However, for these countries the mine-to-coast infrastructure will necessarily cut through some "transit" neighbors. Imports from these neighbors will then benefit from the mine-to-coast infrastructure just as much as those from overseas countries do, if not more. It follows that, if mine-to-coast transport infrastructure is what is driving the trade re-direction effect, we should expect this effect to be smaller (or even of opposite sign) for landlocked destinations. This prediction is very specific to our hypothesis, and we test for it by modifying our baseline specification to distinguish between coastal and landlocked destinations.

Second, for our sample of colonial and African destinations, we collect data on mine-to-coast road infrastructure, and construct a measure of its potential to re-direct trade in each country. More specifically, we use almost 80,000 online MapQuest queries to identify the roads connecting each mine in each country to the coast. We then construct an index capturing the extent to which such infrastructure overlaps with the roads connecting the country's cities to its main container port (city-port corridors). If the trade re-direction effect of mines is due to mine-to-coast infrastructure, we would expect it to be stronger when their mine-to-coast infrastructure overlaps a lot with city-port corridors, since in this case the infrastructure would have a strong potential to reduce the cost of importing from overseas. This prediction is exclusive to our hypothesis, and we test for it by running a very demanding specification which distinguishes not only between coastal and landlocked destinations, but also between destinations with a high value of the index, and destinations with a low value.

Our last strategy consists of a falsification exercise. If mine-to-coast infrastructure is what is driving the trade re-direction effect of mines, this effect should disappear when we look at specific types of mineral resources that are unlikely to generate infrastructure usable to import other goods. We therefore add the number of oil and gas fields to our baseline specification, on the premise that oil and gas, differently from other mineral resources, are mostly transported through pipelines.

We find compelling evidence in favor of our hypothesis. First, while coastal destinations with more mines import relatively less from neighbors, landlocked destinations do not. As

expected, this differential effect is only present in former colonies and is particularly strong in Africa. Second, the trade re-direction effect of mines is stronger, the more their observed mine-to-coast infrastructure overlaps with city-port corridors. Finally, our falsification exercise yields the expected result: there is no trade re-direction effect associated with oil and gas fields. These results hold across various robustness tests such as changing the measure of mine-to-coast infrastructure, accounting for potential selection bias due to 'zeros in trade', and including only countries with at least one mine.

Our results are supportive of the notion that interior-to-coast infrastructure penalises regional trade, at least in relative terms. We cannot, however, draw precise welfare implications: do to so, one would require strict randomness in the placement of infrastructure, and the construction and estimation of a rich quantitative model of infrastructure, trade and growth. Nonetheless, there are good reasons to hypothesise that interior-to-coast infrastructure is suboptimal, which we discuss in some detail. For example, interior-to-coast infrastructure may be particularly bad for *neighbors* of resource-rich countries, who will face a structure of transport costs biased against them. We also discuss the possibility to interpret our results as an economic legacy of colonialism, and the extent to which recent Chinese investment in Africa may contribute to exacerbate that legacy.

The paper is related to a growing literature on the economic impact of transport infrastructure. This has looked at the impact of infrastructure on the location of economic activity (e.g., Duranton *et al.*, forthcoming, for the US; Faber, forthcoming, for China), long-run economic growth (e.g. Banerjee *et al.*, 2012, for China; Jedwab and Moradi, 2012, for Ghana), and market integration (e.g. Cosar and Demir, 2015, for Turkey; Donaldson, forthcoming, for 19th-century India; Keller and Shiue, 2008, for 19th-century Germany).[4] We contribute to this literature by investigating the asymmetric market integration effect of transport infrastructure across a large sample of countries.

The paper is also related to the literature on the economic legacy of colonial empires. Recent contributions include Nunn (2008), on the long-run consequences of the slave trade on Africa;

[4]Michaels (2008) uses the exogenous placement of transport infrastructure as an exogenous source of variation in trade barriers in US counties, and study the effect on the demand for skilled labor.

Huillery (2009), on the long-run effects of public investment in colonial French Africa; and Iyer (2010) on the comparative long-run impact of direct versus indirect colonial rule in India. We contribute to this literature by looking at the long-run effect of colonial investment in transport infrastructure. Although Huilery (2009), Banerjee *et al.* (2012), and Jedwab and Moradi (2012) also look at this, we test for a *specific hypothesis* regarding the negative impact of colonial infrastructure on contemporary regional trade. The idea that a country's natural resource production may adversely bias national trade patterns dates back to the so-called "Dependency School" (e.g. Dos Santos, 1970; Amin, 1972). The argument that transport infrastructure played a key role in all this has been made, among others, by Rodney (1982), and Freund (1998).[5] However, to the best of our knowledge, no other paper has systematically tested this with data on mines.

Next, the paper is related to the gravity literature on intra-African trade. Limao and Venables (2001) find that trade between pairs of Sub-Saharan African (SSA) countries is significantly lower than trade between pairs of non SSA countries. However after controlling for a rough measure of the stock of national infrastructure, this difference becomes significantly positive. They also find that the negative effect of distance on bilateral trade flows is larger for SSA than for non-SSA pairs. We contribute to this literature by looking at the historical root causes of poor infrastructure connecting the African countries.[6] Finally, the paper is related to literature on the resource curse (see van der Ploeg, 2011, for a recent survey), which has presented various arguments why natural resource booms may not be a great source of domestic growth for developing countries. Our results suggest that they may not be a great source of growth for regional trading partners either, if they are accompanied by an infrastructure-driven re-orientation of

[5]For example, Rodney (1982), p. 209, states that "These [colonial roads and railways] had a clear geographical distribution according to the extent to which particular regions needed to be opened up to import-export activities. [...] The only slight exception is that certain roads and railways were built to move troops and make conquest and oppression easier. [...] There were no roads connecting different colonies and different parts of the same colony in a manner that made sense with regard to Africa's needs and development. All roads and railways led down to the sea. They were built to extract gold or manganese or coffee or cotton. They were built to make business possible for the timber companies trading companies, and agricultural concessions firms, and for white settlers. Any catering to African interests was purely coincidental."

[6]The effect of interior-to-coast transport infrastructure is conceptually similar to that of a reduction in tariff that is biased in favour of overseas countries. Thus, our paper is related to a literature that has sought to understand whether the interests of developing countries are best served by North-South or South-South trade agreements. For example, Venables (2003) finds that for a medium-income developing country, to sign a custom union with developed countries may be less welfare-enhancing than to sign it with a low-income neighbor, while for the latter the opposite is likely to be true.

trade towards overseas countries.[7]

The paper is organized as follows. The next two sections develop a simple model illustrating our hypothesis (Section 2) and describe how we construct the mine-impact index (Section 3). After describing the data in Section 4, we test our hypothesis in Section 5. Section 6 contains a discussion of results, and Section 7 concludes.

2 Model

To formalise our hypothesis, we start with a standard gravity model specifying the imports of country d ("destination") from country o ("origin"):

$$\ln \text{imp}_{od} = k - \ln \widetilde{\tau}_{od} + f_o + f_d + v_{od}, \tag{1}$$

where k is a constant, $\widetilde{\tau}_{od}$ is a measure of costs (among which, transport costs) incurred to import from o to d, f_o and f_d are origin and destination fixed effects, and v_{od} is an error term. Our goal is to determine how $\widetilde{\tau}_{od}$ depends on mine-related transport infrastructure in d, for all possible o.

Consider first a world with only coastal countries. This is represented in Figure 3, Panel I, where a destination d imports from n origins, both on the same continent as d ($o_i = o_1, ..., o_5$) and overseas ($o_i = o_6, ..., o_n$). Overseas origins are connected to the destination through a sea route, terminating at port P. Suppose a mine M exists in d. How will its transport infrastructure affect d's cost of importing from all o? Our argument proceeds in four steps.

First, because in developing countries mineral products are mostly exported overseas, M's transport infrastructure is more likely to connect it to P, than to any of $o_i = o_1, ..., o_5$. In the figure, this is represented by the thicker line connecting M to P. To capture this, we define $\phi^N, \phi^{\not N} \in (0, 1)$ as the probabilities that the mine-related infrastructure leads to, respectively, neighboring and non-neighboring markets (through P), and hypothesise that $\phi^N < \phi^{\not N}$.

Second, in many cases the roads and railways built to serve M will also be usable to import

[7]Because of these implications, the paper is related to the literature on international growth spillovers (e.g. Easterly and Levine, 1998; Roberts and Deichman, 2009), and particularly those papers that look at natural resource booms explicitly (e.g. Venables, 2009).

goods and will thus reduce the country's overall transport costs. However, since M's transport infrastructure is particularly likely to lead to P, and imports from $o_i = o_6, ..., o_n$ are more likely to be channeled through P than imports from $o_i = o_1, ..., o_5$,[8] M's transport infrastructure is more likely to reduce the cost of importing from $o_i = o_6, ..., o_n$ then the cost of importing from $o_i = o_1, ..., o_5$.

Third, it is reasonable to assume that the more mines a country has the larger and of better quality its stock of mine-related transport infrastructure will be.[9] At the same time, a given stock of mine-related infrastructure may have a stronger effect on transport costs in a small country than in a large one. Following the logic of steps 1 and 2, we may then expect that countries with more mines *per square km* should, on average, face lower costs of importing from non-neighbors relative to neighbors. Therefore, we use the number of mines in d, m_d, as a proxy for d's stock of mine-related infrastructure after normalizing it by d's area, a_d.

Finally, there may be cases in which the mine-to-coast infrastructure uses a purpose-built port that is faraway from P, or, even if it does use P, it may have a trajectory that is quite separate from that of the routes used by consumers to import through P. In those cases, we would expect the mine-to-coast infrastructure to have a small impact on the cost of importing from non-neighbors. Now suppose we *observe* the routes used by d's consumers to import through P (as well as the routes used by country d's mines) and that we are able to construct an index $I_d \in [0, 1]$ measuring the extent to which the latter overlaps with the former. We would then expect that a certain stock of mine-related infrastructure (as proxied by m_d) has a higher impact on the cost of importing from non-neighbors in countries with a higher I_d.

Combining these four steps, we relate the number of mines in a destination country to trade

[8]Imports from $o_i = o_6, ..., o_n$ will *always* have to be routed through P, whereas imports from $o_i = o_1, ..., o_5$ will, in at least some cases, be more efficiently routed via overland connections.

[9]If mines are scattered throughout the national territory, more of them necessarily implies a larger stock of mine-related infrastructure. If mines are concentrated in a region, more of them may not imply a larger stock, but will still imply a better quality of mine-related infrastructure, since roads and railways must be strong enough to withstand higher tonnages of goods traveling across them. In both cases, more mines imply a larger number of trucks and carriages that reach the ports with mining products and that can be used to import goods on their way back. Nevertheless, in Section 5.5 we show that the main results are robust to replacing the number of mines with an indicator variable equal to one if there are mines in the country, zero otherwise.

costs as follows:

$$\ln \widetilde{\tau}_{od} = \ln \tau_{od} - \delta N_{od} - \phi^{N} \gamma \ln \frac{m_d}{a_d} N_{od} - \phi^{\not N} \gamma \ln \frac{m_d^{1+I_d}}{a_d} (1 - N_{od}) , \tag{2}$$

where τ_{od} is a vector of standard determinants of trade costs and N_{od} is a neighbor dummy.[10] We expect that mines per square km (m_d/a_d) decrease overall trade costs to the extent that the mine-related infrastructure can be used for imports as well (if $\gamma > 0$), and they decrease them with non-neighbors more than with neighbors to the extent that the mine-related infrastructure is more likely to have a mine-to-coast shape ($\phi^{\not N} > \phi^{N}$). The effect of mines on trade costs with non-neighbors is higher the the larger is I_d, the index capturing the degree of overlap between the mine-to-coast infrastructure and the route used by consumers to import through P.[11]

Next, consider a world in which there also exist landlocked countries (Figure 3, Panel II). Steps 1-4 are still valid to describe the effect of mine-related infrastructure on the cost of importing from neighboring o_1, o_2 and o_5 (relative to non-neighbors). However, there are now two neighbors, o_3 and o_4, that will also benefit from the mine-to-coast infrastructure since such infrastructure cuts through them. In general, landlocked destinations will use at least some of their neighbors as transit. The probability that the mine-to-coast infrastructure reduces the cost of importing from neighbors will thus be higher for these destinations. We therefore modify equation (2) by adding a second line, which singles out landlocked destinations:

$$\begin{aligned} \ln \widetilde{\tau}_{od} = \ln \tau_{od} - \delta N_{od} - \phi^{N} \gamma \ln \frac{m_d}{a_d} N_{od} - \phi^{\not N} \gamma \ln \frac{m_d^{1+I_d}}{a_d} (1 - N_{od}) + \\ - \rho L_d N_{od} - \xi^{N} \gamma \ln \frac{m_d}{a_d} L_d N_{od} - \xi^{\not N} \gamma \ln \frac{m_d^{1+I_d}}{a_d} L_d (1 - N_{od}) , \end{aligned} \tag{3}$$

where L_d is a landlocked destination dummy, $\xi^{N}, \xi^{\not N} \in (0, 1)$ are parameters that modify the probabilities ϕ^{N} and $\phi^{\not N}$ for landlocked destinations. We hypothesise $\xi^{N} > \xi^{\not N}$: the differential probability that the mine-related infrastructure reduces the cost of importing from non-neighbors

[10] We add the term δN_{od} to capture the fact that the cost of importing from neighbors may, in general, be different from the cost of importing from non-neighbors.

