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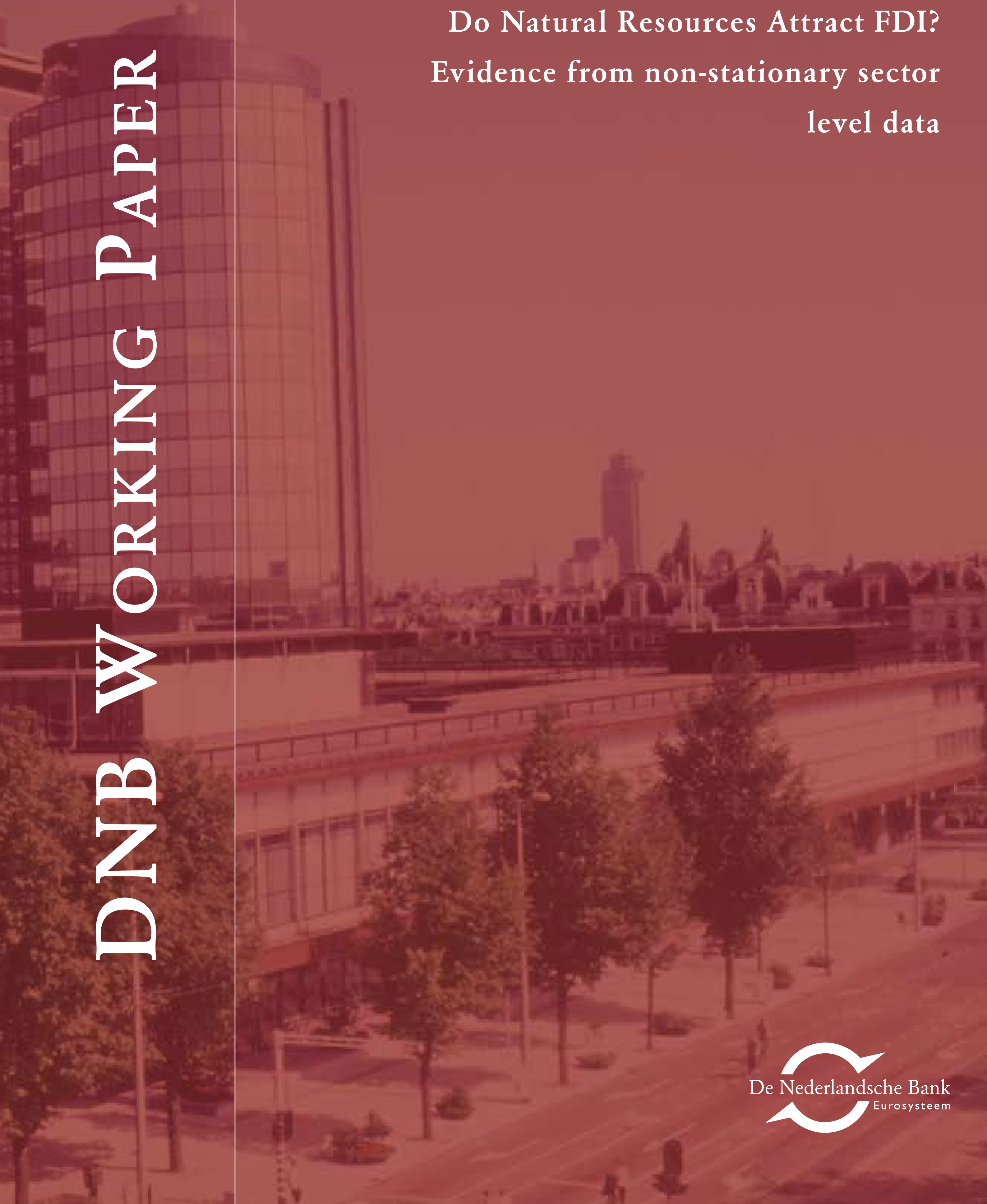

De Nederlandsche Bank
Eurosysteem

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Steven Poelhekke and Frederick van der Ploeg *

* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

DO NATURAL RESOURCES ATTRACT FDI?
Evidence from non-stationary sector level data*

Steven Poelhekke, De Nederlandsche Bank, The Netherlands**

Frederick van der Ploeg, University of Oxford, United Kingdom***

Abstract

A new and extensive panel of outward foreign direct investment (FDI) at the sector level is used to estimate the determinants of non-resource and resource FDI. Since FDI is I(1), we estimate panel error-correction models of FDI with spatial lags for FDI and market potential. Our main result is that subsoil assets boost resource FDI, but crowd out non-resource FDI. The effect on non-resource FDI dominates, so that aggregate FDI is less in resource-rich countries. Spatial lags aggravate this crowding out of non-resource FDI. In addition, we find that (i) resource FDI is mainly vertical whereas other FDI is of the export-fragmentation variety; (ii) trade openness, free trade agreements and institutional quality do not impact non-resource FDI but institutional quality does have a positive effect on resource FDI; and (iii) the short-run dynamics comes mostly from shocks to FDI itself. Our main and ancillary results are robust to different measures of resource reserves and the oil price and to allowing for sample selection bias.

Keywords: outward sector level FDI, subsoil assets, co-integration tests, spatial econometrics, hydrocarbon reserves, external margin, sample selection bias
JEL code: C21, C33, F21, Q33

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Correspondence address:
Oxcarre, University of Oxford, Manor Road Building, Oxford OX1 3UQ, England
Email: rick.vanderploeg@economics.ox.ac.uk

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** Also affiliated with OxCarre, University of Oxford and CESifo.
*** Also affiliated with OxCarre, University of Amsterdam, CEPR and CESifo.

1. Introduction

Foreign direct investment (FDI) is an important driver of technology transfer, economic growth and development, but many resource-rich countries do not attract as much FDI as resource-poor countries. In this light it is surprising that there is no research available on the effects of natural resources on both the composition and volume of FDI. Since the resource curse literature documents adverse effects of natural resources on growth performance[1], war and conflict[2], and social conditions[3], one might expect a negative effect of natural resource endowments on non-resource FDI. Natural resources are often extracted by foreign multinationals that bring in capital and knowledge. However, resource FDI is very capital intensive and we conjecture that it leads to fewer spill-over effects into the non-resource sectors of the host economy because it relies less on local subcontractors or suppliers. Non-resource FDI on the other hand seems to promise more scope for spill-over effects and is therefore more attractive for receiving countries. If resource FDI indeed crowds out non-resource FDI, then this is an additional channel through with natural resource abundance can be a drag on economic development.

Our main objective is therefore to assess the importance of subsoil assets as a determinant of FDI and to test whether there is evidence for a negative effect of subsoil assets on non-resource FDI but a positive effect on the inflow of resource FDI. Using detailed sector level data on outward FDI, we indeed find strong evidence for this hypothesis. Furthermore, our results indicate that resource abundance has a negative impact on aggregate FDI, suggesting the presence of a curse. We deal with the thorny econometric issue that standard gravity equation errors are heteroskedastic when estimated with a panel

[1] The resource curse states that natural resource exports harm growth prospects, even after controlling for the effects of initial income per capita, human capital, investments, trade openness and institutional quality on economic growth (Sachs and Warner, 1997). However, in countries with good institutions the curse is turned into a blessing, whereas in countries with bad rule of law natural resource dependence harms growth prospects (Mehlum, et al., 2006). The curse is severest for more easily appropriable resources such as oil, gas, gold or diamonds (Boschini, et al., 2007). Furthermore, commodity prices are notoriously volatile and contribute to the resource curse so that a well developed financial system helps to turn the curse into a blessing (van der Ploeg and Poelhekke, 2009). If natural resource exports are instrumented by natural resource abundance, as measured by the World Bank (1997) estimates of sub-soil assets, and institutional and constitutional variables, the resource curse turns out to be a “red herring” while resource abundance has a significant positive effect on growth (Brunnschweiler and Bulte, 2008). Resources do, however, negatively impact growth performance via volatility (van der Ploeg and Poelhekke, 2010). Using detailed data for Brazilian municipalities, there is no evidence for an effect of oil discovery and exploitation on non-oil GDP (Caselli and Michaels, 2008).

[2] Cross-country evidence suggests that natural resources fuel war and conflict (Collier and Hoeffler, 1998, 2004, 2005; Reynal-Querol, 2002; Ross, 2004; Ron, 2005; Fearon, 2005). Once natural resource dependence is instrumented for, this effect disappears but resource abundance is associated with a reduced probability of the onset of war and conflict increases dependence on natural resources (Brunnschweiler and Bulte, 2009). Detailed evidence for Columbia suggests that increases in the price of capital-intensive commodities like oil lower wages and fuel conflict whereas increases in the price of labor-intensive commodities such as coffee or banana boost wages and dampen conflict (Dube and Vargas, 2007).

[3] For example, exploiting variations in world commodity prices to identify resource booms, panel data evidence for 90 countries between 1965 and 1999 suggests that inequality falls immediately after a boom and then gradually returns back to its original level (Goderis and Malone, 2010). A detailed survey is given in van der Ploeg (2010).

by allowing FDI to be I(1) and estimating various co-integrating relationships to arrive at a satisfactory error-correction-mechanism specification.

We have two ancillary objectives. First, we investigate in which ways resource FDI differs from non-resource FDI. Spatial econometric studies on the determinants of aggregate FDI indicate that, apart from the usual effects of host market potential, population size, distance, quality of institutions, trade openness, etc., there is a positive effect of surrounding FDI - the spatial lag - and a negative effect of surrounding market potential on FDI in the host country (e.g., Blonigen, et al., 2007; Baltagi, et al., 2007; Poelhekke and van der Ploeg, 2009). This suggests that FDI is mostly of the complex-vertical fragmentation variety or at least a combination of all forms. In contrast, resource FDI involves mostly extraction which relies less on regional suppliers. Even processing (refining) is often done in home markets close to final consumers. Detailed sector level data allows resource FDI for the first time to be distinguished from all other FDI. Our empirical results indicate that the spatial lag is insignificant for resource FDI and positive for non-resource FDI while surrounding market potential has an insignificant effect on resource FDI and a negative effect on non-resource FDI. This suggests that non-resource FDI is characterized by complex-vertical fragmentation whereas resource FDI is mainly vertical with distance and human capital having much less effect. Third-country effects have additional implications for our main objective. The positive spatial lag in non-resource FDI suggests that third-country effects, motivated by multinationals' complex production chains, extend the negative impact of resource abundance on non-resource FDI to neighboring countries and thus worsen the negative impact of resource abundance on non-resource FDI.

Of course, there are rival stories why natural resource abundance may result in less non-resource FDI. For example, bad institutions may play an important role. To test this rival hypothesis and to tackle the problem that institutional quality and market potential in the host country may not be exogenous with respect to FDI, we offer panel estimates and include the initial value of institutional quality in every five-year period and lag market potential by one year. Since institutions are an insignificant explanatory variable of non-resource FDI, we conclude that it is natural resource abundance rather than bad institutions that deters FDI. We also considered the conjecture that the ruling elite of a country forms a coalition with foreign resource companies to appropriate resource rents at the expense of the people in an environment where information on resource exploration/exploitation and returns to companies and the government are not very transparent.[4] However, we could not find empirical support for the hypothesis that resource sectors attract more FDI in badly governed countries. In fact, our empirical evidence suggests that institutional quality stimulates resource FDI.

[4] Predatory governments may induce corporations to become less transparent and less efficient, especially in industries whose profits are highly correlated with oil prices (Durnev and Guriev, 2007).

Second, we tackle the problem that FDI outflows to some sectors of some countries are zero. Building on the econometric literature on sample selection bias as specification error (Heckman, 1979) and the recent literature on estimating trade flows allowing for the number of trading partners (Helpman et al., 2008), we offer two-stage estimates of the determinants of both the external and internal margin in FDI. A novelty is that we allow for spatial dependence in both the selection and the volume of FDI equation. This does not alter our qualitative conclusions on the determinants of the volume of non-resource and resource FDI. However, we do find differences in the determinants of whether to locate FDI or not in a particular host country. For example, distance has a positive impact on the location decision but a negative impact on the volume of non-resource FDI. This suggests that setting up an affiliate in a distant country might be a substitute for international trade.

The outline of our paper is as follows. Section 2 demonstrates that in a simple three-sector trade model with intra-sectoral capital mobility subsoil assets can have a negative effect on non-resource FDI. It also discusses how the different types of FDI imply different effects of surrounding market potential and surrounding FDI, which allows one to test whether FDI is horizontal, vertical, export platform or characterized by vertical fragmentation. Section 2 thus puts forward a testable econometric specification of the theory. Section 3 discusses the unique dataset on FDI outflows from the Netherlands, and also the problem of obtaining reliable data on sub-soil assets. Section 4 establishes that FDI is I(1) and puts forward an error-correction mechanism to estimate the core determinants of non-resource FDI. Section 5 tests whether institutional quality rather than natural resource endowments deters non-resource FDI, but finds no support for this rival hypothesis. It also performs robustness tests by allowing for trade openness and free trading arrangements and using detailed data on oil/gas/coal reserves and the price of crude oil as determinants of FDI. Section 6 corrects for sample selection bias by providing estimates of the external and internal margin of FDI. Section 7 estimates the determinants of resource FDI and discusses the negative impact of resource endowments on aggregate FDI. Section 8 concludes.

