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The Dutch disease and the technological gap[☆]

Reda Cherif

International Monetary Fund, Washington, DC 20431, USA

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ABSTRACT

I present a theory explaining why less technologically advanced countries could be more vulnerable to the Dutch disease. In a bilateral trade model with monopolistic competition and increasing returns to scale, the extent of the crowding-out in the tradable sector depends positively on an interaction between the amount of revenues from natural resources' exports and the productivity gap vis-à-vis the trade partners. With learning-by-doing, the mechanism is self-reinforcing leading to a productivity divergence pattern. The predictions of the model are consistent with cross-country empirical evidence.

1. Introduction

The Dutch disease phenomenon attracted attention in the 1970s in the Netherlands where the discovery of natural gas fields was followed by rapid de-industrialization. The phenomenon is not peculiar to advanced economies and seems more severe in developing ones. The Netherlands is still an industrial power and in the 19th century, Canada and the U.S. managed to industrialize despite a heavy dependence on commodities exports. Yet, the familiar experience of a developing economy that discovers a tradable natural resource is to become completely dependent on its exports revenues and to fail to build an industrial base. This paper suggests that the extent of the decline in the manufacturing sector depends positively on the technological gap vis-à-vis the trading partner. Moreover, while a country receives windfalls, its technological gap keeps widening. The industrial development of Germany, Japan, and the Asian miracles points to the important role played by the manufacturing sector in their development. It is therefore crucial to understand what determines the extent of the Dutch disease in developing economies.

I present a bilateral trade model with monopolistic competition and increasing returns to scale, in the vein of Krugman (1979). As in most Dutch disease models, the main channel of transmission is the "spending effect" in the terminology of the seminal work of Corden and Neary (1982).[1] In essence it describes how an increase in the exports' revenues from the natural resource sector leads to an appreciation of the real exchange rate and a crowding-out in the other tradable sectors. Because consumers in the recipient country are richer, they will in general want more of all goods and in particular the non-tradable ones assuming that goods are normal and assuming a non-perverse output response. As a result, production factors are reallocated into the non-tradable sector to the detriments of the other tradable sectors while the real exchange rate appreciates.

In the model I present, the natural resource sector does not appear explicitly. Instead, I represent its exports' revenues by pure transfer payments from the foreign to the home country. The discussion is essentially about comparing the extent of the crowding-out in the tradable sector given different technological distances vis-à-vis the trade partner, for example in the Netherlands vs. Nigeria. To make the thought experiment meaningful, I assume that each country receives a certain amount of transfers in terms of the foreign country wages. The next step is to convert the transfer payments into units of home wages. I show in the paper that in the monopolistic competition and increasing returns framework,

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E-mail address: acherif@imf.org.

[1] The other effect they define is the "resource movement effect" toward the natural resource sector. A boom in the resource sector would attract factors of production. They indicate that it is usually negligible in comparison to the spending effect. Although the extractive industry can generate massive revenues it is usually a small sector in terms of factors' employment with little links to the rest of the economy. Matsuyama (1992) is a notable exception in the literature where his version of the Dutch disease stems from the "resource movement effect".

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the wage gap vis-à-vis the trade partner is an increasing function of the productivity gap. If, compared to the Netherlands, Nigeria has a much bigger productivity gap vis-à-vis its trade partners, then its wage gap will also be much greater. The comparative static analysis indicates that if each country receives as transfers an additional unit of foreign wages, then the increase in income in terms of domestic wages and the spending effect associated will be far greater in Nigeria, and so will be the crowding-out effect.

The crowding-out in the tradable sector would be problematic in the presence of externalities. I illustrate this point with a simple dynamic version of the model in the presence of learning-by-doing and cross-country knowledge spillovers. I show that a steady stream of transfers unleashes a vicious cycle of productivity divergence instead of the counterfactual convergence. The crowding-out effect of transfers today leads to a bigger productivity gap tomorrow, which in turn means a bigger marginal effect of transfers in the tradable sector as long as transfers are received.

The standard models of the Dutch disease are based on the neo-classical trade theory. In their seminal paper, Corden and Neary (1982), use the Heckscher–Ohlin type framework to study the effect of a boom in a tradable resource sector on resource allocation and income distribution under different assumptions on sectoral factor intensity. Krugman (1987) uses the comparative advantage model of Dornbusch et al. (1977) to show that temporary transfers can have long term negative effects as some industries disappear irreversibly.[2] As the premise of this paper is that technological distance (i.e. absolute advantage) matters, it seems natural to depart from neo-classical trade models. The factor proportions theory in its standard formulation rules out technological differences while in Ricardian trade it is comparative advantage that matters. Although originally designed to justify trade between perfectly similar economies, I show that in the new trade theory approach (of the Krugman–Helpman type) the effect of technological distance on trade plays an important role and is driven by the relative wage. The latter is in turn a function of relative productivity and structural parameters.