[11] The index I_d is in the exponent because we expect a higher $\ln m_d$ to have a larger impact when I_d is high. Results are robust to using the alternative formulation $\ln (m_d/a_d)^{1+I_d}$.

and from neighbors is smaller for landlocked destinations than for coastal destinations.[12]

Having constructed an expression for the expected impact of mine-related infrastructure on transport costs (3) we can plug this back into our gravity equation (1) and re-arrange to obtain:

$$\begin{aligned}\ln \text{imp}_{od} = k - \ln \tau_{od} + f_o + f_d + \\ + \beta_1 N_{od} + \beta_2 N_{od} M_d + \beta_3 N_{od} A_d + \beta_4 N_{od} M_d I_d + \\ + \beta_5 N_{od} L_d + \beta_6 N_{od} L_d M_d + \beta_7 N_{od} L_d A_d + \beta_8 N_{od} L_d M_d I_d + v_{od},\end{aligned} \tag{4}$$

where $M_d \equiv \ln m_d$ and $A_d \equiv \ln a_d$.[13] [14] We have included all terms that in (3) do not depend on bilateral variables in the destination fixed effect f_d.[15] Equation (4) is our main theoretical equation. The variables contained in the first row are standard gravity variables, whereas our coefficients of interest are $\beta_2, \beta_4, \beta_6$ and β_8. If equation (3) is true, we would expect $\beta_2, \beta_4 < 0$, and $\beta_6 > 0$.[16] We do not, instead, have any reason to expect $\beta_8 \neq 0$.[17]

In words, coastal destinations with more mines should import relatively less from neighbors, since mine-to-coast infrastructure biases national transport costs in favor of overseas countries ($\beta_2 < 0$). This *trade re-direction effect* should be weaker for landlocked destinations ($\beta_6 > 0$) since in this case the mine-to-coast infrastructure will benefit trade with at least some neighbors. Finally, the trade re-direction effect should be stronger in coastal destinations where the mine-to-coast infrastructure overlaps more with the routes used by consumers to import from overseas ($\beta_4 < 0$).

One additional hypothesis is that we should only observe $\beta_2 < 0$, $\beta_6 > 0$ and $\beta_4 < 0$ for destination countries that were decolonised relatively recently, among which are the African countries.

[12] In other words, it is $\phi^{\not N} - \phi^N > \phi^{\not N} + \xi^{\not N} - (\phi^N + \xi^N)$.

[13] We could have treated $\ln m_d/a_d$ as a single regressor, instead of breaking it into $\ln m_d$ and $\ln a_d$. However we prefer the latter specification because it is more flexible, and allows for an independent effect of area on trade with neighbors. For example, larger countries could import more from neighbors simply because of longer borders.

[14] In the empirical analysis, we measure A_d as deviation from average, so that $A_d = 0$ represents the case of a destination country with average size.

[15] That is, the terms $\phi^{\not N}\gamma \ln \frac{m_d^{1+I_d}}{a_d}$ and $\xi^{\not N}\gamma \ln \frac{m_d^{1+I_d}}{a_d} L_d$.

[16] That's because $\beta_2 \equiv -\left(\phi^{\not N} - \phi^N\right)\gamma$, $\beta_4 \equiv -\phi^{\not N}\gamma$, $\beta_6 \equiv (\xi^N - \xi^{\not N})\gamma$

[17] $\beta_8 = -\xi^{\not N}\gamma$. Based on the argument above, we have no reason to hypothesise $\xi^{\not N} \neq 0$, since $\xi^{\not N} \neq 0$ would mean that the mine-related infrastructure reduces the cost of importing from non-neighbors differently in landlocked and coastal destinations.

The transport infrastructure of these countries will be more heavily shaped by colonial transport infrastructure, which according to critics was mostly designed to export natural resources. The effect of mine-to-coast infrastructure should then be more visible in these countries, relative to countries that have had the time to develop a more balanced transport network. To test for this hypothesis we always run (4) separately for destination countries that were recently decolonised and for African destinations.

3 The impact of the location of mines on import routes

Before introducing the data and our estimation strategy, we discuss in this section the aforementioned index in more detail.

We have hypothesized that the mine-related infrastructure will typically have a mine-to-coast trajectory in developing countries and will thus reduce the cost of importing from overseas countries more than from neighbors. For each mine in our data set we now construct a mine impact index measuring the extent to which the related mine-to-coast infrastructure overlaps with the route used by consumers in cities to import from overseas. As further discussed at the end of this section, the index provides an exogenous source of variation that improves the identification of our mechanism.

Our approach is to obtain from MapQuest's online routing server the route of the shortest road connecting the mine to its nearest coastal point, and to compare such a route to that of the shortest route connecting each of the country's main *cities* to the country's main *container port*.[18] The index thus obtained offers a stylized interpretation of all potentially relevant geography, but one that, in our view, provides the simplest sufficient approximation without having to resort to a full cost-benefit analysis of all possible routes and transport modes.[19]

Consider mine M in destination country d. Take a city C in this country, as well as the country's main container port, P. We begin by asking MapQuest what is the shortest route along roads connecting C to P, CP. The city, port and shortest route connecting them are

[18]The procedure is explained in more detail in the Technical Appendix.

[19]To only consider main cities as population centers is admittedly restrictive. Notice, however, that many imports directed to the countryside (or to smaller cities) are likely to be routed through distribution centers located in big cities.

represented in each of the four panels of Figure 4. For illustrative purposes we have represented CP (and other road connections to be discussed below) as a straight line but this, of course, does not need to be the case in the data. Now consider the mine-to-coast infrastructure associated with mine M. We identify this by asking MapQuest what is the shortest route connecting the mine to the nearest coastal point, S, and denote such connection by MS.[20] We then construct an index measuring the extent to which MS overlaps with CP. Because P is the country's main container port, we expect most of the goods imported by C from overseas countries to be channeled through CP. Our logic is that the more MS overlaps with CP - the higher is the index - the more the mine-to-coast infrastructure will reduce the cost for the country to import from overseas countries.

Our proposed index for mine M is:

$$i = i_1 * i_2 * i_3, \tag{5}$$

where:

$$i_1 = \begin{cases} \frac{MS+1}{MP+1} & \text{if} \quad MS < MP \\ 1 & \text{if} \quad MS > MP \end{cases} \tag{6}$$

$$i_2 = \begin{cases} \frac{MP+1}{MJ+JP+1} & \text{if} \quad JP < CP \\ \frac{MP+1}{MC+CP+1} & \text{if} \quad JP > CP \end{cases} \tag{7}$$

$$i_3 = \begin{cases} \frac{JP+1}{CP+1} & \text{if} \quad JP < CP \\ 1 & \text{if} \quad JP > CP. \end{cases} \tag{8}$$

The mine impact index is the product of three distinct terms, all ranging between 0 and 1.[21] The first term, i_1, compares the length of MS to the length of the shortest route connecting M to P, MP, and captures the probability that the mine uses P to export. The term is high when S is close to P or when S is far from P but MS still follows a large share of MP. In other words, i_1 is high when M is naturally positioned to use P as a shipping port. It may also be high

[20] For landlocked destinations, both S and P will be located in a different country.

[21] The term i_2 actually ranges between $\frac{\sqrt{2}*JP+1}{2*JP+1}$ and 1.

if M is *not* naturally positioned to use P yet the *actual* mine-to-coast infrastructure overlaps with MP. Figure 4 provides an example. The figure contains four panels, each representing a mine, its mine-to-coast infrastructure (in blue) and the shortest route connecting the mine to P (in red). The term i_1 is low (0.3) for mine M_1. That is because this mine is located faraway from P and close to the coast and is thus naturally positioned to use a different coastal point as a shipping port. In the example the mine-to-coast infrastructure for this mine is completely separate from P, suggesting that it is likely that the mine uses a dedicated port. Next, consider mine M_2. This mine is also faraway from P. However, our MapQuest query reveals that the *actual* mine-to-coast infrastructure for this mine passes through P; there is apparently no road connecting M to S directly. The term i_1 is then high for mine M_2. Finally, i_1 is also high for mines M_3 and M_4 since S is close to P for both: they are both naturally positioned to use P as a shipping port.

The second term, i_2, compares the length of MP to the length of the shortest road connecting M to P, passing through point J. This is defined as the junction between CP, and the perpendicular coming from M. The term i_2 is high when MP passes "close" to CP: this term captures the probability that some part of CP is used by the mine. In other words, it is high for a mine whose shortest connection to P is on the same axis as C's shortest connection. Compare mine M_2 to mines M_3 and M_4. As discussed earlier, these mines have all a high i_1, since their mine-to-coast infrastructure passes through P. However, mine M_2 has a relatively low value of i_2 (0.6) while M_3 and M_4 have a high value (1): that is because M_2 is located far from the axis of CP, whereas M_3 and M_4 are located right on it.

Finally, the term i_3 compares the length of JP to that of CP. This term is high for a mine whose shortest connection to P is not only close to CP but also overlaps with a large share of it. Compare mines M_3 and M_4. These mines have both a high i_2 since they are both close to CP. However i_3 is relatively low in the former (0.7), while it is high in the latter (1). This can be explained with the fact that M_3 overlaps with only a portion of CP, whereas M_4 overlaps with all of it.

Putting things together we see that the overall index is highest (1) for mine M_4 and lowest for mine M_1 (0.08). This is because the mine-to-coast infrastructure of the former perfectly

overlaps with CP, whereas that of the latter does not overlap with it at all. The index takes an intermediate value (0.70 and 0.42) for mines M_3 and M_2 whose mine-to-coast infrastructure overlaps partially with CP.

Based on the index i for each mine-city combination, we sum all i with city population weights[22] and divide by the sum of all weights to arrive at a national i_d which is bounded by 0 and 1. Figure 5 provides an example based on actual data points (see the next section for sources). For each of four African countries, the figure reports the location of mines, main cities and main container port.[23] The top pair of countries (Mozambique and Egypt) receive a low value of the index, whereas the bottom pair (Cameroon and Ghana) receive a high value. That is because, in the former pair, the mines are located faraway from city-port corridors and are also relatively close to the sea. Furthermore, MapQuest reveals that roads are in place (not shown in the figure) that quickly connect the mines to the coast. In contrast, mines in Cameroon and Ghana are located close to city-port corridors and their mine-to-coast infrastructure is revealed to overlap substantially with such corridors. Within both pairs, the country on the right has more mines than the country on the left. However, because the bottom pair have a higher value of the index we would expect the trade re-direction effect of mines to be stronger for Ghana compared to Cameroon, than for Egypt compared to Mozambique.

Having calculated the index i_d, we then take a discrete version of it, I_d, and use this as a our mine impact index:[24]

$$\begin{aligned} I_d &= 0 \quad \text{if } i_d \text{ below average} \\ I_d &= 1 \quad \text{if } i_d \text{ above average.} \end{aligned} \tag{9}$$

[22] That is, we implicitly assume that the share of national imports each route represents is proportional to the population size of the city.

[23] For illustrative purposes only, we have reported the closest coastal point to the *midpoint* of mines, and not the various mine-specific S that we use in the computation of the index.

[24] Although it is possible to work with i_d directly, we found that this did not lead to meaningful results. This probably means that our approximation is not accurate enough, for example because it omits some other relevant feature of geography or because of variation in the modes of transport of different goods in different countries. However, without other priors on how to measure the true impact of the location of mines on city-port infrastructure and total imports, we choose to split the sample into two groups: those with a 'high' score, and those with a 'low' score of i_d. The index I_d is then attributed value 1 when i_d is above the average, value 0 when it is below. It is unlikely that these two groups would change composition much by choosing a different definition of i_d. For example, we indeed find that the results based on the indicator are robust to changing the population weights from 1950 to the year 2005.

We improve on the identification of the effect of mine-to-coast infrastructure on trade, by constructing the index from an exogenous source of variation in the placement of mine-to-coast infrastructure: The location of mines depends largely on geology, which is exogenous. One may be concerned that the location cities, however, is not completely exogenous to the location of mine-to-port infrastructure. Moreover, mine location may depend also on non-random exploration efforts. For example, interior-to-coast infrastructure may have initially been placed to serve military needs, or for the extraction of the deposits of natural resources that were randomly discovered first. Subsequently, additional mines may have opened close to this infrastructure if exploration efforts concentrated around these routes and cities may have developed faster along the same route. Furthermore, neighboring countries that were already less inclined to trade with each other may have only invested in trade routes with overseas countries, leading to interior-to-coast infrastructure that again may have been followed by exploration efforts and city growth close to the initial infrastructure.

We deal with these issues in the following ways and argue that our index is not likely to suffer from this source of endogeneity bias. First, even if exploration efforts concentrate on areas close to pre-existing infrastructure, it is still a matter of geology whether additional deposits exist, making the number of mines discovered random. Second, we weigh by 1950 population of cities. Most colonial powers limited internal migration (O'Connor, 1983). Such bans were only lifted after independence, which happened after 1950 for 80% of former African colonies. Third, we control for "same empire" dummies (see the next section for more details) to capture the military motives for the layout of infrastructure.[25] Fourth, we control for a wide range of trade costs, which controls for the baseline probability of trade that is unrelated to mines and thus for the incentive to build cross-country infrastructure between neighbors.

4 Data

To estimate the effect of mine-related transport infrastructure on trade we need bilateral trade flows between as many countries as possible as well as a measure of mine-related transport

[25] Arguably, the military need for interior-to-coast infrastructure was weaker in colonies that bordered with other colonies of the same coloniser.

infrastructure. For trade, we rely on the UN Comtrade database which reports all known bilateral trade flows between countries in the world based on the nationality of the buyer and seller.[26] We measure the value of trade at the importing country and use the 2006 cross-section, which should cover more countries (particularly for Africa) and be of better quality than historical data. Even for this recent year, we find that out of 49,506 (223 by 223-1) possible trade flows only 57% are positive, while the other observations are coded as missing in Comtrade. Within Africa, there are 55 by 54 possible trade flows of which we observe 60%. Our typical regression will be able to include around 24,000 observations.