2. Theoretical determinants of resource and non-resource FDI

We are interested in two hypotheses. The first comes from the Hecksher-Ohlin model and suggests that resource endowments attract resource FDI, but deter non-resource FDI. The second gives a prominent role to surrounding market potential and surrounding FDI, which enables one to distinguish whether FDI is horizontal, vertical, export-platform or vertically fragmented.

2.1 Predictions from a three-sector trade model with intra-sectoral capital mobility[5]

Suppose that output of tradeables, non-tradeables and natural resources are given by, respectively, $Y^T = \mathrm{F}(K^T, L^T)$, $Y^N = L^N$, and $Y^R = \mathrm{G}(K^R, R)$, where K^T, L^T, L^N, K^R and R denote capital and employment used in production of tradables, employment in production of non-tradables, and capital and subsoil assets used in natural resource production, respectively, and F(.) and G(.) exhibit constant returns to scale. Prices of non-tradeables and natural resource output are, respectively, p and q^*, the wage rate is w, and the interest rate is r^*. Tradeables are the numeraire, so the price of tradables is unity. The interest rate and price of natural resources are set on world markets. Capital used in the traded and resource sectors is imported and can be viewed as FDI. For simplicity, we suppose that the non-resource sectors do not use resources as intermediate input and that production of non-tradables requires no capital input.

Profit maximization demands that the marginal product of labor in the traded sector is set to the wage and the linear production function for non-tradables implies that the price simply equals the wage, so that $\mathrm{F}_L(K^T, L^T) = w = p$ and conditional labor demand decreases in the wage, $L^T = K^T \Phi(p), \Phi' < 0.$ Profit maximization also requires $\mathrm{F}_K(1, \Phi(p)) = r^*$ and $q^* \mathrm{G}_K(K^R, R) = r^*$, so the world interest rate pins down the real exchange rate and the wage , $p = w = \mathrm{p}(r^*) \equiv p^*$, $\mathrm{p}'<0$ (the factor price frontier) and the labor-capital ratio in the traded sector, $\Phi(p) = \Phi^*$; demand for capital in the resource sector ('resource FDI') declines with the world interest rate and rises with the world price of resources and resource use,

(1) $$K^R = R\Psi(q^*/r^*), \Psi' > 0.$$

With labor supply exogenous, labor market clearing implies $L = L^N + L^T$ and national income equals

(2) $$Y = \mathrm{F}(1, \Phi^*)K^T + p^*(L - \Phi^* K^T) + q^* \mathrm{G}(\Psi(q^*/r^*))R \equiv \mathrm{Y}(\overset{+}{R}, \overset{+}{L}, \overset{+}{K^T}, \overset{+}{p^*}, \overset{+}{q^*})$$

with partial derivatives $\mathrm{Y}_R = q^* Y^R / R > 0, \mathrm{Y}_L = p^* > 0, \mathrm{Y}_{K^T} = r^* > 0, Y_{p^*} = L^N > 0$ and $\mathrm{Y}_{q^*} = Y^R > 0.$

With homothetic preferences, we have the unit-expenditure function E(p), $\mathrm{E}'>0$. Using this and the GNI function (2), equilibrium on the markets for tradables and non-tradables is given by:

(3) $$\mathrm{Y}(R, L, K^T, p^*, q^*) = \mathrm{E}(p^*)u + r^*\left[K^T + \Psi(q^*/r^*)R\right]$$

(4) $$\mathrm{Y}_{p^*}(R, L, K^T, p^*, q^*) = \mathrm{E}'(p^*)u,$$

[5] We allow for intra-sectoral mobility of all factors of production, so do not focus on movements in the real exchange rate (e.g., Neary, 1988) but on movements in capital use in the various sectors of the economy.

where c denotes real consumption ('utility'), E(p*)c total consumer expenditure, and E′(p*)c consumption of non-tradables. Total differentiating (3) and (4) and abstracting from price effects p^* and r^*, we obtain real consumption and capital use in the traded sector ('non-resource FDI'):

(5) $$\mathrm{E}(p^*)\mathrm{d}c = p^*\mathrm{d}L + (1-\alpha^R)q^*Y^R\left(\frac{\mathrm{d}R}{R}+\frac{\mathrm{d}q^*}{q^*}\right)+\left(1-\frac{\varepsilon^{YR}}{\alpha^R}\right)r^*K^R\frac{\mathrm{d}q^*}{q^*} \quad\Rightarrow\quad c = \mathrm{c}\left(\overset{+}{R},\overset{+}{L},\overset{(+)}{q^*}\right)$$

(6) $$\Phi^*\mathrm{d}K^T = (1-\theta)\mathrm{d}L - \frac{\theta}{p^*}(1-\alpha^R)\left(\frac{\mathrm{d}R}{R}+\frac{\mathrm{d}q^*}{q^*}\right)-\theta\left(1-\frac{\varepsilon^{YR}}{\alpha^R}\right)r^*K^R\frac{\mathrm{d}q^*}{q^*}$$
$$\Rightarrow K^T = \mathrm{K}^\mathrm{T}\left(\overset{-}{R},\overset{+}{L},\overset{(-)}{q^*}\right),$$

where $0 < \theta \equiv p^*\mathrm{E}'/\mathrm{E} < 1$ is the share of non-tradables in consumption, $0 < \alpha^R \equiv r^*K^R / q^*Y^R < 1$ the share of capital in resource value added, and $\varepsilon^{YR} \equiv \Psi' R / Y^R > 0$ the supply elasticity of natural resource output. Conditional demand for capital in resource production is more price elastic than resource output, especially if the share of capital in resource production is relatively small (i.e., $\varepsilon^{KR} = \varepsilon^{YR} / \alpha^R > \varepsilon^{YR}$).

Equation (5) indicates that a bigger endowment of natural resources or labor (higher q^*R or L) boosts real consumption, especially if the share of capital and rents are high in the resource sector and of non-tradables in the consumption basket is high. Apart from via this endowment effect, a higher world resource price also has an output effect boosting real consumption and a substitution effect reducing it. The output effect dominates if the price elasticity of the demand for capital in the resource sector is less than one (i.e., $\varepsilon^{KR} < 1$). Both the output and the substitution effect are bigger if the share of capital in resource production and the share of non-tradables in consumption are large.

Equation (6) indicates that a bigger labor force attracts more non-resource FDI. If natural resource production also requires labor, more labor would also attract more resource FDI. This labor force determinant of FDI results from abundance of labor rather than market potential. Equations (1) and (6) indicate that a bigger value of subsoil natural assets (higher q^*R) attracts resource FDI, but leads to less non-resource FDI. More subsoil assets induce a bigger natural resource industry and thus lead to reallocation of resources from the traded to the resource sector. In both cases the effects are bigger if resource rents $\left(q^*Y^R - r^*K^R\right)$ are more substantial and non-tradables constitute a bigger fraction of the consumption basket. On top of this endowment effect, we see from (6) that higher world price of natural resources has an extra output and substitution effect on non-resource FDI which is negative (positive) if the price elasticity of the conditional demand for capital in the resource sector is smaller (larger) than unity. Furthermore, (1) indicates that higher world prices of natural resources boost resource FDI.

2.2. Different types of FDI, spatial determinants of FDI, and econometric specification

Vertical FDI occurs if manufacturing multinationals chop up their production chains into skill-intensive headquarters and R&D in home countries abundant in high-skilled labor and production in countries abundant in low-skilled labor. This off-shoring exploits cost and factor price differentials. Since production is shipped back to be sold at home, this leads to trade (Helpman, 1984). **Horizontal FDI** focuses at cutting trade and transportation costs by moving production plants and distribution centers overseas (Markusen, 1984, 2002). **Export-platform FDI** takes place if multinationals use horizontal FDI to sell in the host market and as export platform to sell in neighboring countries (Ekholm et al., 2007; Baltagi et al., 2007). **Export-fragmentation FDI** allows fragmentation of the production process where different intermediaries of the final good are produced in different countries, assembled in a third country, and then shipped back to the parent or another country (Yeaple, 2003).

Inspired by this classification of types of FDI, we add surrounding market potential and surrounding FDI as explanatory variables to equations (1) and 6) to arrive at the following econometric specification (cf., Blonigen et al., 2007; Baltagi et al., 2007; Poelhekke and van der Ploeg, 2009):

$$(7) \qquad f_{it}^{R} = \alpha_0 + \alpha_1 s_{it} + \alpha_2 q_{it} + \alpha_3 n_{it} + \boldsymbol{\alpha}_4 ' \mathbf{x}_{it} + \alpha_5 m_{\hat{\jmath}t} + \alpha_6 f_{\hat{\jmath}t}^{R} + \varepsilon_{it}^{R}, \quad \varepsilon_{it}^{R} \sim \mathrm{N}\left(0, \sigma_i^{R2}\right)$$

$$(8) \qquad f_{it}^{N} = \beta_0 + \beta_1 s_{it} + \beta_2 q_{it} + \beta_3 n_{it} + \boldsymbol{\beta}_4 ' \mathbf{x}_{it} + \beta_5 m_{\hat{\jmath}t} + \beta_6 f_{\hat{\jmath}t}^{N} + \varepsilon_{it}^{N}, \quad \varepsilon_{it}^{N} \sim \mathrm{N}\left(0, \sigma_i^{N2}\right),$$

where f_{it}^{R} and f_{it}^{N} denote, respectively, resource FDI and non-resource FDI going to country *i* at time *t*, s_{it} the subsoil assets of country *i* at time *t*, q_{it} the world commodity prices corresponding to the export basket of these subsoil assets in country *i* at time *t*, n_{it} the population size (a proxy for the labor force) of country *i* at time *t*, $\mathbf{x}_{it}$ the vector of other explanatory variables in country *i* at time *t* (e.g., income per capita, distance, institutional quality, trade openness and host country taxation), $m_{\hat{\jmath}t}$ and $f_{\hat{\jmath}t}^{R}$, respectively, surrounding market potential and surrounding resource FDI of countries neighboring country *i* at time *t*, $f_{\hat{\jmath}t}^{N}$ surrounding non-resource FDI, and ε_{it}^{R} and ε_{it}^{N} the stochastic error terms for the resource and non-resource FDI equations with zero means and variances σ_i^{R2} and σ_i^{N2}, respectively. Our null hypothesis based on equations (1) and (6) for the effect of subsoil assets is $\alpha_1 > 0$ and $\beta_1 < 0$. We also expect higher world commodity prices to boost resource FDI and curb non-resource FDI, so our null hypothesis for the effect of the world price of natural resources on the two types of FDI is $\alpha_2 > 0$ and $\beta_2 < 0$. Our null hypothesis based on equations (1) and (6) for the effect of population size is that $\alpha_3 = 0$ and $\beta_3 > 0$.

However, if the resource sector uses some labor, there will be a positive effect of population size on mineral/mining FDI, $\alpha_3 > 0$. If population size also captures part of host market potential, it should have an additional positive impact on FDI.

By estimating FDI at the sector level, we can distinguish between the various sorts of FDI by inspecting the signs of the coefficients on the spatial lag of FDI and surrounding market potential (Blonigen et al., 2007; Poelhekke and van der Ploeg, 2009). The gravity model emphasizes trade and transportation costs and is relevant for horizontal FDI which allows production in multiple locations close to the market with market size of the host country (proxied by income per capita and population size of the host country) and distance from parent company being key determinants of FDI. If exports to third countries are unattractive, a zero coefficient on the spatial lag of FDI and a zero coefficient on surrounding market potential ($\beta_5 = 0$ and $\beta_6 = 0$ for non-resource FDI) suggest evidence for **horizontal FDI**. In contrast, a negative coefficient on the spatial lag of FDI and a zero coefficient on surrounding market potential ($\beta_5 = 0$ and $\beta_6 < 0$) provide evidence for **purely vertical FDI** driven by multinationals seeking the lowest cost destination. Effectively, FDI in one country harms FDI in neighboring countries if multinationals seek out the best regional location. This applies to non-resource FDI but not to resource FDI, since the latter is determined not so much by cost advantage as by the presence of natural resources in the crust of the earth. Resource FDI is thus by nature vertical in nature. **Export-platform FDI** has the proximity benefits of horizontal FDI without the costs of setting up affiliates in surrounding countries. If trade protection between destination markets is less than frictions between parent and destination countries, export-platform FDI makes sense and one expects a negative coefficient for the spatial lag on FDI and a positive one for surrounding market potential ($\beta_5 > 0$ and $\beta_6 < 0$). However, with intermediate levels of border costs between the host country and its neighbors and a large peripheral (not centrally located within the group of neighboring countries) host market, surrounding market potential may have a negative effect (Blonigen, et al., 2007). With **complex-vertical fragmentation FDI** we expect a positive coefficient for the spatial lag on FDI ($\beta_6 > 0$) as more suppliers, ports, and other agglomeration advantages in surrounding countries make fragmentation FDI more attractive. A negative effect of surrounding GDP per capita supports the border-cost hypothesis ($\beta_5 < 0$). Evidence for aggregate FDI suggests a positive coefficient on the spatial lag of FDI and a negative coefficient for surrounding market potential, which points towards complex-vertical fragmentation FDI and the border-cost hypothesis (Blonigen et al., 2007; Poelhekke and van der Ploeg, 2009). Our prior is that we expect most non-resource FDI to be of this sort.