I examine empirically the validity of my theory using cross-country data. I use the dataset of McMillan and Rodrik (2011), which is itself an extension of Timmer and de Vries (2009). It comprises internationally comparable data of sectoral value added and employment for 38 countries. I find that the interaction between the initial labor productivity gap in manufacturing vis-à-vis trade partners (a measure of technological distance which I define in Section 4) and the average share of primary exports in total exports contributes (i) positively to the divergence of the relative labor productivity gap in manufacturing over the period 1990–2000 (ii) and negatively to the change in the employment share in manufacturing. The rest of the paper is organized in the following fashion. Section 2 presents the model. Section 3 extends it into a dynamic version. Section 4 presents cross-country empirical evidence. Section 5 draws conclusions.

2. The model

I present a model of bilateral trade with monopolistic competition and increasing returns to scale in which I introduce a non-tradable good and asymmetry in technologies.

2.1. Preferences

There is a large number of potential tradable goods that enter symmetrically in the utility function of consumers. These goods are assumed to be relatively good substitutes among themselves but poor substitutes for a non-tradable good. Given a number of goods produced at home denoted n, and a number of goods produced abroad denoted n^*, all individuals have the same utility function,

$$U\left(x_0, \left\{\int_0^{n+n^*} x(s)^\rho \, ds\right\}^{\frac{1}{\rho}}\right), \quad 0<\rho<1 \tag{1}$$

where $x(s)$ represents the consumption of tradable good s and x_0 the consumption of the non-tradable good. I will assume that U is Cobb–Douglas and that the number of goods produced is smaller than the number of potential goods.

2.2. Technologies

Labor is the only factor of production in the economy. The two countries differ in the technology they use to produce tradable goods. I define l_1 the labor cost of a domestic producer in terms of quantities produced x_1, and l_2 the labor cost of a foreign producer in terms of quantities produced x_2 as,

$$l_1 = \alpha_1 + \beta_1 x_1 \tag{2}$$

and,

$$l_2 = \alpha_2 + \beta_2 x_2 \tag{3}$$

assuming a fixed labor cost α_1 and a constant marginal labor cost β_1 in the home economy and similarly a fixed labor cost α_2 and a constant marginal labor cost β_2 in the foreign economy. The production of the non-tradable good is of constant marginal cost where I assume for simplicity a unit labor cost per unit produced in both countries.

2.3. Markets clearing and resource constraints

Population size is L and L^* in the home and foreign country respectively. Given the symmetries in the model, each home consumer will consume the same quantity of tradable goods produced domestically, c_1, and quantity of goods produced abroad, c_2. Similarly, each foreign consumer will consume the same quantity of goods produced in the domestic economy c_1^* and the same quantity of tradable goods produced in the foreign economy c_2^*.

The quantity produced of each good should be equal to the sum of individual consumption at home and abroad. For goods produced domestically the constraint is,

$$x_1 = Lc_1 + L^* c_1^* \tag{4}$$

while for goods produced abroad it is,

$$x_2 = Lc_2 + L^* c_2^* \tag{5}$$

Given n the number of goods produced domestically, the labor employed in the tradable sector at home is equal to n multiplied by the labor employed by each producer l_1. The labor employed in the non-tradable sector is simply L times the individual consumption x_0 by construction. Thus, the full employment constraint is written (where I use Eq. (2)),

$$n(\alpha_1 + \beta_1 x_1) + Lx_0 = L \tag{6}$$

and similarly in the foreign country,

$$n^*(\alpha_2 + \beta_2 x_2) + Lx_0^* = L^* \tag{7}$$

There is free entry and exit of firms such that profits are equal to zero in equilibrium.

[2] For early contributions, see also Corden (1984) for an extension of Corden and Neary(1982) including immigration dynamics; Van Wijnbergen (1984) for a two period trade model with learning-by-doing and a welfare analysis and policy discussion and Aoki and Edwards (1983) for a small open economy model. Recent contributions focus on the Dutch disease effect in dynamic general equilibrium models. See for example Arellano et al. (2009), Caballero and Lorenzoni (2007) and Lama and Medina (2012) who study the criterion for exchange rate intervention in the presence of financial frictions.

2.4. Trade

I express all prices in terms of the domestic wage which is in turn assumed to be numeraire. I will note e the wage ratio, expressing one unit of foreign wage in terms of units of domestic wage. I first solve the consumers' maximization problem, then the producers', and finally impose the zero profit condition, to find the equilibrium values of the number of goods produced domestically n, the number of goods produced abroad n^* and the wage ratio e.