For mine-related transport infrastructure, we first of all need data on the number of active mines in each country (M_d). This is provided by the US Geological Survey's Mineral Resources Data System (MRDS)[27], giving us both the number and the location of mines (used for point M in Figure 4). The full database contains 305,832 records, but after extensive cleaning we are left with 20,900 mines.[28] Within this selection of mines 66% are located in the US, whereas the remaining 7,122 mines cover 129 countries.[29]

To calculate the mine impact index, we also need the point on the shoreline nearest to each mine (point S), for which we rely on the "Global Self-consistent, Hierarchical, High-resolution Shoreline Database" (GSHHSD) provided by the National Oceanic and Atmospheric Administration (NOAA).[30] The location and population of each country's main cities (point C) is taken from the UN's "World Urbanization Prospects" database of urban agglomerations with at least 750,000 inhabitants in 2010, to which we add hand collected city coordinates. We choose the

[26]SITC Rev. 2, downloaded on Oct 30th, 2009.

[27]Edition 20090205. Source: http://tin.er.usgs.gov/mrds/.

[28]Our empirical strategy requires that we focus on mines that were active in 2006 (or ceased activity not too long before then, since for these mine-related infrastructure will still be in place), and for whom we know the location. We thus drop the following records: OPER TYPE is processing plant or offshore; PROD SIZE is missing, small, none or undetermined; WORK TYPE is water or unknown; YR LST PRD was before 1960; DEV STAT is prospect, plant, occurrence, or unknown; SITE NAME is unnamed or unknown; and mines for which the coordinates fall outside their country's mainland.

[29]Some countries appear to have no mines. Based on the notion that the existence of subsoil assets - and therefore mines - depends mostly on geology (which is essentially random), we add one unit to the count variable of the number of mines, to prevent selection on a sample with only non-zero mines. The second rationale for doing this is that it is unlikely that any country truly has no mine at all, while it is probably due to random measurement error that some mines do not appear in the MRDS data. In the Online Appendix we show that this does not affect our main results.

[30]`http://www.ngdc.noaa.gov/mgg/shorelines/gshhs.html`

earliest available figure for population (1950), because current population sizes may have been influenced by infrastructure itself.[31] The location of the country's main container port (point P) is derived from the "World Port Ranking 2009" provided by the American Association of Port Authorities (AAPA) and Maersk's website, to track the port used by Maersk Line - the world's leading container shipping company - to import a container from Shanghai into the country's capital. Finally, information on the length and route along roads connecting all of these points is obtained by sending pairs of coordinates to MapQuest's online routing server.[32] Since calculating the distances along roads needed for the index is computationally intensive, we only calculate indices for former colonies and Africa. We elaborate on the details of these procedures in the Technical Appendix.[33] We calculate country d's overall mine impact index, i_d, by aggregated up from all possible mine-city-port combinations within the country. These individual indices are summed with 1950 city population weights such that larger cities add relatively more to the aggregate index.

Table 1 reports the top countries according to the number of mines in combination with the mine impact index i_d.[34] The US is clearly over-represented while China is probably under-represented. The table also shows that there is little correlation between the number of mines and the extent to which the mine-to-coast infrastructure overlaps with the infrastructure used by consumers to import from overseas (measured by i_d).[35] For example, Canada has many mines but these are too remote to affect city-port corridors much. In Australia the mines are so far from cities that they most likely have dedicated ports which cannot easily be used for imports by cities. In contrast, Zimbabwe has fewer mines, but these are much closes to city-port

[31]Results are robust to using current (2005) population.

[32]One could be tempted to use railways to measure distances, but a database of railways provided by Vmap0 (www.mapability.com) shows that 86% of rail kilometers in Africa connect to roads, while the remaining 14% have a road within 1 km at the median. Moreover, railways tend to be in poor shape and are not likely to be the main mode of transport in all cases. Since we rely on distances rather than travel time (which requires data of much higher quality) we focus on roads here.

[33]We defend the use of current infrastructure to measure distances in the Online Appendix. We use data from the International Road Federation to show that the average African country, which had only 34,000 kms of roads and 4,000 km of paved roads in 1963, built only an additional 12 and 6 thousands by 2006. Africa built much fewer roads than non-African countries. This is robust to controlling for other determinants of road building, such as land area, initial income, and the initial stock of roads.

[34]The top three products are gold, sand & gravel, and copper. Other heavy ores such as iron and aluminium (bauxite) rank seventh and eighth and each represent 3% of all mines.

[35]The correlation is -0.20, but not significant at 95% confidence.

corridors. The average value for the index i_d is 0.49 for former colonies and 0.61 for Africa. We therefore categorize African countries with $i_d > 0.61$ as those where city-port corridors are affected by mining, $I_d = 1$ (such as South Africa), and those with $i_d < 0.61$ as those where city-port corridors are not affected by mining, $I_d = 0$ (such as Egypt).

Table 2 shows, for major groups of countries, summary statistics on the number of mines and the mine impact index, both in its continuous and discrete version (i_d and I_d). Landlocked countries, from which the shipping costs to export resources are much higher, tend to have fewer mines, but the mines in these countries tend to affect city-port corridors more (although this is less clear when we collapse the index into a dummy). The table also shows that Africa does not have so many mines even though many African countries depend on natural resource production. However, the index value is high in Africa suggesting that mines may have a large influence on the transport costs between ports and cities.

We always control for a broad set of standard determinants of trade costs, taken from Head *et al.* (2010). These are *ln distance*, the natural log of distance between countries; *Shared language*, a dummy equal to one if both countries share a language; *Shared legal*, a dummy equal to one if both countries share the same legal origin; *ColHist*, a dummy equal to one if both trading partners were once or are still (as of 2006) in a colonial relationship; *RTA*, a dummy equal to one if both trading partners belong to a regional trade agreement; *Both WTO*, a dummy equal to one if both are members of the WTO; *Shared currency*, a dummy equal to one if they share a currency; and *ACP*, which is a dummy equal to one for trade between EC/EU countries and members of the 'Asia−Caribbean−Pacific' preferential tariff agreement for former European colonies. In addition, we construct controls for *Shared emp, one colonizer* and *Shared emp, none colonizer* which are dummies equal to one if the bilateral trade partners were once part of the same empire. We interact each of these two variables with the neighbor dummy. The former captures the possibility that one of the countries was the colonizer and the latter the possibility that neither was the colonizer. Such empires often strived to connect colonies by building infrastructure between them.

To construct the empire dummies and to be able to split the World sample of countries into African destinations and former colonies, we need to define colonies. We start from the definition

by Head *et al.* (2010) who consider a former colony a country that was colonized and obtained independence after 1900. This seems an appropriate definition for our purposes since we do not expect colonial investment to still matter in countries that became independent too long ago (such as the USA); and since the Dependency School argument on interior-to-coast infrastructure was mostly made for countries that were colonized after the mid 19th century with the advent of railroad technology. We further refine the definition by Head *et al.* (2010) by excluding those countries that were only colonized by a neighbor since we do not expect colonial infrastructure to have an interior-to-coast shape in those cases.[36]

5 Results

Our central interest in this section is to investigate whether or not equation (4) holds *because* equation (3) holds. In other words, we want to investigate whether or not mines reduce relative imports from neighbors because of mine-to-coast transport infrastructure. This is not an easy task, since, not observing τ_{od}, we cannot test for equation (3) directly. Fortunately, the rich structure of equation (4) helps us in this task. It is not easy to imagine many reasons - other than mine-to-coast infrastructure - why mines should reduce relative imports from neighbors in coastal destination ($\beta_2 < 0$), but less so when the destination country is landlocked ($\beta_6 > 0$), and more so when the observed mine-to-coast infrastructure overlaps substantially with city-port corridors ($\beta_4 < 0$). We test for these three predictions in sections 5.1, 5.2, and 5.3 respectively, always controlling for a rich set of determinants of trade flows, where we follow the standard estimation of a gravity model of trade with destination and origin fixed effects. All variables therefore capture trade costs that are specific to each bilateral trade flow.

Throughout this section we separately estimate equation (4) for former colonies and African destinations.

[36]For robustness, we have run all our specifications using both the broader Head *et al.* (2010) definition, as well as a third, even narrower definition. See Technical Appendix A.2 for further details.

5.1 The trade re-direction effect of mines

Our baseline specification is a simplified version of equation (4), where we do not distinguish between coastal and landlocked destinations, and abstract from the mine impact index:

$$\ln \text{imp}_{od} = k - \ln \tau_{od} + f_o + f_d + \\ + \beta_1 N_{od} + \beta_2 N_{od} M_d + \beta_3 N_{od} A_d + v_{od},$$

and we expect $\beta_2 < 0$. Our results are reported in Table 3, columns (a) to (e). For a world sample of bilateral trade (column a) we find the usual determinants of trade: it decreases in distance and increases in country-pair characteristics that make trade easier such as a common language, legal origin, a former colonial relationship, membership of regional trade agreement and the WTO, sharing a currency and membership of Asia-Caribbean-Pacific (ACP) treatment of imports into the European Union. For our main variables of interest, N_{od}, $N_{od}M_d$ and $N_{od}A_d$, we find the standard result that a country imports much more from its neighbors than from its non-neighbors (N_{od}). $N_{od}A_d$ is the interaction between the neighbor dummy and the log of the deviation of a country's land area from the mean. It is zero for the average country and increasing in destination land size. It controls for the possibility that larger countries (with long borders) trade more with neighbors and that such large countries may also have more mines. The former is indeed what we find. Nevertheless, the neighbor effect on trade is significantly decreasing in the number of mines in the destination country ($N_{od}M_d$), which cannot be explained by country size. We refer to this effect ($\beta_2 < 0$) as to the *trade re-direction effect* of mines.

Figure 6 summarizes this relationship. The figure plots the marginal effect of being neighbors on trade as a function of the number of mines in the destination country, for a country of average size in terms of land area ($A_d = 0$). As we increase the number of mines, the marginal effect of N_{od} decreases, to the extent that a country of average size with more than 3 (= exp(1.099)) mines does *not* import significantly more from its neighbors than from non-neighbors. In the extreme case of the US, which has the largest number of mines in the sample - but also has the fourth largest land area - we even find a significant negative marginal effect of N_{od} if we add the positive effect of its land mass. Our results hold if we exclude this extreme case (column b of

Table 3). Because countries with a larger number of active mines will have a larger and better stock of mine-to-coast infrastructure, this is *prima facie* evidence in favor of our main hypothesis that countries with more mine-to-coast infrastructure import relatively less from neighbors.

Our additional hypothesis is that the trade re-direction effect of mines should be more visible in former colonies and in Africa. This is because the transport infrastructure of these countries will be more heavily shaped by colonial transport infrastructure, which in turn was mostly designed to export natural resources. When we split the sample in former colonies and non-colony destinations (columns c and d), we find precisely this result. Only former colonies import significantly less from neighbors, although this is not significant for the *average* country in Africa. However, because the interaction is between a dummy and a continuous variable, the coefficient, its variance and the covariance between $N_{od}M_d$ and N_{od} determine a range for which also the African countries do not import significantly more from neighbors. Conditional on relative country area, this occurs if they have more than 6 mines.

Part of the explanation for the negative effect of mines on trade with neighbors could be that countries with mines and higher natural resource export revenues start importing more sophisticated products through an asymmetric income effect on consumption. On average, such goods will be produced in countries that are not neighbors, or at least from the perspective of many former colonies. Therefore, in columns (f) to (j) we additionally control for interactions of the log of the deviation of GDP per capita from the world average in the destination (y_d), and the origin country (y_o), with the neighbor dummy. As expected, $N * y_d$ enters significant and negative. Controlling for distance and trade costs, wealthier countries import relatively less from neighbors; an effect that is stronger among former colonies and African countries. However, this does not completely explain away the negative effect of mines. Colonies with more than 58 mines still trade significantly less with neighbors at the 95% confidence level, as illustrated by Figure 7.[37]

For the Africa sample we do not find a significant $N_{od}M_d$ term. However, looking at the illustrative maps of infrastructure in Africa suggests that the *average* trade re-direction effect may

[37]Even taking into account the fact that countries in this sample of colonies are somewhat poorer and larger than the average country in the world does not change this conclusion qualitatively. The sample means of A_d, y_d and y_o are respectively: 0.19, -0.19, and 0.24, which causes the line to shift up somewhat.

be weaker in Africa because many destination countries are landlocked. Furthermore, the trade re-direction effect may depend explicitly on the extent to which the mine-to-coast infrastructure overlaps with city-port corridors. This will be examined in the next two sections.

5.2 Coastal versus landlocked destinations

The regressions in Table 3 estimate the average trade re-direction effect of mines for both landlocked countries and coastal countries simultaneously. However a landlocked country has to transit through some of its neighbors to import from overseas. This suggests that, it the trade re-direction effect of mines is due to mine-to-coast infrastructure, it should then be weaker in landlocked destinations, since the mine-to-coast infrastructure will also benefit some "transit" neighbors. Africa has many such transit relationships. For example, Uganda's main roads and railway cross Kenya to reach the sea: but then these should decrease the cost of importing from Kenya, and to a lesser extent also from overseas countries. We test this using the following more general specification:

$$\begin{aligned}\ln \text{imp}_{od} = k - \ln \tau_{od} + f_o + f_d + \\ + \beta_1 N_{od} + \beta_2 N_{od} M_d + \beta_3 N_{od} A_d + \\ + \beta_5 N_{od} L_d + \beta_6 N_{od} L_d M_d + \beta_7 N_{od} L_d A_d + v_{od},\end{aligned} \tag{10}$$

where we expect $\beta_2 < 0$ and $\beta_6 > 0$. $N_{od}L_d$ captures the average effect of being landlocked on trade with neighbors. If our mechanism is true, then we expect this effect to depend *positively* on the number of mines in the landlocked country, such that $\partial \ln \text{imp}/\partial N_{od} L_d M_d > 0$. Controlling for the effect of landlocked countries, we should still find a negative effect of $N_{od}M_d$.

