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The Structural Manifestation of the `Dutch Disease': The Case of Oil Exporting Countries

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The Structural Manifestation of the `Dutch Disease': The Case of Oil Exporting Countries

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Abstract

This study derives structural implications of the Dutch disease in oil-exporting countries due to permanent oil price shocks from a typical model. We then test these implications in manufacturing sector data across a wide group of countries including oil-exporters covering 1977 to 2004. The results on oil-exporting countries are fourfold. First, we find that permanent increases in oil price negatively impact output in manufacturing as consistent with the Dutch disease. Second, evidence in the data shows that oil windfall shocks have a stronger impact on manufacturing sectors in countries with more open capital markets to foreign investment. Third, we find that the relative factor price of labor to capital, and capital intensity in manufacturing sectors appreciate as windfall increases. Fourth, we find that manufacturing sectors with higher capital intensity are less affected by windfall shocks than their peers, possibly due to a larger share of the effect being absorbed by more labor-intensive tradable sectors. An implication of the fourth result is that having diverse manufacturing sectors in capital intensity helps cushion the volatility of oil shocks.

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I. INTRODUCTION

The Dutch disease is the process by which a boom in a natural resource sector results in shrinking non-resource tradables. This process leads to increased specialization in the resource and non-tradable sectors leaving the economy more vulnerable to resource-specific shocks. In this paper, I illustrate a theoretical model to examine the Dutch disease effect due to permanent oil price shocks under open and closed capital markets. In the paper, I examine the consistency of the propositions derived from the model within disaggregated cross-country manufacturing sector data covering a group of oil-exporting countries. I find strong evidence for the existence of the Dutch disease in response to oil price shocks. I also find that oil windfall shocks have a stronger impact on manufacturing sectors with more open capital markets to foreign investment. Moreover, I find that oil price shocks affect relative factor prices, and the factor intensity of production of these manufacturers in a manner consistent with the model, when non-tradables are labor-intensive. Finally, I find that within manufacturing, sectors with higher capital intensity are less affected by windfall shocks. In this section, I start with an introduction of the Dutch disease and a discussion of its remedies, its welfare implication, and its measurement. I conclude this introduction with an elaboration on why microeconomic data may provide a more accurate way of measuring the Dutch disease.

First, I illustrate the Dutch disease theory through the following example. If a positive shock to the resource sector takes place (this can be resource price increase, discovery of resource stock or decrease in costs of extraction) in a country that is a net resource exporter, then the resource wealth of the country effectively increases, and more natural resource revenue is expected to be generated. Regardless of whether the resource windfall is appropriated by the public or private sectors, total spending on non-tradables is expected to rise. If the supply of non-tradables is not perfectly elastic, then this spending effect results in an appreciation in the price of non-tradables, while the price of tradables remains fixed in a small open economy. This effectively appreciates the real exchange rate, which is the relative price. The appreciation in the real exchange rate moves factors of production from the non-resource tradables to non-tradables, which leads to an expansion in non-tradable services and shrinkage in tradable manufacturing and agriculture.

There are fiscal and structural policies that may mitigate the Dutch disease. On the fiscal side, mitigating the Dutch disease effect comes down to decreasing the degree of spending out of windfall on non-tradable services. Thus the two most direct fiscal policy measures to counter the Dutch disease is to decrease spending out of windfall income through investment in foreign assets or to direct that spending towards import-heavy expenditure. On the structural side, policies related to the openness of the factors market to inflows of labor and capital may help offset some of the impact of resource price shocks. Easier immigration policies can offset the pressures on the exchange rate by drawing labor from outside to supply the increased demand for non-tradables. Similarly more open capital accounts can mitigate the shortage of capital during windfall booms by allowing for capital inflow. However, openness towards capital outflows may aggravate the

Dutch disease, as I show later. I show in Section III theoretically, and in Section IV empirically, that openness of capital markets can lead to stronger Dutch disease effects when non-tradables are labor-intensive.