Under homothetic preferences domestic consumers will maximize utility subject to their budget constraint according to a two-step budgeting process as in Dixit and Stiglitz (1977). The first step simply states that under homothetic preferences the expenditure shares of the non tradable good consumption and an index of tradable goods consumptions noted y are functions of an index price q. In the case of Cobb–Douglas preferences, these shares are constant and assumed to be equal to $1-\gamma$ and γ respectively:

$$y=\gamma\frac{I}{q} \tag{8}$$

and,

$$x_0=(1-\gamma)I \tag{9}$$

where I is income and where I implicitly used the fact that the price of the non tradable good is equal to one. The second stage of the problem implies that the demand for each good produced domestically at a given price p_1 is,

$$c_1=y\left(\frac{q}{p_1}\right)^{\frac{1}{\rho-1}} \tag{10}$$

and the demand for each good produced abroad at a given price p_2 is,

$$c_2=y\left(\frac{q}{p_2}\right)^{\frac{1}{\rho-1}} \tag{11}$$

where $y=\left\{\int_0^{n+n^*}x(s)^\rho\, ds\right\}^{\frac{1}{\rho}}$ and $q=\left\{\int_0^{n+n^*}p(s)^{\frac{\rho-1}{\rho}}\, ds\right\}^{\frac{\rho}{\rho-1}}$.

Similarly in the foreign country,

$$y^*=eI^*/q \tag{12}$$

and,

$$x_0^*=(1-\gamma)I^* \tag{13}$$

In addition to,

$$c_1^*=y^*\left(\frac{q}{p_1}\right)^{\frac{1}{1-\rho}} \tag{14}$$

and,

$$c_2^*=y^*\left(\frac{q}{p_2}\right)^{\frac{1}{1-\rho}} \tag{15}$$

Each producer faces an aggregate demand the price elasticity of which is $1/(1-\rho)$, assuming that the pricing decision of each firm has a negligible effect on the index price. The optimal price chosen by the monopolists is:

$$p_1=\frac{\beta_1}{\rho} \tag{16}$$

and,

$$p_2=\beta_2\ \frac{e}{\rho} \tag{17}$$

Profits in each country are,

$$\pi_1=p_1\ x_1-(\alpha_1+\beta_1\ x_1)$$

and

$$\pi_2=p_2\ x_2-(\alpha_2+\beta_2\ x_2)e$$

The zero profit condition in each country implies,

$$x_1=\frac{\alpha_1}{p_1-\beta_1}=\frac{\alpha_1\ \rho}{\beta_1(1-\rho)} \tag{18}$$

and

$$x_2=\frac{\alpha_2}{\frac{p_2}{e}-\beta_1}=\frac{\alpha_2\ \rho}{\beta_2(1-\rho)} \tag{19}$$

We can solve for the number of goods produced using Eq. (6) or the full employment constraint, and replacing x_1 from Eq. (18),

$$n=\frac{L-L(1-\gamma)}{(\alpha_1+\beta_1 x_1)}=\frac{\gamma L(1-\rho)}{\alpha_1} \tag{20}$$

A similar method for the foreign country implies,

$$n^*=\frac{\gamma L^*(1-\rho)}{\alpha_2} \tag{21}$$

The relative scale (and scope) of production depends on the relative population size as well as on the relative fixed cost. I turn to solving for the relative wage e. Using Eq. (4), and Eqs. (10) and (14) and replacing p_1 from Eq. (16), I obtain:

$$x_1=Lc_1+L^*c_1^*=\left(Ly+Ly^*\right)(q\rho/\beta_1)^{\frac{1}{1-\rho}} \tag{22}$$

Similarly for the foreign producers,

$$x_2=\left(Ly+Ly^*\right)(q\rho/\beta_2\ e)^{\frac{1}{1-\rho}} \tag{23}$$

and e is given by taking the ratio of equation Eq. (23) to Eq. (22) and replacing Eqs. (18) and (19),

$$\frac{x_2}{x_1}=\left(\frac{\beta_2\ e}{\beta_1}\right)^{\frac{1}{1-\rho}}=\frac{\beta_1\ \alpha_2}{\beta_2\ \alpha_1}$$

Therefore,

$$e=\left(\frac{\beta_1}{\beta_2}\right)^\rho\left(\frac{\alpha_1}{\alpha_2}\right)^{1-\rho} \tag{24}$$

The wage ratio above simply states that the zero profit conditions are simultaneously verified in both countries given the respective demand schedules. It is a function of the ratios of productivities and fixed costs as a result of monopolistic competition between home and foreign producers. The equation above can be re-written,

$$\ln(e)=\rho\ln\left(\frac{\beta_1}{\beta_2}\right)+(1-\rho)\ln\left(\frac{\alpha_1}{\alpha_2}\right)$$

such that the difference in (log) wages is equal to a weighted average of the difference in (log) variable costs and the difference in (log) fixed costs. The weight associated with the difference in variable costs is ρ which is by construction an increasing function of the elasticity of substitution θ where $\theta = 1/(1-\rho)$. The intuition behind the relationship is that the more elastic are the demand curves, the more sensitive is the wage differential to the variable costs ratios as they appear in the pricing equation, and at the same time, the less sensitive it is to the fixed costs ratios.