The results are presented in Table 4.[38] Again, we find that a higher number of mines redirects trade away from neighbors, to the extent that the positive marginal effect of neighbors may disappear for a high enough number of mines, but again this does not hold in the sample of non-former colonies. Compared to the results in Table 3, we now find a more significant re-

[38]We do not report the controls listed in Table 3 from now on, although these are always included in the regressions.

direction effect of mines on trade with neighbors in coastal countries in both the colony and the Africa sample. However, and in line with our hypothesis, we find for the colony and the African sample strong evidence that landlocked countries with more mines trade *more* with neighbors. In the last two rows of Table 4 we summarize the marginal effect of mines on trade with neighbors for landlocked ($L_d = 1$) and coastal ($L_d = 0$) countries separately. Only for the African continent we find for landlocked countries a significant *positive* effect of mines on trade with neighbors.[39] As expected, we find in terms of equation (10) that $\beta_2 < 0$ and $\beta_6 > 0$. It is hard to explain why landlocked countries with more mines import more from neighboring countries if not for the infrastructure channel we propose.[40]

5.3 Does the location of mine-to-coast infrastructure matter?

The previous two sections found evidence in favor of our main hypothesis that mine-to-coast infrastructure biases transport costs in favour of overseas countries, reducing relative imports from neighbors. So far, however, we have implicitly assumed that all mine-related infrastructure overlaps in the same way with city-port corridors, the route used by consumers to import from overseas. This is not necessarily true for mines that export through dedicated ports, for example when they are located close to the coast but far away from the country's main port. Australia is one example of a country with dedicated ports for the export of minerals. Controlling for the

[39]The effect may seem large, but this can easily be rationalized. First, the infrastructure connecting the landlocked country to a transit neighbor improves 100% of the route, whereas it only improves a small percentage of the route connecting the landlocked country to overseas countries. Second and third, the mine-to-coast infrastructure also improves the *domestic* infrastructure of the transit country (whereas it does not affect the domestic infrastructure of overseas countries), and it does so in a very specific way (along the route that heads for the landlocked country). The latter two factors are likely to be particularly important in the case of Africa, where transportation infrastructure is, in general, extremely poor.

[40]We are agnostic about which neighboring country of a landlocked country is the transit country, since this may depend on the type of imports and may be endogenous to the number of mines. Results available on request show that the mechanism is smaller and less precisely estimated for an indicator specifying for each landlocked country one neighbor as its transit partner (based on Maersk container shipping routes). Further adding cross-country railway connections (which are always accompanied by roads) to identify multiple possible transit countries yields a more significant, but also a somewhat smaller effect. We suspect that countries with more mines build more transit connections to avoid hold up, and are able to do so because they have the financial means. Restricting the indicator to one – hard to identify – transit country will thus bias our estimates downwards. Finally, for landlocked countries we checked whether the origin of their imports was mostly one of its (transit) neighbors, which could be due to repackaging at the transit country or the result of an accounting error. However, by far the largest share of imports into landlocked countries has non-neighbors as its country of origin.

location of mines within a country and their related mine-to-coast infrastructure should help us separate mines into those that affect city-port corridors, and those that do not.

We then move to estimating our full specification (4), which we report here for convenience:

$$\begin{aligned}\ln \text{imp}_{od} = k - \ln \tau_{od} + f_o + f_d + \\ + \beta_1 N_{od} + \beta_2 N_{od} M_d + \beta_3 N_{od} A_d + \beta_4 N_{od} M_d I_d + \\ + \beta_5 N_{od} L_d + \beta_6 N_{od} L_d M_d + \beta_7 N_{od} L_d A_d + \beta_8 N_{od} L_d M_d I_d + v_{od},\end{aligned} \tag{11}$$

where we expect $\beta_2 < 0$, $\beta_4 < 0$ and $\beta_6 > 0$. The mine impact index I_d is constructed using the geographical location of mines and the related mine-to-coast road infrastructure. It measures the extent to which the observed mine-to-coast infrastructure overlaps with the country's city-port corridors, and thus its potential to re-direct trade in favor of overseas countries. If the trade re-direction effect of mines is stronger in countries with a high value of the index ($\beta_4 < 0$), then this effect must be due to mine-to-coast infrastructure. Furthermore, the index provides us with an exogenous source of variation in the placement of mine-to-coast infrastructure, that helps us identify the impact of mine-to-coast infrastructure on trade.[41]

Results are reported in Table 5. To interpret the coefficients on the multiple interactions, we proceed by calculating the marginal effect of M_d on imports from neighbors, and look at how this depends on the value of the index, I_d, and on the landlocked status, L_d.

By setting $N = 1$, we focus on imports from neighbors. Due to the triple interaction between N_{od}, M_d and I_d, the size of the marginal effect of M_d, and its significance, will depend on the mine impact index I_d, and through $N_{od}L_dM_d$ and $N_{od}L_dM_dI_d$, also on the landlocked status. As explained before, we calculated distances along actual roads using MapQuest's online database

[41] We do not include the term $N_{od}I_d$ and $N_{od}L_dI_d$ in our regressions for the following two reasons. On the one hand, there is no clear theoretical reason to include it. In fact, to do so would be equivalent to hypothesizing that the geographical location of mines - in the very specific sense implied by the index I_d - matters, *per se* - that is, independently on the number of mines - for how much a country trades with its neighbors. We consider this to be unrealistic. On the other hand, this term may soak up much of the variation in M_dI_d in our Africa sample. We feel that this strategy improves interpretation, and estimation because it economizes on the degrees of freedom. In results available on request we show that including the index I_d without interactions with M_d shows that high index countries import significantly less from neighbors: this is because the index can only be positive for a positive number of mines. Furthermore, including all possible interactions yields the result that neither $N_{od}I_d$ nor $N_{od}L_dI_d$ are significant.

to construct the index. Because the number of routing requests one can send to the servers are limited per day, this took a long time to achieve, which is why we focus on the colony and the African sample. If our mechanism holds, then we should find evidence that the index matters, and mostly in these two samples.

To facilitate interpretation of the estimated coefficients, we provide the marginal effects of mines on trade with neighbors in the last four rows of Table 5, for each of four cases: landlocked ($L_d = 1$) and coastal ($L_d = 0$) countries, and countries where the index suggests that the location of mines improves connections between cities and ports ($I_d = 1$) and countries where this is not the case ($I_d = 0$).

Column (a) in Table 5 reports the results for countries that were former colonies.[42] The coefficient for $N_{od}M_d$ suggests that countries with more mines import relatively less from neighbors, confirming the main result. However, in this specification this coefficient only captures the effect for average coastal countries where mines do not necessarily affect city to port infrastructure ($L_d = 0$ and $I_d = 0$). For example, letting $L_d = 1$ shows that this effect is overturned for landlocked countries. In that case the marginal effect is 0.180 and insignificant. We also find evidence that the marginal effect of mines on trade with neighbors is negative for countries where the exogenous location of mines is such that they influence the infrastructure between cities and the main container port. The coefficient is negative (-0.306), although only significant at a confidence level of 82%. For landlocked countries, trade costs also decrease with neighbors used for transit, explaining the reversal of the sign of the marginal effect of M_d.

In column (b) we find an even stronger pattern for African destinations. In fact, we find in terms of equation (11) the expected signs: $\beta_2 < 0$, $\beta_4 < 0$, and $\beta_6 > 0$. First, we find that coastal countries with mines that are remote from cities and ports do not trade significantly less with neighbors ($L_d = 0$ and $I_d = 0$). Most likely, such mines have dedicated ports that do not affect the costs of importing goods to cities through the main container port. In contrast, we find a significant and more negative effect of mines on trade with neighbors in coastal countries where the mines are likely to affect such port to city infrastructure ($L_d = 0$ and $I_d = 1$). The reason

[42]Results are robust to allowing for two-way non-nested clustered standard errors on importers and exporters using the method proposed by Cameron *et al.* (2011). Overall, we conclude that controlling for importer and exporter fixed effects in a cross-section of bilateral trade absorbs most of the relevant shocks.

is that in these countries, the mines are positioned in such a way that the associated mine-to-coast transport infrastructure improves existing trade routes between cities and ports, causing a large decline in trade costs with overseas countries relative to trade costs with neighbors. For landlocked countries, we find again the opposite sign. Moreover, consistent with the theoretical expectation that β_8 may be zero, we find no effect of the index in landlocked countries. There may be few transit connections from landlocked destinations to the coast forcing all goods to take this route, irrespective of where mines are located in the landlocked country. In other words, it is unlikely that any mines in landlocked countries have dedicated ports.

Overall, Table 5 presents consistent evidence in favor of our hypothesis. Mines decreases trade costs in an asymmetric way: trade costs with the rest of the world decline relative to trade costs with neighbors, which, possibly due to a colonial legacy, is most apparent in former colonies and in Africa and could provide an explanation for limited intra-African trade.

5.4 A falsification test: mines versus oil and gas fields

In the previous three sections, we have used the number of mines as a proxy for the stock of mine-to-coast infrastructure. A potential problem with this proxy is that mines could have an asymmetric effect on the way countries spend their income, over and above the symmetric income effect which is controlled for by origin and destination dummies, and the asymmetric income effect controlled for by the interaction between income and the neighbor dummy. For example, if for given income, countries with more mines spend disproportionately more on luxury goods which they purchase on world markets rather than on neighboring markets, this would lead to a trade re-direction effect very similar to the one we find. Alternatively, we could be picking up the fact that for given income, countries with more mines import more mine-related machinery, which they also tend to purchase on world markets. Even though these alternative channels cannot explain the fact that the trade re-direction of mines is very different in coastal versus landlocked destinations (section 5.2), nor that the location of observed mine-to-coast infrastructure also matters (section 5.3), one may still worry that they may be driving our results.

A natural falsification exercise is to investigate whether oil and gas fields have a similar

trade re-direction effect to that of mines.[43] While the asymmetric expenditure channel and the possibility that mining equipment is imported from world markets should both be at play for oil and gas fields, the infrastructure channel should not. To see why, recall that the infrastructure channel relies on the assumption that the mine-to-coast infrastructure can be used not only to export the minerals but also to import a broad set of commodities. But while metals and other non-hydrocarbon minerals are mostly transported through roads and railways, oil and gas are mostly transported through pipelines. Clearly, the former may also be used for imports, while the latter cannot.[44] Thus, if the trade re-direction effect is due to those alternative channels, it should be there for both mines and oil and gas fields. If it is due to mine-to-coast infrastructure, on the contrary, it should be there for mines only.

We extend our regressions in Section 5.1 with a measure of oil and gas fields. We use data from Horn (2003), who reports 878 on- and offshore oil and gas fields with a minimum pre-extraction size of 500 million barrels of oil equivalent (MMBOE), including year of discovery from 1868-2003, geographic coordinates and field size measures. This data set builds on previous data sets (e.g. Halbouty *et al.* 1970), and attempts to include every giant oilfield discovered around the world. Oil, condensate and gas are summed, with a factor of 1/.006 applied to convert gas trillion cubic feet to oil equivalent million barrels. We define OG_d as the log of the number of fields plus one, similarly as we did for mines. The top-5 countries with oil and gas fields are Russia, the United States, Iran, Saudi Arabia, and Nigeria.

Results are reported in Table 6, where the main regressions of Table 3 are augmented with the neighbor dummy interacted with OG_d. Note that in columns (a) to (e) we control for all control variables except the interaction between income and neighbor. We still pick up a negative effect of mines on trade with neighbors in the World sample, and a smaller and less significant effect in the non-colony sample, while the largest significant effect shows up in the colony sample. The coefficient is negative and significant for Africa with 89% confidence. However, we now also

[43] In an earlier version, we additionally analyzed the impact of mines on imports from countries that, while not being neighbors, are still part of the same region of the destination country. If our results were driven by one of the alternative channels, then a mining country should be importing relatively less not only from neighbors, but also from other, non-neighboring African countries (since African countries typically do not export sophisticated machines). This is not borne out by the data, supporting our hypothesis.

[44] Pipelines may have an effect through the construction of maintenance and access roads, but we expect this to be small.

find a significant trade re-direction effect of oil and gas fields in columns (a) to (e). While this seems to contradict our hypothesis, the negative coefficient on both $N_{od}M_d$ and $N_{od}OG_d$ could be explained by an asymmetric income effect on imports from neighbors. Therefore, in columns (f) to (j) we control for the interactions between income and the neighbor dummy.[45]

The difference between regressions (a) to (e) and (f) to (j) is striking. Controlling for the asymmetric income effect explicitly, we no longer find a significant effect for oil and gas fields. The wealth associated with hydrocarbon extraction may well be associated with an asymmetric income effect that leads to more imports from world markets; in fact, controlling for this explains away the negative interaction of oil and gas fields. However, controlling for the asymmetric income effect does not explain away the negative interaction of mines. The coefficients are somewhat smaller, suggesting that an income effect is also present for mines, but they are still negative and significant for the world samples and the colony sample. The fact that mines remain significant in columns (f) to (j) but oil and gas fields do not, is strong additional evidence in support of the infrastructure hypothesis, and against the alternative channels described above.