This paper does not examine the welfare impact of the Dutch disease, but it is worth noting that the Dutch disease, while termed "disease", may not clearly have a negative impact on welfare or efficiency. The Dutch disease is a resource re-allocation process away from less profitable tradable sectors to non-tradables, and by so, is efficient and welfare improving when markets are complete. However, the Dutch disease can exert a negative impact on growth when there are infant industries or learning-by-doing external to the firm in the shrinking tradable sector.[1] This learning-by-doing may be related to more than the size of the sector. A sector following more capital-intensive production–that in turn uses higher skilled labor–may generate more positive spillover effects than a larger sector following a low-skill labor-intensive production. The Dutch disease may affect relative factor prices, and not only the level of production. As a result, the relationship between the Dutch disease and these positive spillovers may be ambiguous. In this chapter, I find a significant increase in the capital-to-labor ratio in manufacturing sectors in response to positive oil shocks, as shown in Table 7. This is the case, while also observing shrinking labor force in manufacturing and shrinking size both in terms of value added and output due to positive oil shocks, as shown in Table 3. Thus, it may be difficult to directly associate the Dutch disease with decreased learning-by-doing from the sample as the size-effect on tradables is counter to the effect on relative factor prices that may create incentives to train high-skilled labor to augment the more capital-intensive production.

When measuring the Dutch disease it is crucial to first understand what we aim to measure exactly. Given two states in time for a resource-exporting economy, one prior to an oil boom and one post, we wish to measure the deterioration in growth in non-resource tradables relative to the growth that would have been the case in the absence of natural resources. In order to find what this counterfactual growth is, a cross country comparison can help us estimate what the growth level would have been if the country was not an oil-exporter. However, different countries have different sectoral compositions within manufacturing, and each sector can have a different growth trend. What leads countries to have different sectoral compositions are factors beyond natural resource abundance, such as factors of production abundance relative to trading partners. Thus if we only use aggregate manufacturing output data, any estimate of trend growth across countries may be biased as sectoral composition plays a major role in the differentiation of manufacturing growth rates across countries.[2] For example, if we compare the growth rate of aggregate manufacturing in two countries, one resource rich and one resource poor, with two different sectoral compositions within, we may infer biased conclusions on the size of the Dutch disease as sectors are heterogenous and may be subject to separate demand conditions and consequently

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[1] Krugman (1987), Matsuyama (1992), and Sachs and Warner (1995) make this argument through various endogenous growth models.

[2] This may have played a role in why studies that used aggregated data – such as Gelb (1988), and Spatafora and Warner (1995) – could not find evidence of Dutch disease in manufacturing due to oil booms.

grow at different rates. Thus a comparison across countries within sectors may be a more accurate method to measure the impact of real exchange rate appreciation from the Dutch disease on these sectors as it provides the closest proxy of the counterfactural sectoral growth in the absence of natural resources.

I use microeconomic data for three reasons. The first and primary reason is that aggregate manufacturing data across countries may not adequately describe trend growth when sectors are heterogenous and thus have different growth trends. Thus the practice of deriving growth trend from aggregated manufacturing data across countries as a proxy for the counterfactual growth of manufacturing in the absence of natural resource exports may be biased as it does not account for sectoral composition. The second reason is that the Dutch disease in macroeconomic data has generally yielded very weak results. On this point, using microeconomic data helps in two ways. First, there is a benefit in the quantity of the data, and possibly the quality, due to the wider cross-section of microeconomic data and possibly the smaller scale of measurement errors. Second, using sector level data allows us the convenience of using variables endogenous at a macroeconomic level, such as changes in the rate of resource extraction, as exogenous at the sectoral level. The third reason to use sector level data is to examine structural changes at the sector level such as factor-intensity and relative factor prices, that may otherwise be impossible to examine with macro-level or highly aggregated data. Ideally, firm level data would have given us the clearest sample for this purpose; however due to the difficulty in obtaining data on manufacturing across the oil exporting sample of countries, this sector level data is among the most disaggregated available.