From now on, and without loss of generality, I will assume that fixed costs are the same in both countries i.e. $\alpha_1 = \alpha_2$ and that foreign producers are more efficient than domestic ones i.e. $\beta_1 > \beta_2$.

2.5. The effect of transfers

Suppose that the foreign country transfers an amount of its income to the home country equal to T in terms of foreign wage. This transfer mimics oil exports revenues.[3] By construction, the equilibrium wage differential is not affected by transfers. Each consumer in the domestic economy receives an income I equal to $(1+eT/L)$. Thus, replacing Eq. (9) in the home full employment constraint (Eq. (6)) yields,

$$n(\alpha_1 + \beta_1\, x_1) + (1-\gamma)[L + eT] = L$$

In the foreign country where income per consumer I^* is equal to $(1-T/L^*)$ in terms of foreign wage, replacing Eq. (13) in the full employment constraint (Eq. (7)) yields,

$$n^*(\alpha_2 + \beta_2\, x_2) + (1-\gamma)\left[L^* - T\right] = L^*$$

Therefore by solving the two equations above I can calculate the number of goods produced domestically n and the number of goods produced abroad n^* using Eqs. (18) and (19) respectively,

$$n = \frac{L-(1-\gamma)(L+eT)}{\alpha_1 + \beta_1\, x_1} = (1-\rho)\frac{\gamma L-(1-\gamma)eT}{\alpha_1} \tag{25}$$

and,

$$n^* = \frac{L^*-(1-\gamma)(L^*+T)}{\alpha_1 + \beta_2\, x_2} = (1-\rho)\frac{\gamma L^*-(1-\gamma)T}{\alpha_1} \tag{26}$$

The number of tradable goods produced domestically depends negatively on the amount transferred from abroad and the marginal effect is,

$$\frac{\partial n}{\partial T} = -\frac{(1-\rho)(1-\gamma)e}{\alpha_1} \tag{27}$$

The marginal crowding-out effect, $|\partial n/\partial T|$, depends positively on the share of the non-tradable good in expenditure and on e, the wage ratio. In turn, the marginal crowding out effect depends positively on the ratio of productivities through the wage ratio. The intuition is fairly straightforward. A greater productivity gap implies a greater wage differential and therefore a greater income effect per unit transferred in terms of the demand for the non-tradable good. The extent of the crowding-in in the foreign country does not depend on the wage ratio e.

The effect of the productivity ratio on the relationship between the number of goods produced and the amount of transfers can be verified in terms of the elasticity using Eqs. (25) and (27),

$$-\frac{T}{n}\frac{\partial n}{\partial T} = \frac{(1-\gamma)eT}{\gamma L-(1-\gamma)eT} \tag{28}$$

which is an increasing function of e. Therefore, the elasticity of the number of goods produced domestically with respect to transfers depends positively on the wage ratio and hence on the productivity ratio. The total number of tradable goods produced evolves according to,

$$n + n^* = (1-\rho)\frac{\gamma(L+L^*) + (1-\gamma)T(1-e)}{\alpha_1} \tag{29}$$

where the equation shows that if transfers flow from the most productive to the less productive country such that $e > 1$, then the effect of an increase in transfers on the total numbers of goods produced is negative. This is a natural implication of the fact that the marginal crowding-out in the home economy is greater than the marginal crowding-in in the foreign economy.

3. Making a curse

I present a simple dynamic version of the model where I introduce learning-by-doing. I will assume that the inverses of the variable costs in the tradable sector β_1 and β_2, defined as h_1 and h_2 respectively, depend simultaneously on total labor employed in the sector,

$$\begin{cases} \dot{h}_1(t) = k[L_1(t) + \delta L_2(t)]h_1^{\vartheta}(t) \\ \dot{h}_2(t) = k[L_2(t) + \delta L_1(t)]h_2^{\vartheta}(t) \end{cases}$$

k is a strictly positive scaling parameter and ϑ and δ are constants in [0,1]. $L_1(t)$ and $L_2(t)$ are labor employed in the tradable sector in the domestic and foreign economy respectively. Parameter ϑ measures international spillovers in terms of learning while δ sets the rate at which productivity gains diminish. I will assume a very simple framework. Consumers and producers live for one period and new ones replace them in the following period. I will interpret a period as a generation. Therefore every new generation will solve the same static model I presented in Section 2 but with different productivities. I will assume that all the other parameters will remain constant.[4]