5.5 Alternative measures of mine-to-coast infrastructure

Our main measure of the stock of mine-to-coast transport infrastructure is the number of mines, because more mines require not only more infrastructure, but also infrastructure of higher quality. For example, roads and bridges need to be strong enough to transport a higher tonnage of goods. Similarly, railways require a wider gauge and lower gradient, and cars with a longer wheelbase (and thus fewer curves). Nevertheless, in this robustness exercise we test three alternative measures of the stock of mine-to-coast road infrastructure.

First, if infrastructure is a fixed investment and does not depend on the number of mines, we should include only a dummy equal to one for countries with a positive number of mines. Our results are robust to using this measure as shown in columns (a) and (b) of Table 7, which compare directly to the marginal effects estimated in Table 5.

[45]Since the data on oil and gas fields also includes the field's pre-extraction size in millions of barrels of oil equivalent, we also experimented with redefining OG_d as the log of one plus the volume of reserves in the country. This led to qualitatively identical results. However, pre-extraction field size is probably only a rough measure of current field size.

Second and third, a more direct measure of the stock of mine-to-coast infrastructure may be the distances along actual roads between mines and the coast or the main port in km, which we sum across all mines by country. A country without mines has zero *mine-to-coast road km*, while a country with many mines has potentially many mine-to-coast road km, especially if the mines are located inland. The results, summarized in terms of marginal effects, are displayed in columns (c) to (f) in Table 7 where M_d (the log of the number of mines+1) is replaced with two versions of our mine-to-coast road km measure. To control for the location of mines relative to the coast or to cities, we also include the index interactions. Columns (c) and (d) measure mine-to-coast road km as $\ln(\sum_i min(MS_j, MP_j) + 1)$, where MS_j is the road distance in km between each mine j and its closest point on the coast, and MP_j is the road distance in km between each mine and the main port. We take the minimum of the two to capture the idea that if $MS_j < MP_j$, then the mine may use a dedicated port rather than the country's main port. We add 1 to the sum before taking logs to be able to include countries which according to the MRDS database have no mines. The sum itself captures the idea that even if two mines use one road, we expect the road to be of better quality. For example, heavier traffic requires stronger roads and bridges. In columns (e) and (f) we alternatively measure mine-to-coast road km as the sum of MP_j only.[46] The results are very similar to the first two columns, suggesting the the number of mines is a good approximation of the total number of mine-to-coast road km used by these mines. We choose to keep the number of mines as our preferred proxy because it is, due to the MapQuest server limit, prohibitively time consuming to calculate along-road distances for the non-colony sample.

Finally, we provide various further robustness checks in the Online Appendix. In particular, we run two-step and PML regressions to estimate both the external and internal margin of trade and control for possible selection bias, and re-run our regressions after dropping all countries that are reported as having zero mines. Our main results turn out to be robust to all of these alternative specifications.

[46]The partial correlation between M_d and the first measure of mine-to-coast road km (controlling for GDP per capita, area, and landlockedness) is 81% and a simple regression (not shown) suggests that a doubling of the number of mines leads to 90% more mine-to-coast road km.

6 Discussion

We have shown that coastal countries with more mine-to-coast infrastructure import relatively less from neighbors, while the opposite happens in landlocked countries. This effect is stronger when the mine-to-coast infrastructure overlaps more with the routes used by consumers to import from overseas. Furthermore, the effect is only evident in former colonies, and is particularly strong Africa. We now discuss the interpretations and implications of our results. We begin by discussing the welfare implications. Next, we discuss the possibility to attribute the pattern that we have uncovered to colonial heritage. Finally, we use our results to critically assess the recent surge of Chinese infrastructure investment in Africa.

6.1 Welfare implications

Our results are supportive of the notion that interior-to-coast infrastructure in coastal countries penalises regional trade, at least in relative terms.[47] However, we cannot draw precise welfare implications. To do so, one would require strict randomness in the placement of infrastructure. Furthermore, to argue that a certain structure of transport costs is not optimal one would need to estimate a rich quantitative model of transport infrastructure, trade and growth, and use that to compare the status quo to the relevant counterfactual. While an interesting avenue for future research, such an analysis is beyond the scope of this paper. However, we have good reasons to *hypothesise* that an interior-to-coast structure of transport costs is suboptimal.

As we argue further below, current and colonial transport infrastructure are strongly correlated in Africa and there are good reasons to suspect that the latter was not designed to maximise colonial welfare. In practical terms, more connections between the interior and the coast in destination d means that industries in its neighboring country o that export to d will be at a greater disadvantage compared to other overseas exporters to d. These dynamics risk damaging industries such as simple manufacturing, that in Africa may only be able to take off by serving domestic and regional markets, and that are typically seen as key to spurring genuine non resource-based growth in Africa (e.g. Collier and Venables, 2010). In unreported results, we

[47] Because all our regressions have destination fixed effects, the negative effect on imports from neighbors is always *relative* to total imports from all other countries.

conduct a simple test of this hypothesis. In a cross country regression including former colonies and African countries, we ask whether countries whose coastal neighbors have a higher average value of the mine impact index have a lower volume of total non-resource exports. We find that they do, and this result is highly robust. Thus, countries whose neighbors have transport infrastructure that is more biased towards overseas trade, have developed a more modest capacity to produce non-resource exports, among which manufacturing. While we do not claim that this relation is causal, it provides suggestive evidence that the regional welfare consequences of mine-to-coast infrastructure are negative.

6.2 Current versus colonial transport infrastructure

It is possible that we find a result for former colonies and Africa because in these countries current transport infrastructure is more heavily shaped by colonial transport infrastructure, which in turn was mostly designed to export natural resources. But how strongly correlated are current and colonial transport infrastructure? To answer this question, we collected data on km of roads, paved roads, and main roads at independence (1963), and compared it with current data (2006).[48] Our main finding is that the average African country built very few new roads between 1963 and 2006, when compared to similar countries in terms of initial stock of roads, income and land area. For example, the average non-African country acquired an extra 22 thousand km of main roads between 1963 and 2006. However, the average African country only acquired an extra 3 thousand km. If, as Herbst (2000, p. 164) suggests, these changes were mainly *additions*, we can tentatively say that 73% of current African main roads already existed at independence (though a smaller proportion seem to have been paved).[49] When we extend the analysis to our broader sample of former colonies, we find that colonial and current transport infrastructure are less closely correlated. This may explain why the trade redirection effect of mines is stronger in Africa than in former colonies (see Tables 4 and 5). There is also some evidence in support of the notion that colonial transport infrastructure was mostly designed to

[48] See the Online Appendix for full details.

[49] Not only the *average* African country built very few new roads, but the *ranking* of African countries in terms of their stock of roads remained largely unchanged: in our Africa sample, total roads in 1963 explain 87% of total roads in 2006.

export natural resources: countries with more mines had more roads in 1963, but this was only true in colonies and in Africa.

Why did the African countries change their colonial transport infrastructure so little? According to Herbst (2000), this was largely for political reasons: the post-colonial elite was primarily interested in consolidating their political control over their national territories, and for this the colonial infrastructure was good enough.[50]

Although colonial infrastructure has clearly persisted over time, one must be cautious in entirely attributing our findings to colonial heritage. It is possible that post-colonial investment *exacerbated* the effect of colonial infrastructure, which would then bias our conclusions in the direction of overstating the impact of colonial infrastructure. For example, our data says that, in Africa only, countries with more mines paved more roads between 1963 and 2006. In resource-rich Africa, more than elsewhere, post-1963 infrastructure policies may not have been so different from those of the former colonisers. China's recent involvement in Africa may now continue this pattern.

6.3 China and Africa

> "*And so my advice to African leaders is to make sure that if, in fact, China is putting in roads and bridges, number one, that they're hiring African workers; number two, that the roads don't just lead from the mine to the port to Shanghai, but that there's an ability for the African governments to shape how this infrastructure is going to benefit them in the long term.*"(Barack Obama, August 2014).[51]

In the last decade, China has outpaced the World Bank as the leading investor in Africa's transport infrastructure (OECD, 2012). Critical commentaries, such as the one reported above,

[50]According to Herbst (2000, Ch. 5), the post-colonial elite essentially adopted the system of intra-African relations that had been drawn at the colonial conference of Berlin in 1884-85. In this system, control over a colony's capital entitled a colonial power to claim control over the entire colony. Colonial transport infrastructure, then, always guaranteed control of the capital, and this gave the post-colonial elite just what they needed to secure their own authority. In other words, one reason why the African countries invested little in transport infrastructure was that they did not need to establish control over national borders, a key factor of road and railway expansion in Europe and elsewhere.

[51]Source: "The President on Dealing with China", *The Economist*, August 2 2014.

have accused China of hand-picking projects that connect the African countries to herself, but that have little potential to foster regional integration in Africa (see also Davies, 2010). In other words, China has been accused of exacerbating the legacy of interior-to-coast colonial transport infrastructure in Africa.

To see if this critique is well founded, we collected data on the 40 largest Chinese road and railway projects between 2000 and 2013.[52] For each of these projects, we identified the approximate route of the road or railway, and assigned a label "interior-to-coast" to projects that either connect the interior of a country to the coast, or connect two points in the interior, but are clearly part of a bigger project connecting the interior to the coast. This analysis led to two main findings. First, only 5 of the 40 projects connect two African countries with each other, and in 4 out of 5 cases this involves the connection of a landlocked country to the coast. Second, 83% (by value) of the projects have an interior-to-coast shape. To a first approximation, then, the Chinese infrastructure does resemble colonial infrastructure, an impression that is reinforced by the fact that in many cases, the former amounts to a renovation of the latter.[53] This similarity is easy to rationalise since just like the colonisers, China has a more direct interest in promoting her own trade with Africa, than trade between African countries.

To what extent is this interior-to-coast infrastructure also *mine*-to-coast? Anecdotal evidence suggests that it often is,[54] but more evidence must be gathered to answer this question satisfactorily. One speculation is that African *imports* from China must be a more important factor for Chinese infrastructure than imports from Europe were for colonial infrastructure. The terms of trade between Africa and China are largely determined by world markets and have been favorable to Africa in recent year. Africa must have received relatively large volumes of imports from China, creating the need for import-related infrastructure. In contrast, the colonial infrastructure was built by countries who could manipulate their terms of trade with Africa to their advantage. The famous example is that of the Belgian Congo, from which the Europeans almost exclusively imported goods (Hochshild, 2006).

Another important difference between Chinese and colonial investment is that, in China's

[52]Full details are in the Online Appendix.
[53]See for example Ash (2013) on the Chinese-sponsored renovation of several colonial railway lines.
[54]See, for example, Ash (2013), or Schiere and Rugamba (2011, p. 15).

case, the *de jure* power to decide what infrastructure to build lies in the hands of the African governments.[55] Furthermore, improved democratic conditions may mean that, relative to the post-colonial elite, the current African governments may insist more on welfare-maximising projects.[56] Ultimately, however, the *de facto* power to decide what to build will depend on the bargaining power of the African countries vis-a-vis China, which in turn is likely to depend on factors such as domestic political stability and the price of natural resources. In any case, it is interesting to notice that, if the counterfactual to colonial occupation is a situation in which large trading partners have considerable influence over the placement of transport infrastructure, this must be kept in mind when evaluating the welfare implications of colonial infrastructure.

Some evidence suggests that African manufacturing has suffered from the recent surge in China-Africa trade (e.g. Giovannetti and Sanfilippo, 2009). Whether or not Chinese interior-to-coast infrastructure has exacerbated this, and whether or not Africa should reject China's overtures and pursue an infrastructure policy more aimed towards domestic and regional integration, are important questions for future research.

7 Conclusions

Former colonies with more mines import less from neighbors and our results strongly suggest that this is due to mine-to-coast infrastructure. This patterns is particularly evident in Africa. Countries without mines display a strong positive neighbor effect on bilateral trade, but the results suggest that countries with more than a few mines do *not* import more from neighbors. Mine-to-coast infrastructure appears to lower trade costs with overseas countries proportionately more than trade costs with neighbors. This effect is stronger if the mine-to-coast infrastructure overlaps substantially with city-port corridors, the route used by consumers to import from overseas. The sign reverses for landlocked countries with mines, but does not hold for oil and gas

[55] According to Davies (2010), "Chinese financiers largely finance projects that are proposed by the recipient governments themselves. Decisions on the choice of infrastructure project are thus taken in African capitals and not Beijing".

[56] Burgess *et al.* (2014) find that road investment in Kenya has been getting closer to optimal since the arrival of democracy in the 1990s. Another encouraging piece of evidence is that China has also been investing a lot in seemingly good investments in the area of power generation, school building, etc.

fields which are unlikely to affect import trade costs. Our results are supportive of the notion that African countries received a transportation network that was heavily biased towards trade with Europe, the effects of which have persisted over time. Although it is hard to draw precise welfare conclusions from these results, our results establish a link between resource abundance, history, and lagging domestic and regional market integration, which is often perceived as a drag on growth in Africa.

References

[1] Amin, S. (1972). "Underdevelopment and Development in Black Africa - Origins and Contemporary Forms", in the *Journal of Modern African Studies*, V. 10, N. 4, pp. 503-524.

[2] Ash, P. (2013). "Demand for resources drives African rail boom", *International Railway Journal*, 9 Jan 2013.

[3] Banerjee, A., E. Duflo, and N. Qian (2012). "On the Road: Access to Transportation Infrastructure and Economic Growth in China", *NBER Working Papers*, N. 17897.

[4] Burgess, R., R. Jedwab, E. Miguel, A. Morjaria, and G. Padro-i-Miquel (2014). "The Value of Democracy: Evidence from Road Building in Kenya", forthcoming, *American Economic Review*.