Since section 4 establishes that FDI is I(1), we will estimate an error-correction version of (7)-(8). Because of the spatial terms α_6 and β_6, we estimate by ML instead of OLS (see appendix 1).

3. Data on outward FDI and subsoil assets

3.1. Outward FDI data

We wish to test our hypotheses with outward FDI data on investments done by multinationals in the natural resource and other sectors in as many countries as possible. Since available FDI data sets either have large gaps in them for reasons of confidentiality or do not contain much resource FDI, we use a unique dataset on outward FDI from the Netherlands collected by De Nederlandsche Bank.[6] This dataset benefits from all firms being legally required to report their current-account transactions, including foreign investment flows and positions collected via banks, stating the balance sheet current euro value of FDI stocks and the value of new investment flows. Aggregate FDI and disaggregated FDI data for several broad sectors and large countries are available through the central bank's website.[7] At the more detailed level of specific countries and sectors, the data is confidential and accessible by special permission. They cover 183 host countries for the years 1984 to 2002 for the whole population of affiliates of multinationals; 133 countries receive positive non-resource FDI and 100 countries positive resource FDI. [8] [9] Five of these firms were among the 100 largest non-financial multinationals in the world in 2002 by foreign assets.[10] In 2007 Dutch FDI represented 5.5% of World FDI while US FDI represented 18% (UNCTAD, 2008). Due to limited data availability of regressors, we can use only 1602 of the 3477 (19x183) observations. A further 358 observations are lost when taking logs of resource FDI. The natural resource sector includes extraction of oil, natural gas and other minerals, processing industries of oil, coal and fissionable material, and the base metal industry. Following the Eurostat classification of FDI, outward stocks are classified according to the activity of the non-resident enterprise.

We measure FDI by the value to the parent firm of investments made abroad. It makes more sense to measure FDI by sales volume of affiliate sales if FDI is horizontal, i.e., if multinationals invest locally to sell in the local market, but evidence suggests that horizontal FDI is not very prevalent (Blonigen et al., 2007; Poelhekke and van der Ploeg, 2009). For vertical FDI local sales may be zero, because the affiliate is a link in a longer product chain and sales are made in third or in home countries. Sales within a

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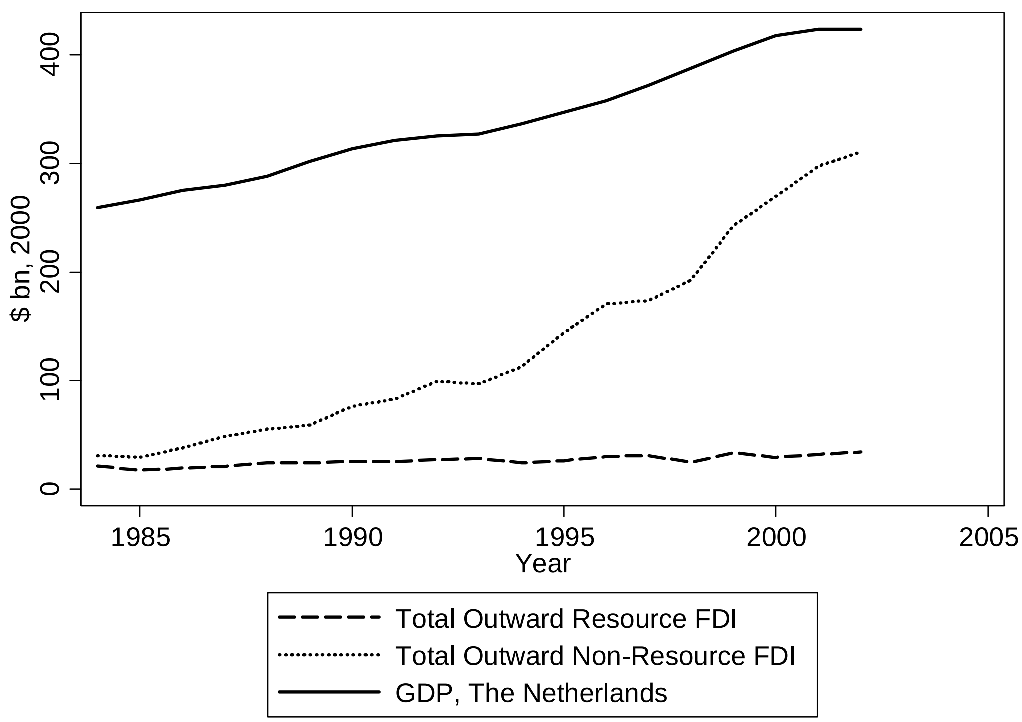
[6] For example, the largest sector sample from publicly available data on US outward FDI in Blonigen et al. (2007) is services. Assuming 16 years are available, there are at most 14 host countries for which FDI is positive and reported, which underestimates outward US FDI. For petroleum at most 9 host countries are available.
[7] See http://www.statistics.dnb.nl/index.cgi?lang=uk&todo=Balans, Table T12.6.2.
[8] Following the standard definition an affiliate is counted as FDI if the parent company owns at least a 10% stake.
[9] A change in the way FDI was reported caused a break in 2003. Before this date, all data was reported through the banking system, since they collect balance sheet data for loan purposes and perform the actual transactions. After April 2003, a new system was introduced based on direct reporting by resident parent companies, although since then a sample is used based on gathering about 95% of the total value of capital stocks and flows.
[10] These are (rank; industry): Shell (6; petroleum), Unilever (36; food product), Philips (37; electrical & electronic equipment), Ahold (51; retail), Reed Elsevier (90; publishing and printing). (UNCTAD, http://www.unctad.org/Templates/Page.asp?intItemID=2443&lang=1)

vertically integrated MNE are also not traded which makes it unclear how the price is determined. The stock of FDI (book value) seems a more accurate reflection of actual investment in the resource sector and other vertical industries. For natural resource extraction it is unlikely that extracted resources are all sold to third parties by the affiliate directly. Royal Dutch/Shell for example, a large oil and gas company, extracts oil in one place, but then ships the oil to refineries closer to markets where actual sales are made.

Among all countries, 149 countries attracted natural resource investment, showing the wide geographical scope of our data.[11] Among the top ten of largest destination countries for resource FDI in 2002 are the United Kingdom, Canada, Nigeria and Brazil. The latter two countries were not in the top 10 in 1984, ranking below Malaysia and Saudi Arabia. Top non-resource FDI destination countries in 2002 include the United States, Germany, Belgium and France. China ranks a mere 31st among all countries in terms of non-resource FDI. Interestingly, total FDI to China is in our sample period less than that to Nigeria. Fig. 1 shows the relative size of natural resource FDI versus non-resource FDI. Although resource FDI has declined as a share of total FDI, it amounted to $ 21 billion in 1984 and over $ 34 billion in 2002.

Figure 1: Total outward FDI



[11] There are currently 203 de facto states in the world.

Table 1: FDI outflows (stocks, 2000 $ millions)

Region	Total resource FDI		of which oil and coal processing industry and oil and gas extraction		Total non-resource FDI	
	2002	1984	2002	1984	2002	1984
East Asia & Pacific	5,095	624	92.7%	88.1%	18,603	1,722
Eastern Europe & Central Asia	1,269	86	94.8%	100.0%	8,957	46
Latin America & Caribbean	3,877	955	97.9%	92.7%	13,023	3,751
Middle East & North Africa	2,169	917	99.9%	99.8%	1,506	251
North America	8,006	15,016	94.5%	99.2%	74,296	9,504
South Asia	553	16	99.2%	100.0%	642	52
Sub-Saharan Africa	3,414	298	96.4%	78.7%	1,486	247
Western Europe	20,350	4,048	84.4%	90.1%	188,995	14,814
Total	44,733	21,960	90.4%	96.7%	307,509	30,387

Table 1 offers some stylized facts on outward FDI. About 85-100 percent of outward resource FDI consists of oil, gas and coal, so minerals and metals constitute a relatively small fraction of resource FDI. Although total resource FDI is 72.3 percent of non-resource FDI in 1984, it falls substantially to 14.5 percent of non-resource FDI in 2002. Non-resource FDI has grown much more during this period (13.7 percent per year on average) than resource FDI (4 percent year). Although resource FDI towards the US has almost halved, FDI stocks towards other parts of the world, including Europe, have grown a lot.

3.2. Measuring sub-soil assets

To estimate (7)-(8) we must measure sub-soil assets s_{it} with enough coverage across both countries and time. But it is difficult to estimate the value of energy and mineral resources (World Bank, 2006, Appendix 1). First, the importance of natural resources in national accounting has only recently been recognized, and most efforts to estimate their value have been undertaken by international organizations (such as the UN or the World Bank). Second, there are no liquid private markets for natural resource deposits which might convey information on their value. Third, reported reserves are only those that are economically worthwhile to extract at the time of determination and thus depend on the prevalent price of resources and cost of extraction. World Bank (2006) values the stocks of hydrocarbon resources (oil, gas and coal) using reserves data from the BP Statistical Review of World Energy and the Energy Information Administration (EIA), and the stocks of ten metals and minerals (bauxite, copper, gold, iron, ore, lead, nickel, phosphate rock, silver, tin and zinc) for those countries that report production figures. In many cases actual reserves data is not available in which case the World Bank makes the bold assumption that resources last another 20 years, regardless of the type or country (making reserves proportional to rents). Production costs themselves are often proxied by costs from other countries. Using this data as measure of reserves (subsoil assets) can lead to biased results, since reserve estimates are sensitive to prices, time to depletion, the social discount rate and extraction costs (van der Ploeg and Poelhekke, 2010).

Reserve data for non-hydrocarbon minerals have been collected by Norman (2009) for 1970 using a variety of sources. However, past production was used to infer 1970 reserves from observed reserves in 2002 so this estimate of reserves depends to a large extent on FDI used for exploration and production after 1970 and thus overestimates known reserves in 1970. Only using 1970 values would make inefficient use of the time variation in FDI.

Reserves data for oil, gas and coal measured in tons or cubic meters is available for a broad sample of countries and years from BP and the EIA. They report economically extractable reserves and production between (at most) 1965 and 2008[12], but the data is internally inconsistent for many country-years.[13]

To get around these issues we adopt different strategies. The World Bank (2006) has also constructed data on rents: the value of resource exports net of production costs. We use this data as a proxy for the value of resource deposits, using that the amount of rents correlates positively and strongly with the value of reserves.[14] This means that there is enough time variation to distinguish long- and short-run effects of resource booms. Alternatively, we summarize the World Bank rents data into a dummy variable, taking the value 1 if rents for any of the minerals are positive and zero else. We assume thus that sub-soil resource levels are positive if rents are non-zero.[15] Instead of measuring the effect of changing reserve levels, we thus measure the effect of resource discovery. Such a discovery should lead to factor allocation towards the resource sector and less FDI into other sectors.[16] An added benefit is that we can allow for countries with zero reserves, since we do not have to take logs of reserve levels.

Since much resource FDI concerns the hydrocarbon sector, we can distinguish between hydrocarbons and other minerals and create two dummy variables. In additional regressions we also show the results for

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[12] Proven oil and gas reserves data starts in 1980, and coal reserves are only recorded for 2005, while oil, gas and coal production data starts in respectively 1965, 1970 and 1980. These refer to reserves 'which geological and engineering data demonstrate with reasonable certainty (i.e., on the basis of successful pilot projects) to be recoverable in future years from known reservoirs under existing economic and operating conditions' (BP).

[13] For example, a country may report production during a number of years, while reporting unchanging reserve levels during that period. This implies that either as much oil was discovered as was produced or that production and/or reserve data are inaccurate. We might be willing to assume that reserve data is accurate if new discoveries require updating of the data. An increase in the reported level of reserves should indicate new discovery. Subtracting subsequent production data may then yield more precise reserve levels in those years where original reserve levels did not change. In some cases where reserve data shows little variation over time production is high enough to yield negative implied reserve levels, casting doubt on the assumption that new discoveries are accurately recorded.

[14] A simple regression tells us that a 1% increase in log amount of hydrocarbon reserves correlates with a 0.8% increase in the log value of hydrocarbon rents. For other minerals we only have reserve data in 1970 from Norman (2009). In this case the correlation with non-hydrocarbon rents in 1970 is 0.7%.

[15] We lag both variables by one year to avoid reverse causality.

[16] For some countries rents are zero in some years and positive in later and earlier years because of (civil) war. During such periods sub-soil resources are not economically extractable, so resource FDI may well be zero then.

taking the oil, gas and coal reserve data from BP/EIA as given (where we convert all reserves to British Thermal Units (BTU) and take logs). Although there may be measurement error in this variable, it does allow us to distinguish between the effects of reserve quantities and their price.[17]

4. Core results: determinants of non-stationary outward non-resource FDI stocks

The strong upwards trend of aggregate outward FDI reported in fig. 1 suggests that FDI is non-stationary. It may be not enough to allow for a common deterministic trend, since FDI may be heterogeneously non-stationary at the country level. Recent studies that do not explicitly take account of these issues assume that each time period is independent from the next and that investment in a specific host country is independent from investments done earlier in the same host country, but this seems overly restrictive. For example, Baltagi et al. (2007) estimate the (spatial) determinants of US outward FDI stocks and affiliate sales between 1989 and 1999 using as much industry level data as is publicly available. Although they carefully allow for third-country effects and industry-time dummies to capture industry-time specific effects common to host countries, they do not test for stationarity of FDI or other regressors. If FDIs to specific host countries trend heterogeneously, the estimated coefficients and standard errors on the pooled data are unreliable. Similarly, Blonigen et al. (2007) use the same data source on affiliate sales data over 16 years; except for a common deterministic trend, they do not investigate the time-series properties of the data. The instability created by potentially trending variables could affect the estimates as well. Carr et al. (2001) and Markusen and Maskus (2002) do not allow for cross-sectional dependence and treat each host country as an independent destination, and are thus susceptible to a similar critique. Brainard (1997) circumvents the problem of non-stationarity by limiting the analysis to cross sections, but this is less efficient than working with panels of observations.