Labor employed in the tradable sector in the domestic economy is given by $n(\alpha_1 + \beta_1 x_1)$ or the number of goods produced multiplied by the labor employed by each producer. Using Eq. (18) I can calculate $L_1(t)$ and I use a similar approach to calculate $L_2(t)$. The dynamic system can be re-written (where k' is a constant),

$$\begin{cases} \dot{h}_1(t) = k'\left[\gamma\left(L + \delta L^*\right) + (1-\gamma)T(t)(\delta - e)\right]h_1^{\vartheta}(t) \\ \dot{h}_2(t) = k'\left[\gamma\left(\delta L + L^*\right) + (1-\gamma)T(t)(1-\delta e)\right]h_2^{\vartheta}(t) \end{cases}$$

I assume that transfers $T(.)$ are equal to a constant $C > 0$ over $[0, t^*]$ and zero elsewhere representing the revenues from exhaustible resources like crude oil. One can see that beyond time horizon t^*, the dynamics are ruled by the equations above where both T and e disappear. Thus the ratio of productivities will converge to its steady-state which is pinned down by:

$$\frac{h_2}{h_1} = \left(\frac{\delta L + L^*}{L + \delta L^*}\right)^{\frac{1}{1-\vartheta}}.$$

The long term productivity ratio depends solely on the population sizes, the extent of international spillovers in learning-by-doing, and the rate at which productivity gains diminish.

During the periods where transfers are strictly positive, the system can exhibit a vicious circle pattern. If the initial productivity gap is high (if the home country receiving transfers is much less productive than the foreign one), then the crowding out effect will be magnified. The result would be slower domestic productivity gains relative to the foreign country and in turn a worsening of next period's productivity ratio. By then, if transfers continue, it will lead to another round of widening productivity gap. Consequently, when

[3] Note that by not modeling explicitly a resource sector, I am ignoring the effect of a change in its relative price or the "resource movement effect" as described by Corden and Neary (1982).

[4] I am implicitly assuming that there are no productivity gains in the non-tradable sector and that there are no spillovers between the tradable and non-tradable sectors.

transfers disappear, the recipient economy will suffer a much larger productivity gap vis-à-vis its trading partner compared to a situation in which transfers did not exist. Moreover, it may take several more generations to close the productivity gap with the trading partner.

To illustrate the dynamics, I solve numerically a discrete version of the model above (see Table 1 for the calibration[5]). Fig. 1 shows the path of the productivity ratio (foreign to domestic) when transfers T are received as described above and compares it to the counterfactual case where no transfers are received. I present the results for an initial productivity ratio of 8. The path without transfers exhibits a smooth convergence to the steady state.[6] In contrast, in the presence of transfers, the productivity ratio increases sharply until it reaches a peak which is consistent with the vicious circle described above. Then it declines toward the steady state while the difference with the counterfactual case of no transfers is persistent. The peak corresponds to the time period when transfers drop to zero.

Simulations also show that initial conditions matter. The high initial productivity ratio leads to a persistently higher path especially during the period where transfers are received, and a wider difference with the counterfactual path with no transfers. With an initial ratio of 8, the domestic economy starts its post-transfers era with a productivity about 11 times smaller than in its trading partner or about double the ratio in the counterfactual case of no transfers. In contrast, with an initial ratio of 4, the domestic economy starts its post-transfers era with a productivity about 7 times smaller than in its trading partner compared to 4 in the counterfactual case.

The relative stagnation of oil exporters is in stark contrast with the rapid convergence in the case of the Asian miracles. In a paper aimed at explaining the Asian miracles, Lucas (1993) points to the fact that industry level productivity gains diminish quickly. In a learning-by-doing model allowing for variety, he finds that rapid growth and productivity gains stem from the ability to consistently reallocate labor in new manufactured goods. The model I present uses a similar diminishing productivity gains property; however, it assumes that all producers have the same productivity in a country. Allowing differences in productivity levels within each economy in the model presented would reinforce our result, but it would not change the main insight.[7] The same mechanism explaining the crowding-out of the tradable sector and the widening productivity gap could be reversed to produce a crowding-in of the tradable sector and a rapid catch-up in terms of productivity. Indeed, if the domestic economy is less productive and it is the one transferring income to the foreign economy (through an under-valued exchange rate for example), the model would predict the pattern described.