In the following, I first give a background on the related literature on the subject. I then introduce two models in Section III that illustrate the Dutch disease and its structural implications. Through these models, I derive a set of propositions, which I test in empirically in Section IV.

II. RELATED LITERATURE

Unlike in this paper, the bulk of the literature on the Dutch disease approached it on a country case level, and mostly centering on the effect of extraction or discovery as a one time incident. The Dutch disease came first into the spotlight in the 1970s following the North Sea oil and gas discovery. It was coined as "Dutch" in reference to the shrinking of manufacturing and rising unemployment in the Netherlands at the time. While the fiscal expansion as a result of the extraction of natural gas is a factor in what occurred in this case, it is still unclear to what extent the shrinkage of the non-oil tradable sector can be attributed to resource extraction alone. The experience of the Netherlands, however, spread fears of similar incidence to other industrial countries with hydrocarbon resources including the United Kingdom, which saw a shrinkage in manufacturing in the late 70s. The possibility of a Dutch disease in the UK triggered interest, which first started with the theoretical work of Codren and Neary (1982) and the empirical analysis of Bruno and Sachs (1982) on examining the Dutch disease in the UK.

In cross-country studies, there has been limited evidence of Dutch disease due to oil discovery. Gelb (1988) provides an extensive empirical cross-country study of the Dutch disease, where the effect of windfall on oil exporters was examined for a group of oil exporting countries, most of whom have spent large amounts of the windfall they gained in the wake of the 1973 oil boom.[3] However, virtually all countries in the study showed no Dutch disease in manufacturing. A possible explanation for the missing Dutch disease was that these sectors were initially too small, and that price controls and subsidies by the government combined with active promotion of the sector kept them from being adversely affected. Services, however, did expand dramatically as a share of output in GDP. In estimating the Dutch disease, I rely on more recent oil price developments from 1983 to 2004. This aids the analysis as by then most countries in the sample have developed a more sizable manufacturing sector relative to the case in 1972.

Only a limited number of studies attempted to test for the Dutch disease directly through movements in oil price or revenue, with weak results. There are two caveats to this analysis. The first is that governments tend to adjust their fiscal policy slowly, especially following the negative experience with the oil price bust of the 1980s. This makes it difficult to assess how much of the fiscal spending was due to contemporary or past oil price shocks, or other factors. The second is that many countries acquire most of their windfall revenues either through lump sum taxation of barrel exports, as is the case in Russia, or through royalties, as the case in Chad, which may cushion the windfall from short-term movements in oil price. Spatafora and Warner (1995) finds a positive link between terms of trade shocks in oil-exporting countries and their real exchange rate as well as public spending. They find that the reaction of public spending to shocks was stronger than that of private spending. However, they could not find evidence of the Dutch disease.

Evidence of the Dutch disease due to oil price shocks in country case studies has also been weak. Sala-i-Martin and Subramanian (2003) could not find evidence of the Dutch disease in Nigeria due to oil price movement. Moreover, they find that the real exchange rate is insensitive to oil price. They highlighted an issue that is all too common in analyzing the impact of oil prices on macroeconomic variables in oil-exporters, which is the importance of knowing the type of spending, and not only the quantity. Spending of revenues on tradables bears no impact on the real exchange rate. Thus if the bulk of windfall is spent on importable goods, any signs of a Dutch disease may be weak. A main advantage of cross-country analysis in this case is that it may help eliminate idiosyncrasies by pooling observation from different countries under different fiscal policy regimes.

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[3] Gelb (1988) finds that Ecuador, Iran, Nigeria and Trinidad and Tobago went through the Dutch disease, mainly due to a decline in Agriculture, over the first and second oil booms of 1972–81, while Algeria, Indonesia and Venezuela went through a strengthening of their non-oil tradables.