Apart from outward FDI, human capital, GDP and the size of the population may also be non-stationary. This need not be a problem if ε_{it} is stationary, because equations (7) and (8) then form a co-integrated relationship from which we can deduce the long-run effects on FDI. To verify whether this is the case, we test whether the independent variables have a unit root taking into account cross-sectional dependence arising from spatial effects. Such cross-sectional dependence renders standard IPS tests for a unit root (Im, Pesaran and Shin, 2003) invalid, but CIPS unit root tests take into account general cross-sectional dependence by augmenting ADF regressions for each country with cross-section averages (Pesaran, 2007). Moreover, the standardized version of the cross-sectionally augmented Dickey-Fuller (CADF)

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[17] Assuming perfect substitutability between coal, gas and oil, we will use the oil price as the price of BTUs.

allows for unbalanced panels.[18] Since this test cannot accommodate gaps in the data and requires at least six time periods, we drop Afghanistan, Ghana and Congo (for which we have less than six observations each) and remove gaps in the data.[19]

Table 2 presents the results of the CADF(p) test for orders $p=0$ and $p=1$ and for two types of deterministic components in columns (a) and (b). In almost all cases we cannot reject the unit root hypothesis at the 10% level. For population and surrounding market potential we can also not reject the null if we restrict the sample to a balanced panel. Column (c) performs the same tests on the first difference of every variable to test for a possible mixture of I(1) and I(2) variables. This time we almost always comfortably reject the null, also if we test a balanced panel of observations for the log of population. Overall, we can thus regard all variables as I(1).

Tabel 2: CIPS panel unit root tests

	(a) Intercept		(b) Intercept + trend		(c) Intercept + First Difference	
	$CADF_i(0)$	$CADF_i(1)$	$CADF_i(0)$	$CADF_i(1)$	$CADF_i(0)$	$CADF_i(1)$
ln non-resource FDI	-1.86**	0.92	0.86	4.33	-16.23***	-3.32***
ln population	-7.01***	0.12	10.43	3.40	5.82	0.05
ln human capital	0.67	5.83	3.76	10.52	-15.20***	-1.01
ln GDP per capita (t-1)	4.92	5.06	2.76	2.21	-9.76***	-2.41***
ln GDP surrounding market potential	-2.66***	2.20	-3.29***	0.91	-10.46***	-0.62
Real exchange rate with NL based on GDP price level	-0.33	-0.94	1.49	1.07	-11.98***	-2.09**
Implicit tax rate (Government share of GDP*100)	-1.01	0.89	0.342	1.51	-12.91***	-3.85***
ln Hydrocarbon resource rents (t-1)	-0.91	1.97	-2.67***	0.94	-18.54***	-4.90***
ln non-resource FDI (i-1)	-1.56*	2.95	0.96	5.44	-11.91***	-2.55***

Note: H0: All series are non-stationary. N=65; T≈16.86. The statistics are the standardized version of the CIPS(p) statistic for an unbalanced panel. The CIPS(p) statistic is the cross-section average of the cross-sectionally augmented Dickey-Fuller test statistic ($CADF_i(p)$)). Following Pesaran (2007), extreme t-values are truncated to avoid any undue influence of extreme outcomes, because t is small (10-20). *** p<0.01, ** p<0.05, * p<0.1 For the first difference of ln population we also reject the null if we restrict the sample to a balanced panel (N=43; T=18; CADF(1) = -11.215***).

We now test the null of no co-integration between FDI, control variables and resource wealth, using the residuals from regression (8) for the sample without gaps used in table 2. The regression is presented in column (a) of table 4. Because cross-sectional dependence is best taken care of by allowing for a spatially

[18] Baltagi, Bresson and Pirotte (2007) show that, if spatial dependence is present in the data, the Pesaran (2007) test performs much better than first generation panel unit root test which do not take cross-sectional dependence into account. In our case this matters because we expect spatial dependence in FDI and GDP.

[19] There are 13 gaps in the data, so we delete the countries Bahrain, Barbados post 2000, Bolivia before 1987, Cameroon, Iran, Kuwait post 2001, Mozambique before 1991, Rwanda post 1997 and Venezuela before 1990, affecting 55 observations in total.

lagged dependent variable according to the robust LM tests[20], we test for co-integration using the standard IPS test procedure which allows for heterogeneous autoregressive parameters. The alternative LLC test (Levin, Lin and Chu, 2002) has more power, but also requires balanced data and assumes a homogenous auto-regressive parameter (Banerjee and Wagner, 2009). For completeness we also report the results from the LLC test in table 3 below. The null of no co-integration is rejected at the 1% level for two augmentation orders. Hence, the variables in regression (a) of table 4 are co-integrating and represent a relationship that is stable over time, thus allowing us to interpret the coefficients as the long-run determinants of FDI.

Table 3: Co-integration test on residuals of equation (8)

IPS	ADF(0) N=65; T≈16.86	ADF(1) N=65; T≈16.86
	-2.51***	-2.56***
LLC	ADF(0) N=43; T=19	ADF(1) N=43; T=19
	-5.52***	-4.76***

Note: IPS: H0: All panels contain unit roots. Allows for panel specific auto-regressive parameter and includes panel means. LLC: H0: Panels contain unit roots. Assumes homogenous auto-regressive parameter.
*** p<0.01, ** p<0.05, * p<0.1

The estimates may nonetheless be biased because the error term ε_{it} in equation (8) may be correlated with each of the disturbances of the I(1) processes belonging to each independent variable. One can correct for this correlation by including leads and lags of the first difference of the I(1) independent variables in the regression – dynamic OLS or D-OLS (Kao and Chiang, 2000; Mark and Sul, 2003). Simulations in Wagner and Hlouskova (2010) suggest that D-OLS outperforms fully modified OLS (Phillips and Moon, 1999) and is least sensitive to I(2) components, cross-sectional correlation and small T (say ≤ 25).

Column (b) in table 4 adds first-differenced leads and lags of the independent variables to equation (7). The resulting regression (not reporting the leads and lags) is very similar to column 1 even though we lose 195 observations because of the leads and lags. This confirms that equation (7) represents a stable and unbiased long-run relationship between FDI and the independent variables. We find that there is evidence that hydrocarbon resource rents have a significant negative impact on non-resource FDI, thus confirming the main prediction entailed in equation (6). Furthermore, we find the usual determinants of non-resource FDI. Market potential (proxied by GDP per capita and population size) and human capital significantly attract non-resource FDI whilst distance and a high implicit tax rate in the host country significantly deter it. Furthermore, we find statistically significant support for the hypothesis that, given informational imperfections in globally integrated capital markets, destination countries where the currency is weak in

[20] The tests are based on a whether the general regression $\mathbf{y} = \mathbf{X}\mathbf{b} + \boldsymbol{\varepsilon}$ can be significantly improved by including either of the terms $\boldsymbol{\rho}\mathbf{W}\mathbf{y}$ or $\boldsymbol{\lambda}\mathbf{W}\boldsymbol{\varepsilon}$, robustified against the alternative of the other form. See also Appendix 1.

real terms attract more FDI due to more spending power of home firms and/or lower costs of non-tradables costs in the destination country (cf., Froot and Stein, 1991).

Table 4: Dynamic estimation of the co-integration relationship

Dependent variable:	(a) SAR **ln non-resource FDI**	(b) Dynamic SAR **ln non-resource FDI**
ln population	1.166***	1.132***
	(0.041)	(0.043)
ln human capital	1.562***	1.728***
	(0.163)	(0.165)
ln distance from NED (Vincenty)	-1.643***	-1.656***
	(0.100)	(0.108)
trend	0.136***	0.128***
	(0.014)	(0.014)
ln GDP per capita (*t*-1)	1.183***	1.047***
	(0.111)	(0.109)
ln GDP surrounding market potential	-3.083***	-3.040***
	(0.221)	(0.231)
Real exchange rate with NL based on GDP price level	-0.369***	-0.416***
	(0.044)	(0.054)
Implicit tax rate (Government share of GDP*100)	-0.059***	-0.065***
	(0.007)	(0.007)
ln Hydrocarbon resource rents (*t*-1)	-0.142***	-0.144***
	(0.019)	(0.021)
ln non-resource FDI (*i*-1)	0.365***	0.397***
	(0.065)	(0.069)
Constant	14.581***	15.840***
	(2.411)	(2.655)
Observations	1096	901
Log-likelihood	-1944	-1506
robust LM rho=0	31.25***	29.78***
robust LM lambda=0	4.152**	2.501
Variance Ratio	0.799	0.825

SAR = spatial auto-regression. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Finally, the significant negative effect of surrounding on market potential and the significant positive spatial lag of the independent variable suggest that non-resource FDI is mainly of the complex-vertical fragmentation variety (cf., Blonigen et al., 2007; Poelhekke and van der Ploeg, 2009). Interestingly, the positive spatial lag implies that the negative effect of resource abundance on non-resource FDI also spreads to other countries (about 40%). This increases the negative effect of resource abundance on FDI even more as there will be less potential suppliers of non-resource FDI in neighbouring countries.

Since equation (8) is a co-integrating relationship, we finally present in table 5 the estimates of both the short- and long-run dynamics of the following panel error-correction model:

$$\text{(8}'\text{)}\qquad \begin{aligned}\Delta f_{it}^{N} &= \beta_0 + \xi[f_{i,t-1}^{N} - \beta_1 s_{i,t-1} - \beta_2 q_{i,t-1} - \beta_3 n_{i,t-1} - \boldsymbol{\beta}_4\,'\mathbf{x}_{i,t-1} - \beta_5 m_{f,t-1} - \beta_6 f_{f,t-1}^{N}] \\ &+\kappa_1 \Delta s_{it} + \kappa_2 \Delta q_{it} + \kappa_3 \Delta n_{it} + \boldsymbol{\kappa}_4\,'\Delta \mathbf{x}_{it} + \kappa_5 \Delta m_{ft} + \kappa_6 \Delta f_{ft}^{N} + \kappa_7 \Delta f_{i,t-1}^{N} + \upsilon_{it}^{N}, \quad \xi > 0.\end{aligned}$$

The error-correction coefficient ξ is significant at the 1% level which confirms convergence towards the steady state after short-term shocks (down to 10% of steady state in 15 years for columns (a) and (b)). Still, column (a) indicates that few of the short-run dynamic effects κ_i are statistically significant. For example, a temporary shock in the price of natural resources leading to higher rents does not induce a statistically robust immediate decline in FDI. However, a *permanent* shock to resource wealth (e.g., due to newly discovered reserves) significantly lowers the equilibrium volume of non-resource FDI.

Although we explicitly model cross-sectional dependence and the long- and short-run dynamics, exogenous shocks might still be correlated within countries. Column (b) therefore provides an additional robustness test by allowing for clustered standard errors at the country level. This hardly changes the results. As a final test we allow in column (c) for fixed country effects, which include distance and other (unmeasured) time invariant determinants of FDI, and we allow FDI to follow a distinct deterministic trend in each country. This changes the coefficients, but does not alter our qualitative results either. The estimated average speed of convergence, conditional on a country-specific trend, is higher (down to 10% in only 3 years) and a resource boom has a stronger effect on the de-meaned and de-trended (by country) level of FDI.

We conclude that resource abundance mainly has a negative impact on non-resource FDI in the long run, but short-run dynamics mostly arise from shocks to non-resource FDI itself. In the following empirical sections we therefore abstract from short-run dynamics other than those arising from FDI itself.