4. Cross-country empirical evidence

The goal of this section is to present cross-country evidence that the effect of oil (or other resources) windfalls on the tradable sector depends on the initial productivity gap vis-à-vis the main trade partners. I use the panel data of McMillan and Rodrik (2011) which complement Timmer and de Vries (2009). It is a panel of 38 countries, three quarters of which are developing economies. It contains comparable employment and value added data (in PPP terms) per sector over the period 1990–2005. There is a number of cross-country empirical studies of the Dutch disease which are in general based on UNIDO's industrial data (see for example Ismail (2010)). However, as the ratio of productivities in the initial year is the focus of my analysis, I need comparable data on output and employment which, to my knowledge, only McMillan and Rodrik (2011) provide for a large enough sample. In the empirical investigation, I restrict the study to the manufacturing sector, the agricultural sector being in the grey area between a non-enclave tradable sector and a natural resource sector. Moreover, productivity gains in agriculture are generally considered to derive from productivity gains in manufacturing. I exclude Hong Kong SAR as it is an obvious outlier with its massive outsourcing to China in the 1990s.[8]

Table 1
Calibration.

Parameter	Value
k	0.5
α_1	0.9
ρ	0.4
δ	0.05
ϑ	0.3
γ	0.5
L	1
L^*	3
C	0.3

Trade data are taken from Feenstra et al. (2005) which runs through 2000. I proxy the dependence on oil and mining with their average share of total exports over the period 1990–2000. Oil and mining exports correspond to the SITC4 codes starting with 2, 3 and 68. I define the technological gap of a country, or technological distance, as the difference (in log) in labor productivity in manufacturing with its trading partner. For example, if a country has a technological gap of 0.1, it means that its trade partner is about 10% more productive in manufacturing. I construct the trade partner's labor productivity as the weighted average of labor productivity in manufacturing in the five biggest countries in terms of shares in total imports.[9] I use as weights the associated relative shares in total imports.

The model predicts that over time oil windfalls affect both the productivity and the relative size of the tradable sector and that the extent of the effect depends on the initial technological gap. Combining the effects means that in the long-run manufacturing output per worker, defined as manufacturing output divided by the total number of workers,[10] should also depend negatively on the initial productivity gap interacted with the dependence on oil. Fig. 2 shows a scatter plot of the level (in log) of the average output in manufacturing in 2000 vs. an interaction between the average dependence on oil and mining in exports over the period 1990–2000 and the technological gap in 1990. The strong negative relationship in the figure is confirmed by regression results in Table 2. Regression (1) shows that in the absence of the interaction term, it could be concluded that oil dependence does not matter in explaining the level of manufacturing output in a cross-section controlling for the logarithm of GDP per worker in 2000. However, the interaction term is significant at the 1% level and has the expected negative sign in both regressions (2) and (3), where I control for the logarithm of GDP per worker in 2000 in both regressions and for the

[5] The constant rate at which productivity gains diminish is close to what is chosen in Lucas (1993). I also choose a foreign country that is bigger in terms of population which is realistic for small oil exporters. The expenditure share of non-tradable goods is set to 50% which is in the order of magnitudes of what CPI weights suggest in several oil exporting countries. I perform a sensitivity analysis on all other parameters and I find that the result remains broadly the same.

[6] Note that the steady-state productivity ratio is equal to four.

[7] The effect of transfers on productivity gains through labor employed in the tradable sector would be compounded by the effect on the number of industries. While the home economy sees its tradable sector shrink, the foreign economy expands its tradable sector and starts producing new goods. As productivity gains are highest at the beginning, the productivity gap between the domestic and foreign economy would widen even faster leading to a stronger crowding out effect next period. The vicious circle brought by transfers could be drastically amplified.

[8] See Hsieh and Woo (2005) for a paper documenting the extent of the outsourcing.

[9] As the sample size is 38, there are several instances where not all the five biggest countries in terms of shares in total imports appear in the sample. However, in all cases the biggest source of imports appears in the sample and the countries that do appear represent at minimum 30% of total imports in 1990.

[10] It could be described as the economy-wide productivity in manufacturing as opposed to the sector specific productivity where the denominator is the number of workers in the sector.

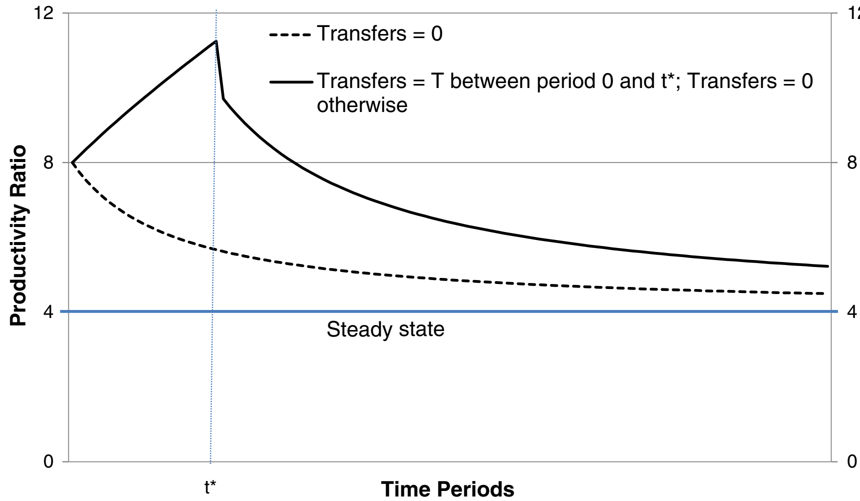

Fig. 1. The dynamics of the productivity gap.