[5] Buys, P., U. Deichmann and D. Wheeler (2006). "Road Network Upgrading and Overland Trade Expansion in Sub-Saharan Africa", *World Bank Policy Research Working Papers*, N. 4097, December 2006.

[6] Center for African Studies, University of Edinburgh (1969). *Proceedings of a Seminar Held in the Center of African Studies*, University of Edinburgh.

[7] Cameron, A.C., J.B. Gelbach and D.L. Miller (2011). Robust inference with multi-way clustering, Journal of Business and Economic Statistics 29(2), 238-249.

[8] Collier, P. and A. J. Venables (2010). "Trade and Economic Performance: Does Africas Fragmentation Matter?", in Lin, J. Y., and B. Pleskovic (Eds.), *People, Politics and Globalization*, World Bank, 2009 ABCDE Conference.

[9] Cosar, A. K. and B. Demir (2015). "Domestic Road Infrastructure and International Trade: Evidence from Turkey", *Mimeo.*

[10] Davies, M. (2010). "How China Is Influencing Africas Development", Background Paper for the *Perspective on Global Development 2010 Shifting Wealth*, OECD, OECD Development Centre.

[11] Donaldson, D. (forthcoming). "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure", forthcoming, *American Economic Review.*

[12] Dos Santos, T. (1970). "The Structure of Dependence", *American Economic Review* 60(2), 231-236.

[13] Duranton, G., P. M. Morrow and M. A. Turner (2014). "Roads and Trade: Evidence from the US", *Review of Economic Studies*, V. 81, N. 2, pp. 681-724.

[14] Easterly, W. and R. Levine (1998). "Troubles with Neighbors: Africa's Problem, Africa's Opportunity", in the *Journal of African Economies* 7(1), 120-142.

[15] Faber, B. (2012). "Trade Integration, Market Size, and Industrialization: Evidence from China's National Trunk Highway System", forthcoming, *Review of Economic Studies.*

[16] Freund, B. (1998). *The Making of Contemporary Africa the Development of African Society Since 1800*, Basingstoke (UK), MacMillan Press.

[17] Giovannetti, G. and M. Sanfilippo (2009). Do Chinese Exports Crowd-out African Goods? An Econometric Analysis by Country and Sector. European Journal of Development Research 21: 506-530.

[18] Halbouty, M.T., A. Meyerhoff, R.E. King, R.H. Dott, D. Klemme and T. Shabad, (1970). "World's Giant Oil and Gas Fields, Geologic Factors Affecting Their Formation, and Basin

Classification: Part I: Giant Oil and Gas Fields."in *AAPG Memoir 14: Geology of Giant Petroleum Fields*, pp. 502-528.

[19] Head, K., T. Mayer and J. Ries (2010). "The erosion of colonial trade linkages after independence", *Journal of International Economics*, V. 81, N. 1, pp. 1-14.

[20] Herbst, J. (2000). *States and Power in Africa Comparative Lessons in Authority and Control*, Princeton, Princeton University Press.

[21] Hochshild, A. (2006).*King Leopold's Ghosts: a story of greed, terror and heroism in colonial Africa*, London, Pan Books.

[22] Horn, M.K. (2003) "Giant Fields 1868-2003 (CD-ROM)", in Halbouty, M.K., ed., *Giant Oil and Gas Fields of the Decade, 1990-1999*, Housto, AAPG Memoir 78.

[23] Huillery, E. (2009). "History Matters: The Long-Term Impact of Colonial Public Investments in French West Africa", A*merican Economic Journal: Applied Economics*, V. 1, N. 2, pp. 176-21.

[24] Iyer, L. (2010). "Direct versus Indirect Colonial Rule in India: Long-term Consequences", *The Review of Economics and Statistics*, V. 92, N. 4, pp. 693-713.

[25] Jedwab, R. and Alexander M. (2012). "Colonial Investment and Long-Term Development in Africa: Evidence form Ghanaian Railroads", mimeo, LSE.

[26] Keller, W. and C. H. Shiue (2008). "Institutions, Technology, and Trade", *NBER Working Papers*, N. 13913.

[27] Limao, N. and A. J. Venables (2001). "Infrastructure, Geographical Disadvantage, Transport Costs, and Trade", in *The World Bank Economic Review*, V. 15, N. 3, pp. 451-479.

[28] Michaels, G. (2008). "The Effect of Trade on the Demand for Skill: Evidence from the Interstate Highway System", *Review of Economics and Statistics*, V. 90, N. 4, pp. 683-701.

[29] Nunn N. (2008). "The long-term effects of Africas slave trades", *Quarterly Journal of Econonics*, N. 123, pp. 139-176.

[30] van der Ploeg, F. (2011). "Natural Resources: Curse of Blessing?" in the *Journal of Economic Literature* 49(2), 366-420.

[31] O'Connor (1983), The African City, Africana Publishing Company, New York.

[32] Roberts, M. and U. Deichmann (2009). "International Growth Spillovers, Geography and Infrastructure", in *Policy Research Working Papers*, Washington, the World Bank.

[33] Rodney, W. (1982). *How Europe Underdeveloped Africa*, Washington DC, Howard University Press.

[34] Sachs, J.D., J.W. McArthur, G. Schmidt-Traub, M. Kruk, C. Bahadur, M. Faye and G. McCord (2004). "Ending Africas Poverty Trap", in *Brookings Papers on Economic Activity* 2004(1), 117-226.

[35] Schiere, R. and A. Rugamba (2011). "Chinese Infrastructure Investment and African Integration, *Working Paper Series*, African Development Bank Group.

[36] Venables, A. J. (2003). "Winners and Losers from Regional Integration Agreements", in the *Economic Journal* 113, 747-761.

[37] Venables, A. J. (2009). "Economic Integration in Remote Resource-Rich Regions", in *Ox-CARRE Research Papers*, N. 22.

Figures and Tables

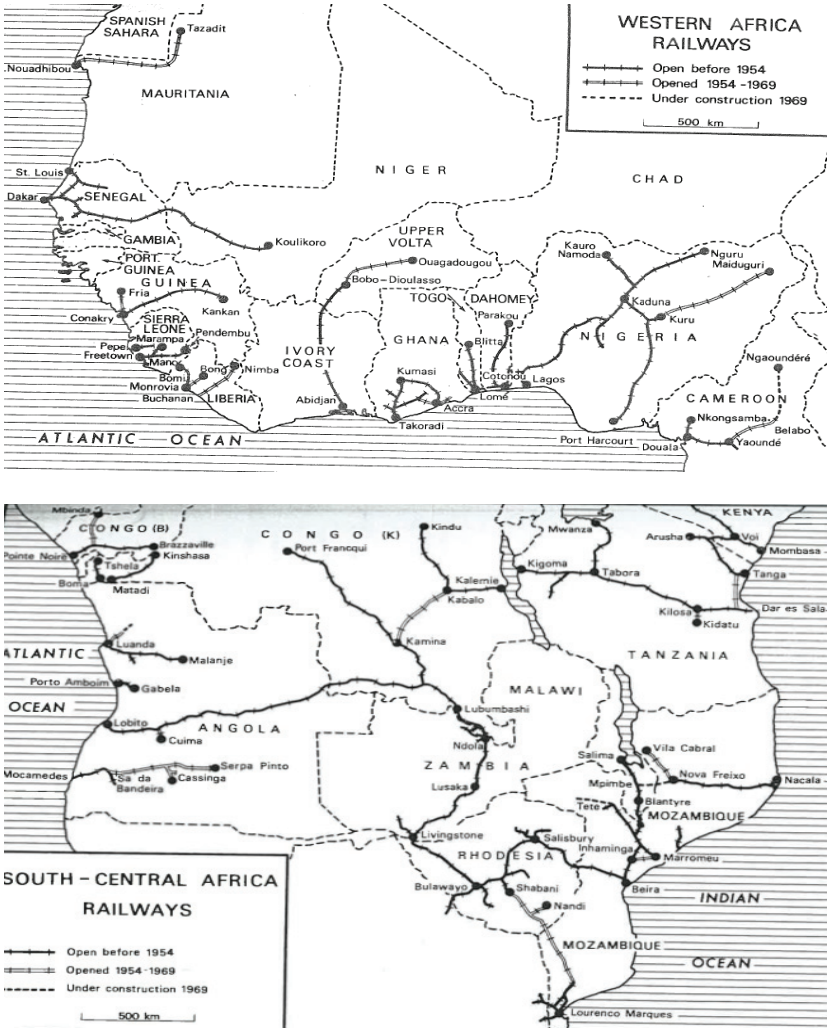
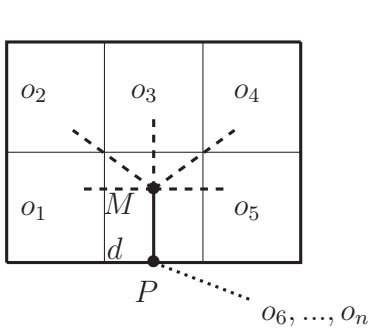
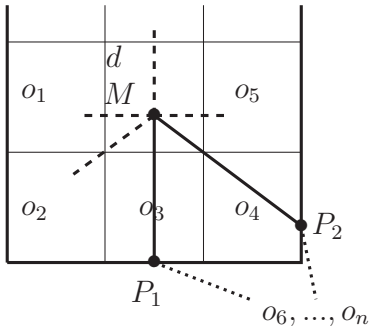


Figure 1: African Colonial Railways, 1960s. Source: Center of African Studies, University of Edinburgh (1969).

Figure 2: African railways, 2002. Source: 'Vmap0' from (www.mapability.com).

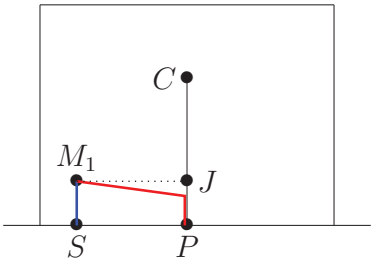


Panel I: coastal d

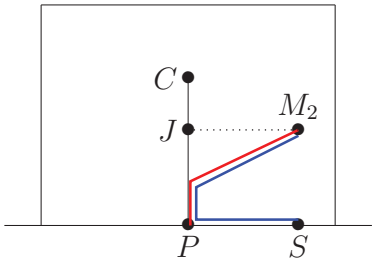


Panel II: landlocked d

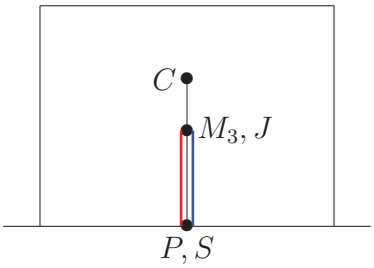
Figure 3: Mine-related transport infrastructure, coastal and landlocked destination.



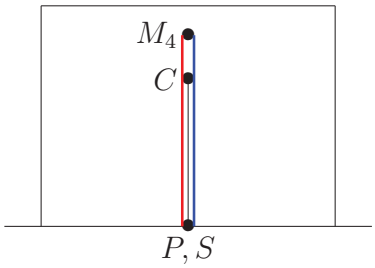
$I_1 = 0.3, I_2 = 0.8, I_3 = 0.35; \mathbf{I} = \mathbf{0.08}$



$I_1 = 1.0, I_2 = 0.6, I_3 = 0.7; I = \mathbf{0.42}$



$I_1 = 1.0, I_2 = 1.0, I_3 = 0.7; \mathbf{I} = \mathbf{0.70}$



$I_1 = 1.0, I_2 = 1.0, I_3 = 1.0; I = \mathbf{1.00}$

Figure 4: Construction of the mine impact index.

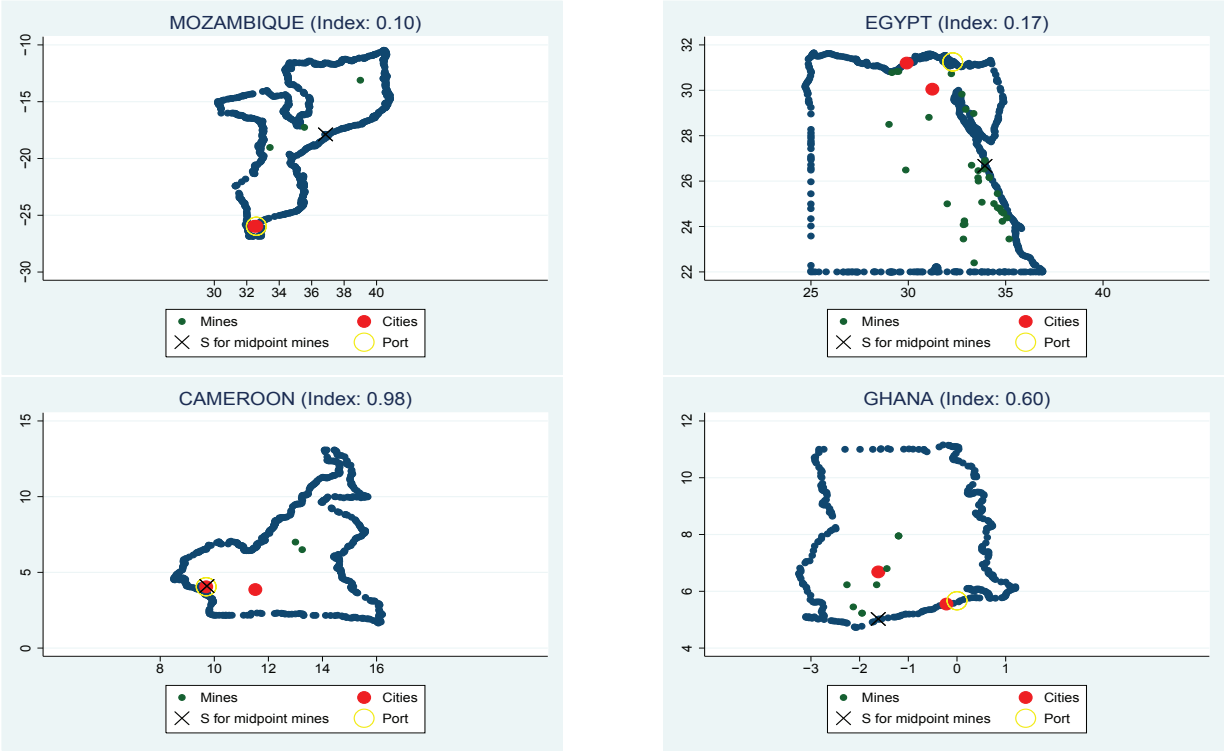


Figure 5: Mine impact index for four African countries.