Table 5: Panel error-correction estimates (SAR with error correction)

Dependent variable: Δ(1) ln non-resource FDI			
Error correction:	(a)	(b)	(c)
ln non-resource FDI (*t*-1)	-0.145***	-0.145***	-0.527***
	(0.035)	(0.031)	(0.080)
ln population (*t*-1)	0.150***	0.150***	1.985**
	(0.038)	(0.037)	(0.972)
ln human capital (*t*-1)	0.376***	0.376***	0.771**
	(0.094)	(0.094)	(0.352)
ln distance from NED (Vincenty) (*t*-1)	-0.193***	-0.193***	
	(0.067)	(0.058)	
trend (*t*-1)	0.002	0.002	2.117***
	(0.007)	(0.007)	(0.366)
ln GDP per capita (*t*-2)	0.060	0.060	0.604
	(0.046)	(0.053)	(0.372)
ln GDP surrounding market potential (*t*-1)	-0.297**	-0.297***	-0.028
	(0.122)	(0.109)	(0.483)
Real exchange rate with NL based on GDP price level (*t*-1)	-0.075***	-0.075***	0.269***
	(0.025)	(0.028)	(0.101)
Implicit tax rate (Government share of GDP*100) (*t*-1)	-0.010***	-0.010***	-0.022**
	(0.003)	(0.004)	(0.011)
ln Hydrocarbon resource rents (*t*-2)	**-0.020****	**-0.020****	**-0.082****
	(0.009)	**(0.009)**	**(0.042)**
ln non-resource FDI (*i*-1, *t*-1)	0.091***	0.091**	0.059
	(0.031)	(0.037)	(0.073)
Short-run dynamics:			
Δ(1) ln non-resource FDI (*t*-1)	-0.009	-0.009	-0.017
	(0.029)	(0.029)	(0.045)
Δ(1) ln population	1.271*	1.271**	1.317**
	(0.738)	(0.540)	(0.525)
Δ(1) ln human capital	0.122	0.122	0.163
	(0.373)	(0.325)	(0.383)
Δ(1) ln GDP per capita (*t*-1)	0.483	0.483	0.645
	(0.548)	(0.450)	(0.536)
Δ(1) ln GDP surrounding market potential	-1.182	-1.182	-1.263*
	(0.769)	(0.809)	(0.754)
Δ(1) Real exchange rate with NL based on GDP price level	0.011	0.011	0.151**
	(0.036)	(0.034)	(0.067)
Δ(1) Implicit tax rate (Government share of GDP*100)	0.008	0.008	-0.006
	(0.011)	(0.012)	(0.017)
Δ(1) ln Hydrocarbon resource rents (*t*-1)	-0.005	-0.005	-0.051
	(0.052)	(0.050)	(0.032)
Δ(1) ln non-resource FDI (*i*-1)	0.247**	0.247	0.212**
	(0.097)	(0.244)	(0.085)
Constant	1.934*	1.934**	-34.524***
	(1.074)	(0.966)	(10.018)
Clustered standard errors		yes	
Fixed effects and heterogeneous trends ($\varepsilon_{it}^{O} = f_i + d_i t + u_{it}^{O}$)			yes
Observations	998	998	998
Log-likelihood	-796.4	-796.4	-573.9
Variance Ratio	0.147	0.147	0.455

Robust standard errors in parentheses unless stated otherwise. *** p<0.01, ** p<0.05, * p<0.1

5. Testing for rival hypotheses and robustness

Our core results presented in table 5 may be the result of the rival hypothesis that FDI is higher in countries with good institutions if natural resource endowments happen to be correlated with bad rule of law, corruption or macroeconomic instability. An alternative rival hypothesis is that resource-rich countries attract more FDI if international trade is restricted. To test for these rival hypotheses (and to avoid potential omitted variables bias), table 6 presents estimates of our space-time auto-regressive (STAR) specification with institutional quality, openness to international trade, and free-trading arrangements (FTA) added as additional explanatory variables. We allow for time-varying institutional quality by taking five-yearly averages of institutional quality, which also deals with the potential endogeneity of institutional quality. Column (a) with total resource rents and column (b) with hydrocarbon and other mineral resource rents entered separately indicate that none of these effects are statistically significant, so we reject the rival hypotheses that natural resource abundance are a proxy for poor quality institutions and that trade protection might boost FDI stocks. We thus drop these variables in the other columns of table 6.[21]

Our finding that institutions do not affect non-resource FDI is consistent with earlier results that a broad measure of risk does not affect FDI[22], although we do not claim that specific characteristics related to the quality of institutions (e.g., corruption) could still matter.[23] Institutional openness to trade also does not affect the amount of outward FDI, but in section 6 we examine the possibility that openness affects the fixed costs of engaging in FDI rather than the volume of FDI.[24] Column (c) indicates that other

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[21] We also experimented by including measures of macroeconomic instability which might deter FDI. But inflation volatility and 5-yearly GDP per capita growth volatility were not significant and did not affect the results.

[22] Wheeler and Mody (1992) did not find a significant correlation between the size of FDI by US firms and the host country's risk factor, a composite measure that includes perception of corruption as one of the components. The authors concluded that the importance of the risk factor should ''be discounted, although it would not be impossible to assign it some small weight as a decision factor'' (p. 70)." Wheeler and Mody (1992) combined the corruption measure with twelve other indicators to form one regressor. These other indicators include ''attitude of opposition groups towards FDI'', ''government support for private business activity'', and ''overall living environment for expatriates'', which may not be overwhelmingly correlated with government corruption, may not be precisely measured, or may not be as important for FDI as one imagines.

[23] A study on bilateral investment from 12 source to 45 host countries finds that a higher tax rate on multinationals or more corruption in the host country deters inward FDI (Wei, 2000). A recent study based their empirical analysis on two measures of activity by U.S. majority-owned foreign affiliates: panel data for aggregate real gross product in manufacturing that originates in a given host country and micro data for a single year regarding the likelihood of a firm locating in a given host country (Mutti and Grubert, 2004). Their estimates indicate that investment geared towards export markets, rather than the domestic market, is particularly sensitive to host country taxation, and that this sensitivity appears to be greater in developing countries than developed countries and growing over time.

[24] Openness to trade (Wacziarg and Welch, 2008) is composed of five criteria for specific trade-related policies. A country is considered closed if it meets at least one of the following: (i) average tariff rates of 40% or more (TAR); (ii) non-tariff barriers covering 40% or more of trade (NTB); (iii) a black market exchange rate at least 20% lower than the official exchange rate (BMP); (iv) a state monopoly on major exports (XMB); (v) a socialist economic

Table 6: Testing for the impact of institutions, trade openness and FTA on FDI

Dependent variable:	**ln Non-Resource FDI**				
	(a) STAR	(b) STAR	(c) STAR	(d) STAR (Preferred estimate)	(e) STAR
ln population	0.221***	0.201***	0.175***	0.168***	0.135***
	(0.075)	(0.049)	(0.042)	(0.036)	(0.030)
Openness dummy	0.117	0.080			
	(0.080)	(0.073)			
ln human capital	0.409**	0.284***	0.303***	0.372***	0.323***
	(0.163)	(0.098)	(0.087)	(0.093)	(0.105)
ln distance from NED (Vincenty)	-0.290***	-0.192***	-0.172***	-0.181***	-0.130***
	(0.107)	(0.070)	(0.050)	(0.047)	(0.037)
trend	0.022*	0.010			
	(0.013)	(0.009)			
ln GDP per capita (*t*-1)	0.131	0.182***	0.163***	0.099**	0.101**
	(0.084)	(0.068)	(0.057)	(0.043)	(0.046)
ln GDP surrounding market potential	-0.529**	-0.253**	-0.197*	-0.304***	-0.186**
	(0.246)	(0.126)	(0.102)	(0.098)	(0.085)
FTA with Netherlands	0.220	0.135			
	(0.163)	(0.097)			
Real exchange rate with NL based on GDP price level	-0.134***	-0.126***	-0.121***	-0.105***	-0.088***
	(0.048)	(0.034)	(0.032)	(0.026)	(0.027)
Implicit tax rate (Government share of GDP*100)	-0.017**	-0.014***	-0.013***	-0.009***	-0.010***
	(0.007)	(0.004)	(0.004)	(0.003)	(0.003)
Institutions 5-yearly	0.003	0.003			
	(0.005)	(0.004)			
ln Total resource rents (*t*-1)	-0.017*				
	(0.009)				
ln Hydrocarbon resource rents (*t*-1)		-0.019*	-0.026**	-0.021**	
		(0.011)	(0.011)	(0.009)	
ln Other mineral resource rents (*t*-1)		0.012	0.005		
		(0.010)	(0.009)		
ln Hydrocarbon reserves in BTU (*t*-1)					-0.018*
					(0.011)
Oil Price (constant 2008 USD)					-0.006***
					(0.002)
ln Non-Resource FDI (*i*-1)	0.120***	0.109***	0.142***	0.150***	0.104***
	(0.045)	(0.036)	(0.039)	(0.035)	(0.034)
ln Non-Resource FDI (*t*-1)	0.751***	0.785***	0.810***	0.831***	0.854***
	(0.091)	(0.053)	(0.045)	(0.034)	(0.031)
Constant	2.857*	0.011	0.169	1.263	0.443
	(1.475)	(1.003)	(0.915)	(0.862)	(0.847)
Observations	1160	863	915	1085	939
Log-likelihood	-1420	-699.2	-771.7	-962.7	-797.6
robust LM rho=0	4.143**	6.430**	13.07***	19.00***	11.47***
robust LM lambda=0	0.547	2.067	1.747	5.125**	0.228
Variance Ratio	0.925	0.962	0.960	0.965	0.966

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

system (SOC). They show that trade liberalization is mostly driven by changes in XMB and BMP. Liberalization of a state monopoly on major exports may be especially important for (resource) FDI.

mineral resource rents do not significantly impact non-resource FDI and thus column (d), our preferred estimate, drops this explanatory variable. The insignificance of other mineral resource stems from the stylized fact displayed in Table 1 that most of resource FDI in our data is of the hydrocarbon type.

For most minerals there is no time-varying data available on the level of reserves, which is why we have used rents so far. However, detailed data on a country-by-country basis are available for oil, gas and coal reserves and for the world price of crude oil (BP, 2009). Although these data exclude minerals, agriculture, etc. and thus do not cover all natural resources, reserves are available for many countries and most outward resource FDI in our sample is related to oil and gas. Column (e) of table 6 shows that the negative effect of natural resources on non-resource FDI is robust if hydrocarbon resource rents are replaced by hydrocarbon reserves in BTU and the world price of oil. The regression suggests that price effects are more detrimental than the effects of changing reserve levels themselves. All other core determinants of FDI remain significant in all columns of table 6.

Further robustness tests using a 0-1 dummy for reserves depending on whether rents are zero or positive rather than rents or reserves are presented in appendix 3, table A2, columns (d)-(f). This yields a bigger sample as now country periods with zero rents can be included (see section 3.2). They confirm our qualitative results on the determinants of non-resource FDI, but given that we now have a larger sample some controls are now significant which were not when we excluded the country years with zero rents. For example, countries with good institutions now attract more non-resource FDI on average, but countries with good institutions *within* a sample of resource exporters (with positive rents) do not significantly attract more non-resource FDI than resource exporters with worse institutions. A similar result now holds for trade openness. Being a member of GATT/WTO has no effect on FDI and there is no robust (negative) effect of being landlocked on FDI either once short-run dynamics are taken into account. A boom in a particular resource (such as gold) leads to a decline in non-resource FDI.

6. Two-stage estimation procedure: correcting for sample selection bias in outward FDI

Gravity equations to estimate bilateral trade flows (e.g., Tinbergen, 1962; Anderson and Wincoop, 2003) have been corrected for sample selection bias by allowing for external and internal margins in international trade (Helpman, et al., 2008).[25] The resulting two-stage procedure estimates selection into trade partners in the first stage and trade flows in the second stage; it indicates that traditional gravity estimates are biased and that most of the bias is due to omission of the extensive margin rather than

[25] This follows the tradition of estimating internal and external margins of labor supply to avoid sample selection bias (Heckman, 1979).

sample selection bias. Since the volume of trade between pairs of countries that trade with each other depends on the fraction of firms that engages in foreign trade, the intensive margin of trade is substantially driven by variations in the fraction of trading firms rather than by new trade partners. The new gravity approach can explain 'zeroes', i.e., that no firm may be productive enough to export from one country to another country, and asymmetric bilateral trade patterns.

Recently, a similar procedure has been used to empirically investigate FDI and the location decisions of heterogeneous multinationals with firm-level data suggesting that the most productive French firms invest in relatively tough host countries (Chen and Moore, 2010). We investigate outward FDI at the sectoral level, where the problem of zeroes is much less severe. In our data there are 20 percent zeroes in resource FDI and 5% zeroes in non-resource FDI versus 55 percent zeroes in the 1986 cross section of bilateral trade flows of Helpman, et al. (2008) and 92 percent zeroes in the mergers & acquisitions data in Head and Ries (2008). To tackle the problem of zeroes in FDI data, we correct for sample selection bias arising from omitted variables that measure the impact of the number of firms that engage in FDI to a particular country. We adopt an agnostic approach and specify probit equations for the first stage to estimate the probability that there is FDI to a particular country and use the resulting predictions in the second stage to estimate the determinants of outward FDI. The advantage of this method is that the decision to invest abroad and the decision on the amount of investment to be made are determined separately. Alternative methods such as simple OLS on the selected sample have to assume that both decisions are independent while a Tobit regression makes the strong assumption that both decisions can be captured by the same model and the nonlinear Poisson model (used in the context of trade by Santos Silva and Tenreyro (2006)) allows inclusion of both zero and non-zero trade flows but makes the assumption that the decision to trade and the amount of trade are a single decision.[26] We favor the two-stage method, because it does not make such assumptions on the nature of the decision process.

Although the two-step method is not necessary to obtain consistent estimates, it is more convincing if at least one of the variables that determine entry in foreign markets does not also determine the size of investment. For example, Helpman et al. (2008) find evidence that the decision to export is well determined by measures of the cost of entry in a foreign market, while entry costs do not affect the amount of trade. A similar argument could be made for FDI, but the available data on entry costs combined with our FDI data does not yield country years for which FDI is zero.[27] We therefore argue that

[26] The non-linear Poisson model tends to underestimate the number of zero trade flows. The alternative, a two-part zero-inflated model with a negative binomial density, corrects this. However, just as with OLS on the selected sample, it also relies on the assumption that the decision of entry and the amount of trade are independent.