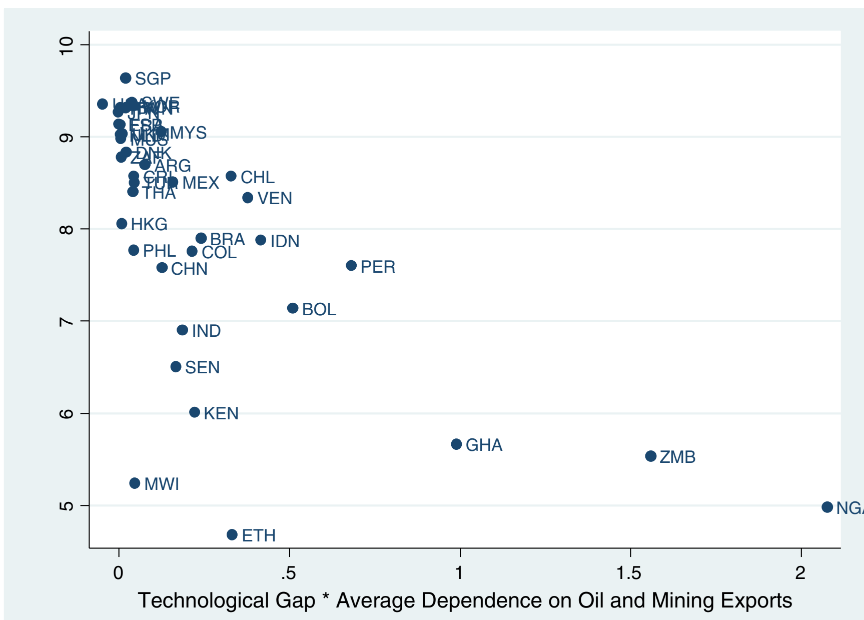

Fig. 2. Manufacturing output per worker (in log in 2000).

quality of institutions (Rule of law) in the latter.[11] Meanwhile, the direct effect of oil dependence has a low significance and the initial technological gap in 1990 is insignificant.

A central implication of the model is that the extent of the Dutch disease depends on the interaction between oil dependence and the technological gap. Table 3 shows regressions where the dependent variable is the change in the share of manufacturing in employment. Regression (1) shows that ignoring the interaction term leads to the conclusion that oil revenues do not affect employment in the manufacturing sector. Regressions (2)–(4) show that the coefficient of the interaction between oil dependence and the initial technological gap has the expected negative sign and is significant at the 5% level controlling for the rule of law and initial GDP per worker. In contrast, the initial technological gap and oil dependence are mostly insignificant. The regressions suggest that the channel of transmission of the Dutch disease depends solely on the interaction with the initial technological gap.

A striking result of the theory is that oil revenues can trigger a productivity divergence cycle vis-à-vis the trade partner. It implies that the technological gap should depend positively on the interaction between the initial technological gap and oil dependence. Table 4 presents regressions where the dependent variable is the change in the technological gap. The dependent variable measures the speed at which an economy is catching up with its main trade partners in terms of productivity in the manufacturing sector. In addition to controls, the regression includes oil dependence, the initial technological gap and their interaction. The previous set of regressions confirms that the interaction between the initial technological gap and oil windfalls is linked to the change in the structure of the economy. So omitting the structural change in the regressions could lead to a sizeable omitted variable bias.[12] Therefore, I control for the change in the (log) share of employment in manufacturing between 1990 and 2000 in all regressions. I also

[11] The variable is the average of the "Rule of Law" index over 1996–2000 available in Kaufmann et al. (2010).

[12] Running the same regressions without the change in the share of employment in manufacturing does lead to a stark change in the coefficient (and significance) of the interaction term.

Table 2
Manufacturing output per worker in 2000.

Variables	log(manufacturing output per worker)		
	(1)	(2)	(3)
log(gdp2000)	1.197***	1.191***	1.234***
	[16.90]	[13.16]	[12.09]
Rule of law			−0.0841
			[−1.053]
Dependence on oil	−0.529	0.498*	0.31
	[−1.503]	[1.794]	[1.023]
Technological gap		0.157	0.133
		[0.849]	[0.713]
Technological gap * Dependence on oil		−0.813***	−0.731**
		[−2.861]	[−2.408]
Constant	−3.441***	−3.546***	−3.893***
	[−4.656]	[−3.572]	[−3.630]
Observations	37	37	37
R-squared	0.936	0.947	0.948

Robust *t*-statistics in brackets.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

control for the quality of institutions in all regressions using the rule of law index of Kaufmann et al. (2010).