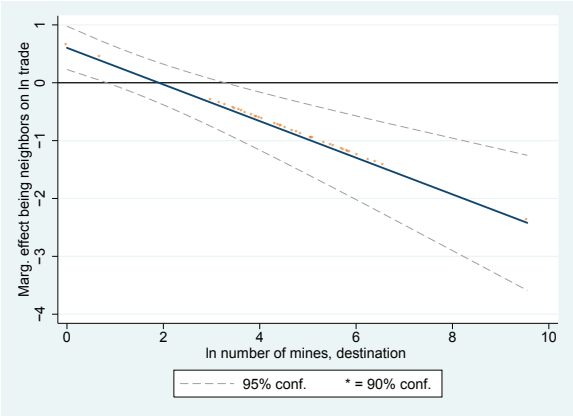


Figure 6: Marginal effect of N_{od} on imports for $A_d = 0$, World sample.

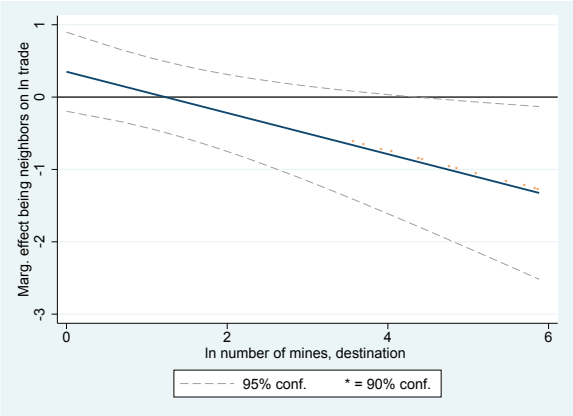


Figure 7: Marginal effect of N_{od} on imports for $A_d = 0$ and $y_d = 0$, Colony sample.

Table 1: Top mining countries and mine impact index i_d.

Country	mines	i_d	Country	mines	i_d	Country	mines	i_d
United States	14090		Jamaica	165	0.46	Guatemala	54	
Mexico	713		Bolivia	161		Honduras	51	
Brazil	610		Chile	159		Zimbabwe	50	0.46
Peru	528		Japan	129		Spain	46	
Argentina	416		Cuba	129	0.08	Dominican R.	40	0.16
Canada	358	0.19	New Zealand	118	0.10	Turkey	37	
Guyana	344	0.56	Ecuador	108		Egypt	35	0.17
Colombia	337		China	93		Italy	35	
Russia	314		Panama	85		Laos	35	0.44
Australia	303	0.10	South Korea	84	0.33	Sweden	35	
Venezuela	254		India	80	0.17	Thailand	35	
South Africa	241	0.70	France	75		Finland	32	0.38
Uruguay	209		Philippines	57	0.09	Germany	31	

Note: $i_d \in [0, 1]$ is an index capturing the extent to which the mine-to-coast infrastructure overlaps with the route used by consumers in cities to import from overseas, thus reducing their cost of importing from overseas.

Table 2: Summary statistics.

Region	Mean M_d	Mean i_d	Mean I_d	Mean M_d	Mean i_d	Mean I_d
	Non-landlocked			*Landlocked*		
World	118.73			9.05		
World ex-US	38.90			9.05		
non-colony	376.41			15.02		
colony	17.95	0.45	0.44	5.91	0.63	0.63
Africa	10.56	0.59	0.46	5.67	0.65	0.50

Table 3: The trade redirection effect of mines.

Dep. Var. = ln imports	(a) World	(b) non-US	(c) non-Colony	(d) Colony	(e) Africa	(f) World	(g) non-US	(h) non-Colony	(i) Colony	(j) Africa
N_{od}	0.603***	0.598***	0.505**	0.877***	1.544***	0.434**	0.436**	1.063***	0.351	0.272
	(0.209)	(0.211)	(0.253)	(0.317)	(0.538)	(0.204)	(0.207)	(0.259)	(0.325)	(0.601)
$N_{od}M_d$	-0.317***	-0.320***	-0.157	-0.345**	-0.371	-0.147**	-0.157**	-0.037	-0.285*	-0.237
	(0.072)	(0.074)	(0.102)	(0.159)	(0.266)	(0.071)	(0.073)	(0.090)	(0.156)	(0.261)
$N_{od}A_d$	0.301***	0.305***	0.178	0.283***	0.221	0.098	0.101	-0.071	0.150	0.247
	(0.072)	(0.072)	(0.116)	(0.091)	(0.159)	(0.073)	(0.073)	(0.110)	(0.100)	(0.152)
$N_{od} * y_d$						-0.500***	-0.507***	-0.514***	-0.542***	-0.533**
						(0.102)	(0.102)	(0.130)	(0.160)	(0.212)
$N_{od} * y_o$						-0.105	-0.100	-0.180	0.049	-0.075
						(0.103)	(0.103)	(0.130)	(0.157)	(0.219)
N_{od}* Shared emp, one colonizer	0.651***	0.639***	1.588***	0.072	-0.490	0.429*	0.416*	1.355***	0.119	-0.465
	(0.220)	(0.221)	(0.348)	(0.264)	(0.420)	(0.251)	(0.251)	(0.351)	(0.298)	(0.418)
N_{od}* Shared emp, none colonizer	-0.936***	-0.949***	-1.132***	-0.519	-0.926	-0.569*	-0.584*	-0.975***	-0.350	-0.846
	(0.321)	(0.322)	(0.364)	(0.570)	(0.750)	(0.321)	(0.323)	(0.354)	(0.674)	(0.779)
Ln distance	-1.516***	-1.522***	-1.298***	-1.600***	-1.715***	-1.565***	-1.571***	-1.316***	-1.690***	-1.780***
	(0.025)	(0.025)	(0.045)	(0.031)	(0.090)	(0.027)	(0.027)	(0.046)	(0.035)	(0.089)
Shared language	0.925***	0.938***	0.710***	0.813***	0.796***	0.879***	0.889***	0.581***	0.807***	0.807***
	(0.052)	(0.052)	(0.109)	(0.062)	(0.098)	(0.054)	(0.054)	(0.109)	(0.066)	(0.099)
Shared legal	0.274***	0.281***	0.498***	0.166***	0.062	0.362***	0.369***	0.577***	0.229***	0.144*
	(0.035)	(0.035)	(0.058)	(0.045)	(0.079)	(0.036)	(0.036)	(0.058)	(0.046)	(0.080)
ColHist	0.898***	0.906***	0.781***	1.035***	1.305***	0.948***	0.966***	0.870***	1.068***	1.332***
	(0.096)	(0.098)	(0.146)	(0.149)	(0.237)	(0.099)	(0.100)	(0.149)	(0.155)	(0.243)
RTA	0.659***	0.648***	0.485***	0.767***	0.447***	0.589***	0.575***	0.449***	0.672***	0.368***
	(0.056)	(0.057)	(0.083)	(0.079)	(0.142)	(0.058)	(0.058)	(0.084)	(0.082)	(0.142)
Both WTO	0.500***	0.501***	0.318	0.596***	0.029	0.267**	0.271**	0.128	0.416***	-0.240
	(0.109)	(0.109)	(0.196)	(0.131)	(0.221)	(0.124)	(0.124)	(0.200)	(0.155)	(0.240)
Shared currency	0.265**	0.274**	-0.740***	0.987***	1.099***	0.290**	0.308**	-0.699***	1.016***	1.118***
	(0.135)	(0.136)	(0.141)	(0.194)	(0.279)	(0.135)	(0.135)	(0.134)	(0.199)	(0.280)
ACP	0.323***	0.323***	0.774***	-0.331		0.388***	0.387***	0.829***	-0.288	
	(0.086)	(0.086)	(0.111)	(0.236)		(0.087)	(0.088)	(0.113)	(0.240)	
Observations	27,023	26,819	9,778	17,245	6,404	24045	23858	9134	14911	6026
R-squared	0.729	0.726	0.777	0.692	0.672	0.739	0.736	0.782	0.703	0.683

Note: $\boldsymbol{N_{od}}$ = neighbor; $\boldsymbol{N_{od}M_d}$ = neighbor * mines in the destination country; $\boldsymbol{N_{od}A_d}$ = neighbor * land area deviation from world average; $\boldsymbol{N_{od} * y_d}$ = neighbor * ln GDP per capita deviation from world average. Destination and origin fixed effects are included. Robust standard errors in parentheses: *** p< 0.01, ** p< 0.05, * p< 0.1. The non-US sample excludes the US as a destination. The non-Colony, Colony and Africa sample refer to all bilateral trade flows in which the destinations country is: not a former colony; a former colony; in Africa, respectively.

Table 4: Landlocked countries with mines import more from neighbors.

Dep. Var. = ln imports	(a) World	(b) non-US	(c) non-Colony	(d) Colony	(e) Africa
N_{od}	0.169	0.177	1.063***	0.026	-0.462
	(0.244)	(0.247)	(0.274)	(0.393)	(0.700)
$N_{od}M_d$	-0.144*	-0.155*	-0.019	-0.391**	-0.527*
	(0.078)	(0.081)	(0.103)	(0.183)	(0.310)
$N_{od}A_d$	0.122	0.127	-0.130	0.289**	0.621***
	(0.085)	(0.085)	(0.121)	(0.131)	(0.217)
$N_{od}L_d$	0.525*	0.501*	-0.443	0.947**	2.076**
	(0.300)	(0.302)	(0.367)	(0.477)	(0.833)
$N_{od}L_dM_d$	0.273*	0.284*	0.053	0.674**	1.217***
	(0.148)	(0.149)	(0.178)	(0.297)	(0.398)
$N_{od}L_dA_d$	0.043	0.041	0.451	-0.155	-0.758**
	(0.141)	(0.141)	(0.278)	(0.181)	(0.306)
$N_{od} * y_d$	Y	Y	Y	Y	Y
$N_{od} * y_o$	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y
Destination FE	Y	Y	Y	Y	Y
Origin FE	Y	Y	Y	Y	Y
Observations	24,045	23,858	9,134	14,911	6,026
R-squared	0.739	0.736	0.782	0.704	0.685
Marginal effect of M_d on ln imports from neighbors for $A_d = 0$					
If $L_d = 0$	-0.144*	-0.155*	-0.019	-0.391**	-0.527*
If $L_d = 1$	0.129	0.129	0.034	0.283	0.689***

Note: $\boldsymbol{N_{od}}$ = neighbor; $\boldsymbol{N_{od}M_d}$ = neighbor * mines in the destination country; $\boldsymbol{N_{od}A_d}$ = neighbor * land area deviation from world average; $\boldsymbol{N_{od} * y_d}$ = neighbor * ln GDP per capita deviation from world average; $\boldsymbol{N_{od}L_dM_d}$ = neighbor * landlocked destination dummy * mines in the destination country. Origin and destination fixed effects are included, and so are the controls listed in Table 3. Robust standard errors in parentheses: *** p< 0.01, ** p< 0.05, * p< 0.1. The non-US sample excludes the US as a destination. The non-Colony, Colony and Africa sample refer to all bilateral trade flows in which the destinations country is: not a former colony; a former colony; in Africa, respectively.

Table 5: Full specification: Trade redirection depends on the impact of mines on import routes in Africa.

Dep. Var. = ln imports	(a) Colony	(b) Africa
N_{od}	0.017	-0.923^{+}
	(0.396)	(0.686)
$N_{od}M_d$	-0.532***	-0.145
	(0.183)	(0.264)
$N_{od}A_d$	0.306**	0.672***
	(0.132)	(0.222)
$N_{od}M_dI_d$	0.226	-0.566*
	(0.220)	(0.313)
$N_{od}L_d$	0.916*	2.214***
	(0.479)	(0.809)
$N_{od}L_dM_d$	0.711*	0.885**
	(0.368)	(0.438)
$N_{od}L_dA_d$	-0.206	-0.781**
	(0.182)	(0.307)
$N_{od}L_dM_dI_d$	0.025	0.538
	(0.441)	(0.534)
$N_{od} * y_d$	Y	Y
$N_{od} * y_o$	Y	Y
Controls	Y	Y
Destination FE	Y	Y
Origin FE	Y	Y
Observations	14,911	6,026
R-squared	0.704	0.685
Marginal effect of M_d on ln imports from neighbors for $A_d = 0$		
If $L_d = 0$, $I_d = 0$	-0.532**	-0.145
If $L_d = 0$, $I_d = 1$	-0.306^{+}	-0.711**
If $L_d = 1$, $I_d = 0$	0.180	0.740**
If $L_d = 1$, $I_d = 1$	0.431^{+}	0.711**

Note: $\boldsymbol{N_{od}}$ = neighbor; $\boldsymbol{N_{od}M_d}$ = neighbor * mines in the destination country; $\boldsymbol{N_{od}A_d}$ = neighbor * land area deviation from world average; $\boldsymbol{N_{od} * y_d}$ = neighbor * ln GDP per capita deviation from world average; $\boldsymbol{N_{od}M_dI_d}$ = $N_{od}M_d$ * mine impact index in the destination country; $\boldsymbol{N_{od}L_dM_d}$ = neighbor * landlocked destination dummy * mines in the destination country; $\boldsymbol{N_{od}L_dM_dI_d}$ = $N_{od}L_dM_d$ * mine impact index in the destination country. Origin and destination fixed effects are included, and so are the controls listed in Table 3. Robust standard errors in parentheses: *** p< 0.01, ** p< 0.05, * p< 0.1, + p< 0.2. The Colony and Africa sample refer to all bilateral trade flows in which the destinations country is: a former colony; in Africa, respectively.