[27] This observation is consistent with the idea that more productive firms engage in foreign trade and only the most productive firms engage in more complex foreign direct investment (Helpman et al., 2004). If multinationals are

the fixed costs of entering a foreign market are better proxied by an index of a country's institutional openness to trade (Wacziarg and Welch, 2008) and whether it is landlocked.[28] Closed economies, whether in the physical sense of infrastructure needed or institutional sense of licenses etc., severely complicate setting up vertical production chains or export-platform operations. Even for horizontal FDI (fixed) inputs may have to be initially imported which is much more costly if the market is closed. An additional advantage of using openness is that it varies (slowly) over time. In the following we denote the selection variables by c_{it}, as a determinant for the first stage that is not used in the second stage (i.e., satisfies the exclusion restriction).[29] Since the decision to invest and the decision that determines the amount of investment in a host country are also determined by investments potentially made in neighboring countries, we also allow for spatial dependence in the first-stage probit regression. We thus estimate the following two-stage model for non-resource FDI with the Heckman (1979) correction:

$$\text{(8a}''\text{)} \qquad \Pr(f_{it}^N > 0 / c_{it}, s_{it}, q_{it}, n_{it}, x_{it}, m_{ft}, f_{ft}^N) = \Phi\left(\gamma_1 s_{it} + \gamma_2 q_{it} + \gamma_3 n_{it} + \boldsymbol{\gamma}_4{}'\mathbf{x}_{it} + \gamma_5 m_{ft} + \gamma_6 f_{ft}^N + \gamma_7 c_{it}\right)$$

$$\text{(8b}''\text{)} \qquad \begin{aligned} \mathrm{E}\left[f_{it}^N / f_{it}^N > 0, s_{it}, q_{it}, n_{it}, x_{it}, m_{ft}, f_{ft}^N\right] &= \beta_0 + \xi[\beta_1 s_{i,t-1} + \beta_2 q_{i,t-1} + \beta_3 n_{i,t-1} + \boldsymbol{\beta}_4{}'\mathbf{x}_{i,t-1} \\ &+ \beta_5 m_{f,t-1} + \beta_6 f_{f,t-1}^N] + (1-\xi) f_{i,t-1}^N + \rho_i^N \sigma_i^N \phi_{it}^N + \varepsilon_{it}^N \end{aligned}$$

where Φ(.) indicates the cumulative normal density function and ρ_i^N are the correlations between unobserved determinants of decisions to start non-resource FDI and unobserved determinants of this FDI once it has already started. The term $\phi_{it}^N = \varphi(.) / [1-\Phi(.)]$ denotes the inverse Mills ratio, where φ(.) denotes the standard normal density function. This ratio is included in the second stage (8b″) to correct for sample selection bias and is calculated from the estimated parameters of the first stage (8a″). By including the inverse Mills ratio in the second stage, estimating the coefficients $\beta_{7i} \equiv \rho_i^N \sigma_i^N$ and realizing that the standard deviation σ_i^N cannot be zero, the null hypothesis that $\beta_{7i} = 0$ is equivalent to testing for sample selectivity (i.e., the null that $\rho_i^N = 0$). The estimates thus generated correspond to a LIML estimator. To obtain the correct standard errors, we re-sample with a bootstrap.[30] Consistency of the estimates requires that the error terms ε_{it}^N are normally distributed. Table 7 presents the two-stage

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more productive than exporting firms on average, than it should be no surprise that all multinationals in our sample have been able to overcome the entry costs which deterred less productive firms from exporting.

[28] There are several alternative candidates, but common language as in Helpman et al. (2008) is not helpful as outside the Netherlands few countries speak Dutch. A dummy for free trade areas is not included, since it perfectly predicts positive other FDI. Colonial ties also make less sense in our context.

[29] In addition, we replace the log of resource rents by the resource dummy which is equal to one if rents are positive in a given country and year. This way we avoid having selection depend also on whether rents are positive.

[30] Because the estimation procedure is very computing intensive we limit the bootstrap to 200 replications.

estimates. The dependent variable in (8a″) is set so that it is zero if FDI is zero and one else. The latter occurs rarely, but signifies an investment relationship between the home and the host country.[31] Following Helpman et al. (2008) we include predictions from the probit model, but also its square and cube. They are added to control for firm heterogeneity (dropping the Pareto assumption). Since trade openness and being landlocked do not affect the amount of FDI, we include them as instruments in the first stage.

The SAR estimates of the first stage correspond to a Bayesian spatial auto-regression probit model and are given in column (a) of table 7. The instruments trade openness and being landlocked are significant and have the correct sign, and judging from the benchmark regression (b) they do not help predict the amount of investment. Column (a) reveals several interesting contrasts with the decision on the amount of FDI to undertake.[32] For example, whether non-resource FDI takes place with a particular destination country is more likely if it is farther away from the home country (consistent with FDI being a substitute to trade) but the volume of FDI undertaken is less (consistent with distance limiting corporate control). Also, surrounding market potential increases the likelihood to invest, but relatively more investment goes to larger neighboring markets. Harder to explain is the positive effect of non-zero resource rents on the decision to invest in combination with the robust negative effect of rents on the volume of investment. The former could relate to a possible spending effect from natural resources, possibly boosting market potential at least in the short run, while the latter relates to the negative reallocation effect from the traded to the resource sector.[33]

Turning to the second stage reported in column (c), we note that the inverse Mill's ratio is significant at the 10% level. However, once we bootstrap the errors and include the predicted probability of FDI occurring and its square and cube as in column (d), we find that neither the inverse Mill's ratio nor the predicted probabilities that control for multinational heterogeneity are statistically significant at the 10% level. We thus conclude that there is no evidence of sample selection bias. This is also reflected in the coefficient estimates of regression (d) compared to the benchmark regression (b), which are all similar.

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[31] The countries with zero FDI in some years are China, Congo, Dem. Rep., Ghana, Honduras, Hungary, Iceland, Mali, Mozambique, Nicaragua, Niger, Papua New Guinea, Poland, Togo, and Uganda.
[32] Marginal effects have similar sign and significance (not reported).
[33] Closer inspection of the resource dummy reveals that quite a few very poor countries have no production of minerals in most years, such as Haiti, Mali, Malawi, El Salvador and Nepal.

Table 7: Testing for sample selection bias in non-resource FDI

Dependent variable:	Non-resource FDI	ln Non-resource FDI		
	1st stage	Benchmark	2nd stage	bootstrapped se
	(a) SAR	(b: STAR)	(c) STAR	(d) STAR
ln population	0.158***	0.176***	0.182***	0.178***
	(0.060)	(0.042)	(0.042)	(0.050)
ln human capital	0.331***	0.352***	0.387***	0.375***
	(0.131)	(0.094)	(0.103)	(0.110)
ln distance from NED (Vincenty)	0.836***	-0.225***	-0.208***	-0.237**
	(0.179)	(0.069)	(0.066)	(0.095)
trend	0.163***	0.009	0.012	0.007
	(0.028)	(0.007)	(0.007)	(0.015)
ln GDP per capita (*t*-1)	0.436***	0.152**	0.167***	0.151
	(0.129)	(0.061)	(0.058)	(0.093)
ln GDP surrounding market potential	0.775**	-0.359***	-0.320***	-0.350***
	(0.334)	(0.125)	(0.119)	(0.128)
Real exchange rate with NL based on GDP price level	0.355***	-0.119***	-0.114***	-0.129***
	(0.171)	(0.029)	(0.028)	(0.041)
Implicit tax rate (Government share of GDP*100)	-0.047***	-0.009***	-0.011***	-0.009
	(0.009)	(0.003)	(0.004)	(0.006)
ln Hydrocarbon resource rents (*t*-1)		-0.020**	-0.018**	-0.018**
		(0.009)	(0.009)	(0.008)
Total resource dummy (*t*-1)	0.716***			
	(0.216)			
Openness dummy	0.518***	0.013		
	(0.187)	(0.064)		
Landlocked dummy	-0.685***	0.016		
	(0.168)	(0.084)		
Inverse Mill's ratio			0.588*	1.591
			(0.353)	(1.176)
estimated FDI probability				0.493
				(0.732)
estimated FDI probability^2				-0.093
				(0.169)
estimated FDI probability^3				0.006
				(0.013)
dependent variable (*i*-1)	-0.276	0.110***	0.106***	0.107***
	(0.239)	(0.037)	(0.034)	(0.028)
ln Non-Resource FDI (*t*-1)		0.823***	0.818***	0.817***
		(0.039)	(0.040)	(0.040)
Constant	-16.636***	1.514	0.860	0.747
	(3.409)	(1.090)	(1.046)	(1.921)
Observations	1842 (6.8%=0)	1049	1049	1049
Log-likelihood		-913.3	-910.4	-908.9
robust LM rho=0		5.467**	5.005**	5.238**
robust LM lambda=0		6.592**	6.832***	6.774***
Variance Ratio		0.965	0.965	0.965

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The main conclusion is that hydrocarbon rents still predict a lower level of non-resource FDI. Analogously (and additionally using also taxation as a selection variable) the two-stage estimates for resource FDI reported in table A3 of appendix 3 suggest that there is no evidence of sample selection bias at the 5% level. This increases our confidence in the single-stage estimates reported in sections 4 and 5.

7. Does the decline in non-resource FDI dominate the boost to resource FDI?

7.1. Determinants of resource FDI

To examine the different impact of natural resource endowments on resource FDI and the different nature of resource FDI, table 8 presents estimates of the determinants of resource FDI. In addition to the variables suggested by equation (1) and the discussion of section 2, we hypothesize that bad institutions, corruption and risk of expropriation may attract resource FDI when corrupt politicians join forces together with foreign mining companies to cream off surplus natural resource rents which will be easier if lack of transparency allows cheating of the public. In such situations corrupt politicians, possibly aided by foreign multinationals, deplete natural resources rapaciously, especially if the chance of being kicked out of office by rebel groups is high. However, the empirical evidence reported in table 7 rejects this hypothesis as good institutions seem to attract resource FDI. Not surprisingly, hydrocarbon resource rents or, alternatively, hydrocarbon reserves in BTU attract resource FDI independent of the world price of oil. In all columns distance deters resource FDI while market potential (proxied by population but not GDP per capita), human capital and relative cheapness of the host country's currency attract it. There does not appear to be a negative effect of the tax rate on resource FDI.[34] Although occasionally foreign investments are expropriated in the resource sector – equivalent to a 100% tax rate – there is no evidence that taxes are high enough on average to deter resource FDI. Convergence is quite sluggish, with shocks bringing resource FDI back to 10% of its new equilibrium value in 13 years. This is unsurprising given the long-term investments needed in mineral exploration, but the adjustment for non-resource FDI is almost as sluggish (see table 6). This implies that, after a negative shock due to expropriation of existing resource FDI stocks, it takes a long time for resource FDI to recover.

There is no evidence for a spatial lag in resource FDI, so resource FDI is not positively or negatively affected by resource FDI in neighboring countries. Surrounding market potential has no impact either on resource FDI. If anything, a high GDP per capita seems to have a negative effect on resource FDI. This suggests that resource FDI is very different from other FDI. It is not complex-vertical fragmentation,

[34] By proxying the tax rate by the government spending share of GDP we have a more comprehensive coverage of countries and, in case of resource FDI, it is probably more relevant than the official corporate tax rate.

export-platform or horizontal, but mainly vertical as a result of being driven by the geographical necessity of local subsoil assets rather than by regional cost advantages (see section 2.2) and of a type that is unrelated to neighborhood effects.

Table 8: Determinants of resource FDI

	ln Resource FDI		
VARIABLES	(a) STAR	(b) OLS	(c) OLS
ln population	0.071**	0.070**	0.074**
	(0.036)	(0.033)	(0.033)
ln human capital	0.393**	0.365**	0.380**
	(0.157)	(0.147)	(0.157)
ln distance from NED (Vincenty)	-0.151**	-0.123***	-0.149**
	(0.063)	(0.038)	(0.073)
ln GDP per capita (*t*-1)	-0.163*	-0.123	-0.165**
	(0.091)	(0.079)	(0.082)
ln GDP surrounding market potential	-0.083		-0.096
	(0.130)		(0.137)
Real exchange rate with NL based on GDP price level	-0.055*	-0.063**	-0.063**
	(0.031)	(0.030)	(0.031)
Implicit tax rate (Government share of GDP*100)	-0.008		
	(0.007)		
Institutions 5-yearly	0.020*	0.017*	0.020**
	(0.011)	(0.010)	(0.010)
ln Hydrocarbon resource rents (*t*-1)	0.048***	0.031***	
	(0.013)	(0.012)	
ln Other mineral resource rents (*t*-1)	0.000		
	(0.024)		
ln Hydrocarbon reserves in BTU (*t*-1)			0.029*
			(0.016)
Oil Price (constant 2008 USD)			-0.004
			(0.005)
ln Resource FDI (*i*-1)	0.083		
	(0.071)		
ln Resource FDI (*t*-1)	0.831***	0.852***	0.847***
	(0.034)	(0.029)	(0.028)
Constant	1.010	0.461	2.059
	(1.596)	(0.686)	(1.905)
Observations	716	803	729
Log-likelihood	-1003	-1110	-1053
robust LM rho=0	0.0471		
robust LM lambda=0	1.460		
Variance Ratio	0.863	0.871 (R2)	0.858 (R2)

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Further robustness tests with a bigger sample using a 0-1 dummy for reserves are presented in appendix 3, table A2, columns (a)-(c). We allow for Singapore being a large transshipment port and the very large amount of resource FDI going through it by including Singapore with a dummy in the regressions. The broader sample shows that hydrocarbon resource endowments attract (mostly hydrocarbon) resource FDI while other mineral resources deter it, which implies that the reallocation of inputs from the non-resource sector to the natural resource industry after a resource boom also extends to the non-hydrocarbon resource sector. A boom in a particular resource (say, gold) thus leads to a fall in FDI of other (unrelated) resources (such as oil). Appendix 3, table A3 indicates that there is no evidence of sample selection bias in our estimates of resource FDI at the 5% level.