The difficulty of finding evidence of the Dutch disease may be attributed to a wide range of factors including such conventional ones as small sample (most oil-exporting countries report key measures only annually), measurement bias in indices of aggregate manufacturing output, and the difficulty in accounting for the counter-factual growth of manufacturing in the absence of a natural resource endowment. Of course another possibility is that the Dutch disease might not exist. In many of the instances where manufacturing is found to be lagging in oil-exporting countries, there has been other factors involved such as structural bottlenecks, weak capital markets, inadequate property right protection, inefficiencies due to rent-seeking, and political instability that could explain the slow growth of manufacturing. But if there is no strong evidence for the Dutch disease, then most of what economists would consider classical trade theory is inconsistent with the data. The impact of hydrocarbons on their exporters provides what is among the most opportune cases to testing trade theory, and this motivates examining the Dutch disease at a structural level.

III. THEORETICAL MODEL

The purpose of this static model is two folds. First, it illustrates how the Dutch disease takes place in response to oil price shocks. Second, the model allows us to build a set of propositions on how we expect the Dutch disease to impact relative factor prices, factor intensities, and foreign investment flows in the case of open capital markets. This allows us later to test these propositions to compare between the theoretical manifestation of the Dutch disease and what is observed in the data. In order to build the simplest possible model that delivers these points, I abstract away from intertemporal saving out of resource windfall, and assume that the government spends the windfall as it recieves it. I also abstract away from production in the oil sector, and thus assume away the re-allocation of factors of production to and from the oil sector due to oil price shocks. This assumption is supported by the oil sector in many oil exporters acting as an enclave sector, where the use of domestic labor and capital is limited, and investment in the sector is either mainly directed by the government or dependent on foreign capital. Thus oil windfall is modeled as an exogenous endowment within a Heckscher-Ohlin model.

In modeling the Dutch disease, I focus on two key structural aspects, relative factor intensities of the sectors and the mobility of factors across countries, capital mobility to be specific in this case. Regarding the first aspect, the Heckscher-Ohlin framework predicts that resource shocks may have a structural impact beyond reducing output in tradables. This includes affecting the relative factor prices and the factor intensities of each sector. Moreover, relative factor intensity determines the degree of output decline in each manufacturing sector. An example would be, if non-tradables are labor-intensive, then the Dutch disease have the effect of raising wages relative to rent. This in turn have a stronger impact on labor-intensive industries than capital-intensive ones. To illustrate the impact of resource shocks on relative factor prices and factor intensity, I use a two-sector model with a tradable and a non-tradable sector, with an endowment of Capital K and Labor L as factors of production.

The second aspect to the model is the mobility of factors of production across sectors. Without frictions to capital and labor mobility, there would be no Dutch disease as the increased demand for non-tradables is compensated for by factor inflows. However, if Labor is immobile, the mobility of capital may result in cushioning or amplifying the Dutch disease depending on structural conditions, as we will see later in Proposition 7. In Section IV, I show that there is suggestive evidence that manufacturers in oil exporting countries with more open capital markets may have been more negatively impacted by oil price shocks than manufacturing in oil exporting counties with less open capital markets.

This paper demonstrates these points through two models of the Dutch disease. Both are two-sectors models with capital and labor as inputs, and both factors are mobile across sectors, with labor immobile across countries. Oil windfall is given as an exogenous endowment, spent without saving. The first model, however, follows the classical assumption of closed capital markets, while the second assumes perfectly mobile capital across borders. For Proofs of the propositions in the model, see Appendix A.

A. The Dutch Disease with No Capital Mobility across Borders

$$\begin{aligned} X_n &= A_n K_n^{\alpha} L_n^{1-\alpha} && (1)\\ X_m &= A_m K_m^{\beta} L_m^{1-\beta} && (2)\\ X_o &= \pi N = \Psi && (3)\\ K &= K_m + K_n && (4)\\ L &= L_m + L_n && (5) \end{aligned}$$

This is a small open economy where X_n is non-tradables and X_m is manufacturing and both follow Cobb–Douglas production. I abstract away from materials, and factors used in the extraction of resources such that X_o is the value added of the resource sector, and is given by the exogenous windfall Ψ, where π is the permanent component of the oil unit price and N is a contant level of extraction. A_n and A_m are Hicks-neutral productivity in each sector. Price of tradables is normalized to 1 such that price of non-tradables p corresponds to the real exchange rate.