Table 6: Mines and oil and gas fields.

Dep. Var. = ln imports	(a) World	(b) non-US	(c) non-Colony	(d) Colony	(e) Africa	(f) World	(g) non-US	(h) non-Colony	(i) Colony	(j) Africa
N_{od}	0.643***	0.644***	0.495**	1.024***	1.617***	0.426**	0.428**	1.058***	0.298	0.332
	(0.210)	(0.212)	(0.247)	(0.332)	(0.537)	(0.204)	(0.206)	(0.259)	(0.366)	(0.663)
$N_{od}M_d$	-0.299***	-0.307***	-0.181*	-0.369**	-0.439^{+}	-0.145**	-0.154**	-0.040	-0.273*	-0.250
	(0.073)	(0.075)	(0.101)	(0.157)	(0.267)	(0.070)	(0.072)	(0.091)	(0.153)	(0.261)
$N_{od}OG_d$	-0.245**	-0.249***	-0.289**	-0.276*	-0.481**	0.045	0.042	-0.023	0.064	-0.051
	(0.096)	(0.096)	(0.144)	(0.150)	(0.199)	(0.102)	(0.102)	(0.129)	(0.193)	(0.291)
$N_{od}A_d$	0.396***	0.401***	0.393**	0.339***	0.345**	0.074	0.079	-0.052	0.126	0.259^{+}
	(0.087)	(0.087)	(0.170)	(0.096)	(0.167)	(0.089)	(0.089)	(0.151)	(0.119)	(0.164)
$N_{od} * y_d$						-0.515***	-0.521***	-0.509***	-0.566***	-0.509*
						(0.110)	(0.110)	(0.127)	(0.194)	(0.288)
$N_{od} * y_o$						-0.104	-0.099	-0.180^{+}	0.044	-0.073
						(0.103)	(0.103)	(0.130)	(0.154)	(0.215)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
D FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
O FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	27,023	26,819	9,778	17,245	6,404	24,045	23,858	9,134	14,911	6,026
R-squared	0.729	0.726	0.777	0.692	0.673	0.739	0.736	0.782	0.703	0.683

Note: $\boldsymbol{N_{od}}$ = neighbor; $\boldsymbol{N_{od}M_d}$ = neighbor * mines in the destination country; $\boldsymbol{N_{od}A_d}$ = neighbor * land area deviation from world average; $\boldsymbol{N_{od} * y_d}$ = neighbor * ln GDP per capita deviation from world average; $\boldsymbol{N_{od}OG_d}$ = neighbor * oil and gas fields in the destination country. Origin and destination fixed effects are included, and so are the controls listed in Table 3. Robust standard errors in parentheses: *** p< 0.01, ** p< 0.05, * p< 0.1, + p< 0.2. The non-US sample excludes the US as a destination. The non-Colony, Colony and Africa sample refer to all bilateral trade flows in which the destinations country is: not a former colony; a former colony; in Africa, respectively.

Table 7: Alternative measures of mine infrastructure.

Dep. Var. = ln imports	(a) Colony	(b) Africa	(c) Colony	(d) Africa	(e) Colony	(f) Africa
$M_d =$	1 if $mines > 0$		$\ln(\sum_j min(MS_j, MP_j) + 1)$		$\ln(\sum_j MP_j + 1)$	
Marginal effect of M_d on ln imports from neighbors for $A_d = 0$						
If $L_d = 0$, $I_d = 0$	-1.377**	$-0,991^{+}$	-0.260***	-0.187*	-0.219***	-0.190**
If $L_d = 0$, $I_d = 1$	-0.830^{+}	-2.240***	-0.140*	-0.312***	-0.133*	-0.322***
If $L_d = 1$, $I_d = 0$	0.539	1.467*	0.084	0.215**	0.068	0.195**
If $L_d = 1$, $I_d = 1$	1.085**	1.503***	0.154***	0.246***	0.119**	0.180***

$\boldsymbol{L_d}$ = landlocked destination dummy; $\boldsymbol{I_d}$ = mine impact index in the destination country; $\boldsymbol{A_d}$ = land area deviation from world average. Origin and destination fixed effects are included, and so are the controls listed in Table 5. Robust standard errors in parentheses: *** p< **0.01**, ** p< **0.05**, * p< **0.1**, + p< **0.2**. The Colony and Africa sample refer to all bilateral trade flows in which the destinations country is: a former colony; in Africa, respectively.

A Technical Appendix

A.1 Data sources, data manipulation, and calculating distances along roads

A comprehensive source of data on the location of mines across the world is available from the US Geological Survey's Mineral Resources Data System (MRDS). MRDS registers the location in geographic coordinates of metallic and nonmetallic mineral resources throughout the world. It was intended for use as reference material supporting mineral resource and environmental assessments on local to regional scale worldwide. Available series are deposit name, location, commodity, deposit description, development status, geologic characteristics, production, reserves, year of discovery, year of first production, and references, although many entries contain missing values. The database is unfortunately focused on the geological setting of mineral deposits rather than on production and reserve information.

We have considered, and rejected, the possibility of using an alternative database of mines. The private company Raw Materials Group (RMG) also provides a database with metallic and nonmetallic mineral resources covering the world. The data has better information on the mine status in different years (although this information is still quite incomplete). However, within the RMG database we observe at least one mine in only 96 countries, versus 133 countries in the MRDS data. This means that the RMG data excludes mines in three OECD countries, 11 African countries and a further 23 non-OECD countries, among which for example Mozambique and Senegal are known to be significant current producers of respectively aluminium and phosphates.

The GSHHSD database[57] used for point S provides the co-ordinates of all coastlines in the world, and comes in four levels of detail (1 =land, 2 =lake, 3 =island in lake, 4 =pond in island in lake) and five resolutions. For our purposes, it is best to use level 1, which excludes the possibility that we find S on the shore of a lake, and a low resolution, which builds up the world's coastlines from $64,000$ coordinates.[58] For each mine in each country, we calculate the distance between the mine and all coastal points, and pick S as the coastal point that minimizes

[57] `http://www.ngdc.noaa.gov/mgg/shorelines/gshhs.html`

[58] An intermediate level of detail would use $380,000$ coordinates, and quickly increase the time it takes to calculate distances.

this distance.

To identify point P, we proceed in several steps. First, we use the "World Port Ranking 2009" provided by the American Association of Port Authorities (AAPA) to infer the main container port for all countries with at least one port included in the ranking. For countries that are not included in the AAPA ranking, we use, when possible, Maersk's website, to track the port used by Maersk Line - the world's leading container shipping company - to import a container from Shanghai into the country's capital.[59] Finally, for countries that are neither included in the AAPA ranking nor reached by Maersk Line, we identify the main commercial port by conducting a series of internet searches.[60] We coded as "port co-ordinates" those of the port's nearest city, which we got from the World Urbanization Prospects database, and, for smaller cities, from Wikipedia/GeoHack.

Having identified points M, P, C and S for each mine and country in our sample, we move to calculate distances between them along actual roads, using MapQuest's online digital maps.[61] Specifically, we use MapQuest's Directions Web Service (`http://www.MapQuestapi.com/directions/`). For each pair of locations we send the coordinates to the server, which returns a route along roads as a string of shapepoints (coordinates) and travel distance.[62] We use the shapepoints of the city-port route to find the point on this route that is closest to the mine in a straight line. We then use that point to find a route and distance along roads from the mine to the city-port route.[63]

[59]Maersk Line has the largest market share (18%) according to http://www.shippingcontainertrader.com/facts.shtml.

[60]This led us to take Shanghai as the reference port for Kyrgystan, Tajikistan and Mongolia, Poti for Turmenistan and Uzbekistan, and St Petersburg for Kazakhstan.

[61]We chose MapQuest rather than for example Google Maps, because the former's servers allowed access to more routing requests per day. For the Africa and Colony sample alone we need to construct 13,463 individual indices, requiring more than 5 routing requests *each*, while the MapQuest daily limit is 5,000. The large number of mines and cities in non-colony countries requires several orders of magnitude additional routing requests. For example, the US would require at least 5*56*14,090=3,945,200 requests for 56 cities and 14,090 mines, which would take more than two years.

[62]We used the shortest route. We chose not to use travel time, because average road speeds in for example central Congo were unrealistically high.

[63]In some cases the server could not calculate a route because the coordinates of the mine were in a remote location with few roads nearby. In that case (private) access roads to the mine may not appear in the database. In those cases we used the Google reverse geocoding service (`https://developers.google.com/maps/documentation/geocoding/#ReverseGeocoding`) to find the geographical name (of the nearest town one level above street name) of the location of the mine. Using this name we retrieved new coordinates using Google's geocoding service, which were subsequently used to calculate a new route. To the resulting distance we add the straight line distance between M and the new starting point of the route. If this method still did not yield a

The index for each mine is calculated as described in (5)-(8). However, in some cases we find that the city is very far from the main container port, but also relatively close to a coast. For these particular cities the main container port may not be the relevant one. Such a city may be supplied through a smaller secondary port, which also means that the mine-city route has little impact on the ability to import through the country's main container port. This occurs for 73 out of 238 cities. Therefore, we multiply (5) by a fourth term:

$$\text{relevance of port} = \begin{cases} 0 & \text{if} \quad CP > Pcentroid \ \wedge \ CS_{city} < Pcentroid \\ 1 & \text{else.} \end{cases} \tag{12}$$

Where 'centroid' is the centroid of a country[64], and S_{city} is a point on the coast nearest to a city C. A weight of zero is given to individual city-mine indices, where (a) the straight-line great-circle city-port distance is *longer* than the distance between the port and the centroid of the country, *and* (b) the distance between the city and the coast is *less* than the distance between the port and the centroid of the country.

The final step is to calculate country d's overall mine impact index, i_d, by aggregated up from all possible mine-city-port combinations within the country.[65] These individual indices are summed with 1950 city population weights such that larger cities add relatively more to the aggregate index.

A.2 Defining former colonies

Our favorite definition of former colony is Head *et al.* (2010)', refined to exclude those countries that were only colonized by a neighbor. To give an example, our definition excludes most of the former Soviet republics (who were only colonized by the USSR), but not Namibia (who was colonized in different periods both by a neighbor, South Africa, and by a non-neighbor,

route, we instead use the straight-line great circle distance. Mostly, this happened for distances MS because S is not necessarily an inhabited location.

[64]From `http://www.cepii.fr/anglaisgraph/bdd/distances.htm`

[65]For example, for a country with four mines (and four points nearest to each on the coast), two cities, and one port we calculate 4*2 individual indices before aggregating. For India for example, we have 59 cities and 80 mines and thus 4720 indices.

Table A.1: Non-African, non-island former colonies.

Asia		America	Europe
Afghanistan	Kuwait	Belize	Albania
Armenia (Russia)	Kyrgyzstan (Russia)	Canada	Bosnia & Herzegovina
AZERBAIJAN (Russia)	Laos	French Guiana	BULGARIA (Turkey)
Bangladesh	Lebanon	Grenada	Croatia (Austria)
BELARUS (Russia)	Macao	Guyana	CZECH REPUBLIC (Austria)
Brunei Darussalam	Malaysia	Suriname	Estonia
Cambodia	Myanmar		FINLAND (Russia, Sweden)
GEORGIA (Russia)	Pakistan		Gibraltar
Hong Kong	Papua New Guinea		IRELAND (Britain)
India	Qatar		LATVIA (Russia)
Indonesia	Syria		LITHUANIA (Russia)
Iraq	Tajikistan (Russia)		
Israel	Turkmenistan		Macedonia
Jordan	UKRAINE (Russia)		Moldova
MONGOLIA (China)	United Arab Emirates		POLAND (Germany)
North Korea	Uzbekistan (Russia)		Romania
South Korea	Viet Nam		SLOVAKIA (Austria)
KAZAKHSTAN (Russia)	Yemen		SLOVENIA (Austria)

Note: non-African, non island former colonies who obtained independence after 1900. "Non-islands" are countries who share a land border with at least another country. In capital letter are countries whose colonizers were all neighbors (reported in parenthesis). Underlined are countries that, even though their colonizers (reported in parenthesis) where not all neighbors, can still be expected to have traded with all their colonizers mostly overland.

Germany). For robustness, we have run all our specifications using both the broader Head *et al.* (2010) definition, as well as a third, even narrower definition. In the latter, we have excluded not only countries who were only colonized by a neighbor, but also those who, despite being colonized by a non-neighbor, can reasonably be expected to have traded with their colonizer overland (e.g. Kyrgyzstan, who was colonized by the USSR). Table A.1 provides a full list of non-African, non-island former colonies. All African countries except for Liberia and Entiopia are in our preferred definition of colonies. Our preferred definition of colony includes all countries whose name is in lower case in Table A.1; the broader definition includes also countries whose name is in upper case; and the narrower definition excludes countries whose names is underlined.