A critique one could levy at our estimates reported in table 8 is that we should correct for some countries having restrictions on resource FDI (e.g., the need to have a license to drill and pump) and others do not. Unfortunately, we were unable to find a variable to capture such differences, although the openness dummy is also based on whether a country has significant non-tariff barriers to trade and/or a state monopoly on major exports, the later of which typically concerns resource exports.

7.2. Negative effect on world non- resource FDI is smaller for isolated countries

Before we investigate whether the negative effect of natural resource abundance on non-resource FDI is bigger than the positive effect on resource FDI, we gauge the dynamic effects of a shock to natural resource wealth. We therefore offer a simulation exercise which takes into account the feedback effects created by the positive spatial dependence of non-resource FDI. The magnitude of the feedback effect depends on the coefficient of the spatially lagged dependent variable *and* on the distance between the country experiencing the resource boom and its neighboring countries. We expect to find that a resource boom in a country that is relatively isolated in space will result in less negative spill-over effects to the region than when a country that has many close neighbors is hit with a similar shock. The local effect of the shock should be less severe if feedback effects through regional FDI are not taken into account.

Our baseline regression is column (d) of table 6. To calculate the impulse response of FDI to a shock to resources, we set all right-hand side variables to zero except the hydrocarbon rents variable.[35] We simulate the effect of a one standard deviation increase of resource rents over its mean, that is a shock of 3.420/19.298*100 = 17.7%. We thus have from the regression estimates (see (d) of Table 6) that

$$\mathbf{f}_{\mathbf{t}}^{N} = 0.83 * \mathbf{f}_{\mathbf{t-1}}^{N} + 0.15 * \mathbf{W}\mathbf{f}_{t}^{N} - 0.021 * \mathbf{R}_{t} \Leftrightarrow$$

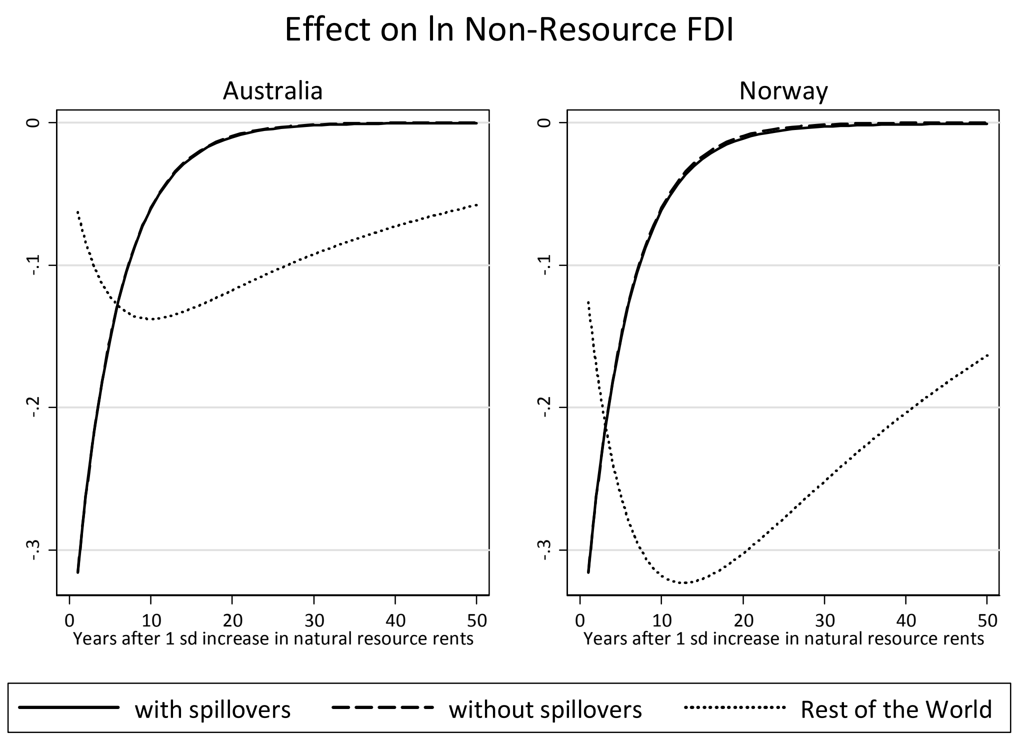
$$\mathbf{f}_{\mathbf{t}}^{N} = 0.83 * (\mathbf{I} - 0.15 * \mathbf{W})^{-1}\mathbf{f}_{\mathbf{t-1}}^{N} - 0.021 * (\mathbf{I} - 0.15 * \mathbf{W})^{-1}\mathbf{R}_{t},$$

where $R_{i0} = 17.7$. The resulting impulse response functions for Norway which is geographically close to many big markets and Australia which is relatively isolated are presented in fig. 2. The solid and dashed

[35] Although we use the coefficients from our preferred model, we base the distance matrix **W** on all 192 countries for which we have geographic coordinates.

lines represent the decrease in non-resource FDI to these two countries over time after a shock to hydrocarbon rents. The high persistence in non-resource FDI causes the shock to dissipate slowly over time, taking over 30 years to disappear. The dashed line ignores the spatial spillovers (effectively setting the coefficient 0.15 to zero). Because the effect of feedback through spillovers is weak and Australia is

Figure 2: Effects of resource abundance on local and worldwide non-resource FDI



relatively remote, the line is almost indistinguishable from the solid line. However, the dotted line represents the aggregate effect on all other countries in the world. A resource boom lowers FDI in Australia and through regional linkages also lowers FDI in neighboring countries. One year later the effect of the shock can still be felt, lowering FDI in the region even further, even though the initial shock to the region is starting to dissipate. At the inflection point the negative spill-over effects from Australia to the region become weaker than the dissipation effect, causing the overall effect in the region to decrease.

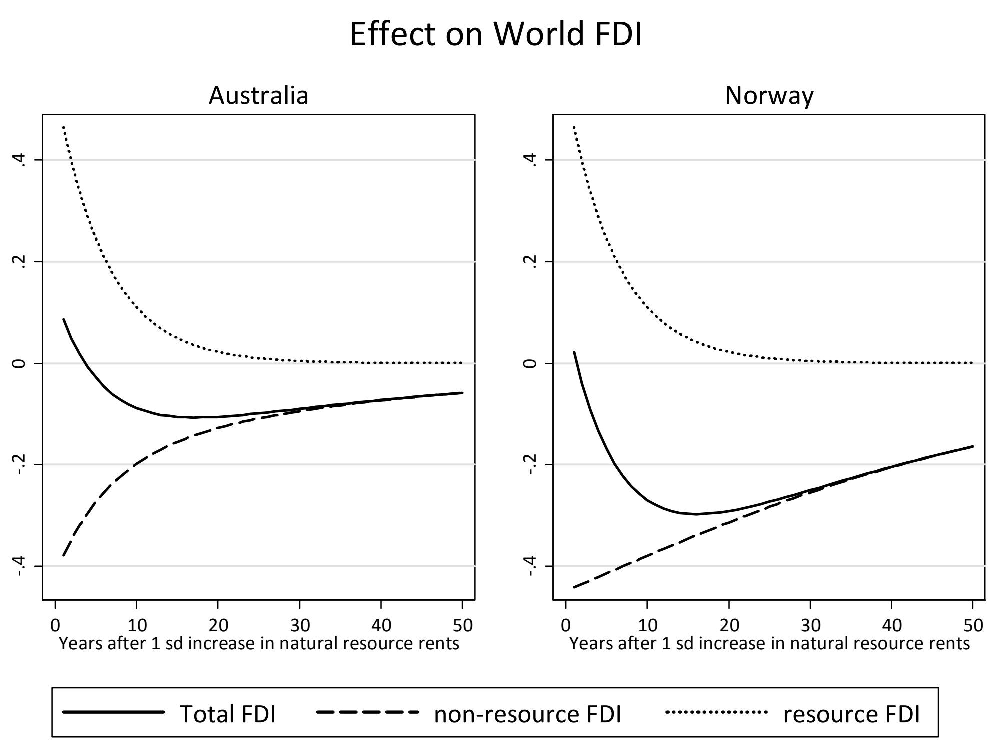
The right panel of fig. 2 shows the same effects for Norway, which has more and closer neighbors. In this case the local effects look very much the same, except that Norway suffers slightly more from negative feedback effects. The big difference is the effect on the rest of the world. Because Norway is much closer to other countries, a negative shock to FDI causes the region to become much less attractive to FDI because of decreasing availability of regional suppliers. Aggregated over all countries, this regional effect becomes as strong as the local shock and persists long after the local affect of the shock has disappeared.

7.3. Is there a 'resource curse' for aggregate FDI?

Our estimation results discussed in sections 4-6 suggest that natural resource abundance deters non-resource FDI, but boosts resource FDI. To find out if there is a curse for total FDI, fig. 3 repeats the simulation exercise of fig. 2 for non-resource, resource and total FDI. For remote countries like Australia we find that the net effect of resource abundance on total FDI becomes negative four years after the shock while for relatively connected countries such as Norway the net effect turns negative after only two years. Also, for connected countries the net effect is deeper and much more persistent, lasting several decades.

The effects are not large in magnitude, but they do persist over many decades and spill over into the region. However, within the sample of regression (d) of Table 6 there are 32 country-years in which hydrocarbon rents more than double in the course of a year. Such shocks are almost six times larger than the one displayed in the simulation exercise above and have proportionally larger effects on FDI.

Figure 3: Does resource abundance have a negative effect on total FDI?



To demonstrate that natural resource endowments are a 'curse' for total FDI, we also calculate the long-run effect on total FDI from table 6, column (d) and table 8, column (b) using the sample averages reported in appendix 2 in the following manner, where we for simplicity ignore the regional spillovers:

$$\mathrm{d}\overline{f}_{it} \ / \ \mathrm{d}\overline{s}_{it} = -0.745\left(\frac{0.021}{1-0.831}\right) + 0.255\left(\frac{0.031}{1-0.852}\right) = -0.093 + 0.053 = -0.039,$$

where $\overline{f}_{it} \equiv \overline{f}_{it}^{N} + \overline{f}_{it}^{R}$, bars indicate country averages, and 74.5% is the average share of total FDI spent on non-resource FDI. We conclude that at the aggregate level high resource endowments are a curse for total FDI, even if we choose to ignore the regional spillovers. Because regional spillovers matter, and because non-resource FDI is the main transmitter of knowledge and technology, the adverse effect of resource abundance on the economy can be substantial.

8. Concluding remarks

We have established that outward FDI is I(1) and therefore estimate panel error-correction models of non-resource and resource FDI with spatial lags for FDI and market potential. Our empirical estimates yield our main conclusions: subsoil assets exert a negative effect on non-resource FDI, but a positive influence on resource FDI. Most of the short-run dynamics comes from shocks to FDI itself; still, the positive spatial lags further increase the negative impact of resource endowments on non-resource FDI. Our estimates suggest that the net effect of resource endowments on total FDI quickly become negative, especially for countries that are geographically close to many other big markets. Our results are robust to different measures of resource reserves. We also find that a doubling of the oil price leads to a 10 percent fall in non-resource FDI. Allowing for both the external and internal margin in FDI, we find that our results are not affected by sample selection bias.

Some of our ancillary conclusions are that non-resource FDI is characterized by export fragmentation whereas resource FDI is mainly horizontal. Trade openness, free trade agreements and institutional quality do not impact non-resource FDI but institutional quality does have a positive effect on resource FDI. We find that distance has a positive effect on the location decision of non-resource FDI, perhaps as a substitute for international trade, but has a negative effect on the volume of non-resource FDI.

Our results indicate the importance of distinguishing FDI by sector in order to assess the type of FDI that is relevant and of allowing for spatial lags. They also indicate a novel channel by which natural resources may hinder the process of economic development. Future research would benefit from using plant-level data to address these important questions.