The result of regression (1) shows that ignoring the interaction term could suggest that oil windfalls do not affect the change in the technological gap. In regression (2) the interaction term between oil dependence and the technological gap is added yielding a positive and significant coefficient. In line with the model, a bigger initial technological gap, interacted with oil dependence, leads to a greater divergence of the technological gap. In both regressions, the coefficient of the initial technological gap is negative and significant in line with the prediction of the model. The initial technological gap has the expected negative and strongly significant coefficient indicating a beta-convergence pattern in the sample. The coefficient of the rule of law index is negative and significant in all regressions (albeit at varying levels of significance). As one might expect, a higher respect for the rule of law is positively correlated with the speed of the productivity catch-up in manufacturing. I verify the robustness of the results in regressions (3) and (4) where I control for the initial (log) level of GDP per worker and the average years of schooling, taken from Barro and Lee (2010), respectively.

5. Conclusion

The goal of this paper is to show that the Dutch disease is more severe in developing countries. Using a non-comparative advantage trade theory in the presence of transfers, I show that the technological distance vis-à-vis trading partners can affect the extent of the crowding out in the tradable sector. A persistent stream of oil revenues can trigger a divergence of the productivity gap vis-à-vis the trading partners. The cross-country empirical evidence I present is consistent with the theory advanced.

Paradoxically, a country can get richer thanks to the discovery of oil and see its living standards improve while rapidly falling behind technologically. When the resource is depleted or oil prices fall persistently, consumption and welfare would have to eventually reflect the relative technological level and thus deteriorate sharply compared to the counterfactual world where oil is not discovered. The mechanism I describe offers an alternative version of the natural resource curse. It also suggests that a remedy would entail stimulating the tradable sector.

There was a revival of interest in industrial policies in development economics in the last decade (see Rodrik (2004, 2008) for recent contributions). Proponents of industrial policies argue that if market failures are of first-order magnitude, then some sort of state intervention may be warranted. This paper suggests that particularly powerful externalities are at play in commodities exporter countries. Their main challenge ahead is to design policies to deal with these externalities by learning from past diversification experiences and adapting to today's environment.

Table 3
Change in the employment share of manufacturing 1990–2000.

Variables	Change in the employment share of manufacturing			
	(1)	(2)	(3)	(4)
Employment share of manufacturing	−0.296***	−0.339***	−0.262***	−0.286***
	[−3.598]	[−3.542]	[−3.799]	[−4.229]
log(gdp1990)	−0.001	−0.010		
	[−0.181]	[−0.772]		
Rule of law			−0.007	
			[−1.213]	
Dependence on oil	−0.033	0.022	0.001	0.0194
	[−1.572]	[0.882]	[0.057]	[0.779]
Technological gap		0.023	0.006	0.0122*
		[1.628]	[0.712]	[1.831]
Technological gap * Dependence on oil		−0.047***	−0.034**	−0.042**
		[−3.155]	[−2.276]	[−2.729]
Constant	0.052	−0.065	0.0353**	0.029*
	[1.122]	[−0.521]	[2.221]	[1.999]
Observations	37	37	37	37
R-squared	0.397	0.457	0.463	0.449

Robust *t*-statistics in brackets.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4
Change in the technological gap 1990–2000.

Variables	Change in the technological gap			
	(1)	(2)	(3)	(4)
Δ log(employment share of manufacturing)	0.709***	0.822***	0.802***	0.725***
	[4.980]	[5.069]	[4.694]	[3.745]
Rule of law	−0.197**	−0.223***	−0.210**	−0.168*
	[−2.502]	[−2.854]	[−2.519]	[−1.730]
log(gdp1990)			−0.051	
			[−0.487]	
School years				−0.060*
				[−1.754]
Dependence on oil	0.342	−0.17	−0.169	−0.268
	[−1.406]	[−0.707]	[−0.667]	[−1.026]
Technological gap	−0.231***	−0.368***	−0.418***	−0.455***
	[−3.742]	[−3.483]	[−2.787]	[−4.343]
Technological gap * Dependence on oil		0.441**	0.438**	0.547**
		[2.252]	[2.156]	[2.215]
Constant	0.221*	0.355***	0.88	0.840***
	[2.019]	[2.921]	[0.803]	[3.191]
Observations	37	37	37	35
R-squared	0.544	0.573	0.576	0.59

Robust *t*-statistics in brackets.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

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