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Appendix 1: Estimating spatial lags

With N potential host countries and T years of observation, we estimate the baseline spatial autoregressive (SAR) specification of (7) and (8) (or of (7′) and (8′)) with maximum likelihood, where:

$$m_{jt} = \mathbf{W}\ln(\text{market potential})_{jt}\,,\ \alpha_6 f_{jt}^R = \alpha_6 \mathbf{W}\ln(\text{resource FDI})_{jt} \text{ and } \beta_6 f_{jt}^N = \beta_6 \mathbf{W}\ln(\text{other FDI})_{jt}$$

$$\text{with } \mathbf{W} \equiv \begin{pmatrix} \mathbf{W}_1 & 0 & 0 \\ 0 & .. & 0 \\ 0 & 0 & \mathbf{W}_T \end{pmatrix},\ \mathbf{W}_t \equiv \begin{pmatrix} 0 & 115.4/d_{1,2} & .. & 115.4/d_{N,1} \\ 115.4/d_{2,1} & 0 & .. & 115.4/d_{N,2} \\ .. & .. & .. & .. \\ 115.4/d_{N,1} & 115.4/d_{N,2} & .. & 0 \end{pmatrix},$$

The block-diagonal matrix **W** corresponds to the spatial lag weighting matrix with each block along the diagonal corresponding to a single year, α_6 and β_6 stand for the spatial autocorrelation coefficients. The blocks along the matrix **W** depend on distances, so are identical for each year. The off-diagonal elements in each block contain the spatial inverse-distance weights between any two potential host countries, where the distances are the Vincenty differences in kilometers between country centroids and are normalized by the shortest distance between two host countries (the distance between Netherlands and Belgium, i.e., 115.4 km). As an alternative to a spatial AR(1) process suggested by theory there may be statistical reasons to include a spatial MA(1) error term instead. We follow Florax et al. (2003) (see also Le Sage and Pace, 2009) and perform robust Likelihood Multiplier (LM) tests. Consistent with FDI theory, the LM tests almost always reject the null hypothesis of no spatial AR(1) correlation at the 99% confidence level. Although they often also cannot reject the null hypothesis of no spatial MA(1) correlation, the test statistics for MA(1) are nearly always smaller. We therefore always allow for spatial AR(1).

Estimation of (7) and (8) is based on maximum likelihood (Anselin, 1988) and involves calculation of the determinant of large matrices. For example, the matrix **W** reaches a maximum dimension of 1842×1842 within our sample. Moreover, Kelejian and Prucha (1999) warn that calculation of the eigenvalues of **W** may be hampered by lack of accuracy. Fortunately, all estimated eigenvalues of our matrices **W** for different samples had zero imaginary parts allowing standard methods of estimation. The properties of the weighting matrix may also violate consistency of the maximum likelihood estimates: the row and column sums should not diverge faster to infinity than the sample size *N*. Since **W** is an inverse distance matrix, it satisfies this condition (Lee, 2004). The spatial probit 1st stage to the Heckman selection model requires Bayesian estimation (LeSage, 2000; LeSage and Pace, 2009), but uses the same weighting matrix for spatially lagged binary variable of zero versus positive FDI.

Appendix 2: data definitions and sources

Variable	Description	Source
ln FDI	value of Dutch outward foreign direct investment, see also text	DNB (2008)
ln population	log of total population (in 1000s)	PWT6.2, from Heston et al. (2006)
Openness dummy	= 1 if open to trade, dummy	Wacziarg & Welch (2008)
ln human capital	average years of schooling age 25+	Barro and Lee (2000)
ln distance from NL (Vincenty)	Vincenty distance in km from the Netherlands between country centroids	CID data and Vincenty (1975)
trend	time trend	-
ln GDP per capita	GDP per capita in constant PPP $ billions	PWT6.2, from Heston et al. (2006)
ln GDP surrounding market potential	distance weighted GDP in constant PPP $ billions	authors' calculation
FTA	=1 if a country has a free trade agreement with The Netherlands in year *t*	Baier and Bergstrand (2007)
GATT/WTO member	=1 if a country is a member of the GATT or WTO in year *t*	World Trade Organisation
Landlocked dummy	=1 if a country has no access to sea	World Bank (2001)
Total resource dummy (*t*-1)	=1 if natural resource rents are non-zero	World Bank (2007)
Hydrocarbon resource dummy (*t*-1)	=1 if natural resource rents of oil, gas or coal are non-zero	idem
Other mineral resource dummy (*t*-1)	=1 if natural resource rents are non-zero, excluding oil, gas and coal	idem
ln hydrocarbon resource value (*t*-1)	combined value of natural resource rents of oil, gas and coal	idem
ln other mineral resource value (*t*-1)	combined value of natural resource rents excluding oil, gas and coal	idem
ln hydrocarbon reserves in BTU (*t*-1)	total amount of oil, gas and coal reserves in BTUs	BP (2009)
Oil price (constant 2008 USD)	World price of oil in constant 2008 US dollars	idem
Institutional Quality	Sum of the following institution indices: Government Stability, Investment Profile, Corruption, Law and Order, Bureaucracy Quality	International Country Risk Guide

Table A1 gives the descriptive statistics of the dependent and independent variables that are used to estimate our econometric model (7) and (8).

Table A1: Descriptive statistics

Variable	mean	sd	min	max
ln non-resource FDI	3.894	3.168	-16.745	11.298
ln resource FDI	2.820	3.254	-7.161	9.645
ln population	9.330	1.577	5.475	14.062
Openness dummy	0.619	0.486	0	1
ln human capital	1.489	0.691	-1.005	2.505
ln distance from NL (Vincenty)	8.448	0.967	4.748	9.808
ln GDP per capita (t-1)	8.527	1.138	5.139	10.445
ln GDP surrounding market potential	6.564	0.495	5.456	8.128
FTA	0.169	0.375	0	1
GATT/WTO member	0.172	0.377	0	1
Landlocked dummy	0.181	0.385	0	1
Total resource dummy (t-1)	0.824	0.381	0	1
Hydrocarbon resource dummy (t-1)	0.661	0.474	0	1
Other mineral resource dummy (t-1)	0.728	0.445	0	1
ln hydrocarbon resource value (t-1)	19.298	3.420	6.842	25.713
ln other mineral resource value (t-1)	17.248	2.956	7.534	22.766
ln hydrocarbon reserves in BTU (t-1)	9.027	2.552	0.842	14.225
Oil price (constant 2008 USD)	31.655	9.915	17.320	58.270
Institutional Quality 5-yearly	22.559	7.199	4.080	38.000
Real exchange rate with NL based on	0.578	0.626	0.111	12.490
Implicit tax rate (Government share of	20.307	8.545	2.463	58.139

Note: Based on largest sample of country-years (regression (a) of Table 7).

Appendix 3: Further robustness and sample selection tests

Table A2 presents some further robustness tests using a 0-1 dummy for reserves (see section 3.2). We also include a dummy for Singapore in the regressions for resource FDI. Since we now have a larger sample some controls are now significant.

We can specify a two-stage model for testing sample selection bias in resource FDI analogous to equation (7″) and table 7 for non-resource FDI. The results are presented in table A3 and the estimate of the inverse Mill's ratio reported in column (d) suggests that there is no evidence of sample selection bias at the 5% level, although there is some weak evidence for it at the 1% level.

Table A2: Further robustness tests on the determinants of FDI

Dependent variable:	ln Resource FDI			ln Non-resource FDI		
	(a) SAR	(b) SAR-EC	(c) OLS	(d) SAR	(e) SAR-EC	(f) SAR-EC
ln population	0.691***	0.122***	0.124***	0.800***	0.181***	0.176***
	(0.059)	(0.035)	(0.033)	(0.033)	(0.057)	(0.054)
Openness dummy	0.442**	0.189	0.161*	0.650***	0.152**	0.163**
	(0.207)	(0.115)	(0.088)	(0.119)	(0.073)	(0.067)
ln human capital	1.171***	0.379***	0.346**	1.379***	0.355***	0.345***
	(0.278)	(0.141)	(0.143)	(0.163)	(0.138)	(0.129)
ln distance from NED (Vincenty)	-0.764***	-0.196**	-0.067	-0.960***	-0.237***	-0.278***
	(0.156)	(0.080)	(0.045)	(0.099)	(0.074)	(0.096)
Trend	0.080***	0.005		0.115***	0.015*	0.014*
	(0.018)	(0.008)		(0.012)	(0.009)	(0.009)
ln GDP per capita (t-1)	0.506***	-0.056	-0.067	0.506***	0.095	0.110
	(0.164)	(0.072)	(0.078)	(0.117)	(0.067)	(0.075)
ln GDP surrounding market potential	-0.312	-0.089	0.016	-2.090***	-0.364**	-0.363**
	(0.313)	(0.158)	(0.095)	(0.220)	(0.151)	(0.154)
FTA	-0.141	-0.226		1.607***	0.183	
	(0.354)	(0.153)		(0.213)	(0.148)	
GATT/WTO member	0.176	0.086		-0.179	-0.026	
	(0.276)	(0.138)		(0.179)	(0.105)	
Landlocked dummy	-0.962***	-0.134		-0.549***	-0.065	
	(0.268)	(0.178)		(0.138)	(0.083)	
Real exchange rate with NL based on GDP price level	-0.071	-0.090		-0.360***	-0.127***	-0.124***
	(0.060)	(0.060)		(0.045)	(0.038)	(0.039)
Implicit tax rate (Government share of GDP*100)	-0.087***	-0.009		-0.083***	-0.016***	-0.016***
	(0.012)	(0.007)		(0.008)	(0.006)	(0.006)
Institutions 5-yearly	0.017	0.017**	0.016*	0.032***	0.009**	0.008**
	(0.018)	(0.009)	(0.009)	(0.008)	(0.004)	(0.004)
Hydrocarbon resource dummy (t-1)	0.729***	0.196**	0.191**			
	(0.182)	(0.089)	(0.091)			
Other mineral resource dummy (t-1)	-0.194	-0.223**	-0.262***			
	(0.197)	(0.112)	(0.068)			
Total resource dummy (t-1)				-0.889***	-0.158**	-0.133*
				(0.123)	(0.078)	(0.070)
dependent variable (i-1)	-0.147	0.012		0.230***	0.101***	0.105***
	(0.096)	(0.065)		(0.070)	(0.038)	(0.038)
dependent variable (t-1)		0.825***	0.835***		0.766***	0.773***
		(0.029)	(0.031)		(0.081)	(0.076)
Constant	-1.669	1.225	-0.535	10.317***	1.922**	2.162**
	(3.382)	(1.752)	(1.199)	(2.434)	(0.956)	(1.010)
Singapore dummy	2.950***	0.666***	0.680***			
	(0.444)	(0.248)	(0.155)			
clustered (by country) s.e.	no	no	yes	no	no	no
Observations	1244	1114	1115	1462	1368	1368
Log-likelihood	-2795	-1625	-1631	-2624	-1626	-1628
robust LM rho=0	7.697***	0.0902		7.631***	3.898**	4.404**
robust LM lambda=0	5.760**	0.0552		0.178	1.144	1.086
Variance Ratio	0.468	0.867	0.866 (R2)	0.772	0.928	0.928

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A3: Testing for selection bias in resource FDI[36]

Dependent variable:	Resource FDI dummy	ln Resource FDI		
	1st stage	Benchmark	2nd stage	bootstrapped se
	(a) Probit	(b) OLS	(c) OLS	(d) OLS
ln population	0.198***	0.061*	0.050	0.029
	(0.037)	(0.031)	(0.032)	(0.033)
ln human capital	0.317***	0.325**	0.322**	0.304**
	(0.112)	(0.133)	(0.142)	(0.144)
ln distance from NED (Vincenty)	0.103*	-0.130***	-0.123***	-0.142***
	(0.060)	(0.040)	(0.038)	(0.043)
ln GDP per capita (*t*-1)	0.386***	-0.139*	-0.110	-0.160**
	(0.083)	(0.082)	(0.073)	(0.080)
Real exchange rate with NL based on GDP price level	0.186**	-0.051*	-0.071**	-0.085**
	(0.085)	(0.029)	(0.031)	(0.039)
Institutions 5-yearly	-0.002	0.014	0.013	0.014
	(0.010)	(0.009)	(0.009)	(0.009)
ln Hydrocarbon resource rents (t-1)		0.038***	0.031***	0.034***
		(0.014)	(0.011)	(0.012)
Hydrocarbon resource dummy (t-1)	-0.194*			
	(0.115)			
Openness dummy	0.235**	0.183		
	(0.105)	(0.135)		
Trend	0.061***	0.002		
	(0.009)	(0.006)		
Landlocked dummy	-0.645***	-0.052		
	(0.112)	(0.234)		
Implicit tax rate (Government share of GDP*100)	-0.025***	-0.005		
	(0.005)	(0.006)		
Inverse Mill's ratio			-0.342	-15.283*
			(0.261)	(8.248)
estimated FDI probability				-10.636*
				(5.812)
estimated FDI probability^2				3.127*
				(1.708)
estimated FDI probability^3				-0.299*
				(0.167)
ln Resource FDI (*t*-1)		0.844***	0.851***	0.845***
		(0.032)	(0.030)	(0.031)
Constant	-5.533***	0.723	0.777	13.578**
	(0.976)	(0.682)	(0.682)	(6.761)
Observations	1601	793	793	793
Log-likelihood	-493.1	-1057	-1059	-1057
R-squared	0.289 (PR2)	0.874	0.874	0.874

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

36 We found no evidence for selection bias for Resource FDI for a somewhat smaller sample when using *ln Hydrocarbon Reserves in BTU (t-1)* and the *oil price* instead of the *ln Hydrocarbon Resource Rents (t-1)*.

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