Consumption out of windfall is modeled through a representative consumer following without loss of generality an additively separable Cobb-Douglas utility in non-tradable services and manufactured goods.

$$\max_{\{c_m, c_n\}} u = (1-\gamma)\log c_m + \gamma \log c_n \qquad (6)$$

$$pc_n + c_m \leq y \tag{7}$$

$$\text{where } y = w(1+\varphi) \tag{8}$$

Where φ is the windfall per capita measured relative to non-resource income w such that $\varphi w = \frac{\pi N}{L} = \frac{\Psi}{L}$.

Proposition 1 *A positive windfall shock results in the movement of labor away from manufacturing and to the non-tradable sector.*

This proposition is given by the following, which is the differentiation of the logarithm of L_n by φ using the market clearing condition for non-tradables (for proof, see Section A.1). From here on, I use the shorthand notation $\tilde{x} = \ln x$.

$\tilde{L}_{n\varphi} = \frac{1}{1+\varphi} > 0$

This proposition is fairly intuitive as the increased demand for non-tradables resulting from higher consumption leads to an excess demand for non-tradables. In order for markets to correct this, the relative price of non-tradables p rises, resulting in higher value marginal product of labor in the sector and thus higher wages. This in return, results in labor moving from the tradable to the non-tradable sector until there is no more excess demand for non-tradables.

Proposition 2 (Dutch Disease) *A positive windfall shock results in shrinking manufacturing and expanding the non-tradable sector.*

This proposition is a generalization of the first, as the same reason that led to moving labor from tradables to non-tradables also applies to capital here. As both capital and labor are re-allocated from tradables to non-tradables, the result is a decline in the production of tradables. This reflects the loss of competitiveness of the tradable sector as the non-tradable sector bids for higher factor prices. The representative houshold consumes more of both goods, except more of the tradable consumption is imported (for proof, see Section A.1).

Proposition 3 *A positive windfall shock results in an appreciation of the real exchange rate.*

This proposition is identical to Proposition 2 given that the price of tradables is fixed to the world level, and thus movement in the price of non-tradables p are also movement in the real exchange rate (for proof, see Section A.1).

Proposition 4 *A positive windfall shock results in increased (decreased) marginal productivity of labor when non-tradables are labor (capital) intensive, and consequently an increased (decreased) wage-rent ratio across sectors.*

This means that the capital-labor ratio increases (decreases) due to the price shock if tradables are labor (capital) intensive. This is a direct result of the Stolper-Samuelson theorem applied to Proposition 3.[4] The explanation is that as non-tradables expand due to windfall spending, the demand on the factor intensively used in non-tradable production increases relative to the demand of the other factor thus appreciating the relative factor price. This in turn causes each sector to follow production more intensive in the relatively cheaper factor. When non-tradables are labor-intensive, this in turn means an appreciation in $\frac{w}{r}$ which in turn raises $a_n = \frac{K_n}{L_n}$ and $a_m = \frac{K_m}{L_m}$ and leads to higher marginal productivity of labor (MP_{Ln} and MP_{Lm}) (for proof, see Section A.1).

$$\widetilde{MP}_{Ln\varphi} = \alpha \tilde{a}_{n\varphi} \tag{9}$$
$$\widetilde{MP}_{Lm\varphi} = \beta \tilde{a}_{m\varphi} \tag{10}$$

The point here is that both sectors are not only affected in terms of size, but also in terms of style of production and that may have implication on how it affects incentives to train a higher-skilled labor force. The significance of this result is that learning-by-doing, which as I described earlier is considered one of the key reasons why the Dutch disease may be detrimental to welfare, may depend on more than the size of the human capital generating sector, but also on its mode of production, which is described here as the ratio of capital to labor units. Increased capital per worker may generate spillovers in terms of higher demand for better trained workers to utilize the more available tools of production to each worker. This may offset the loss of spillover from the shrinking base of workers in manufacturing. This challenges the presumption that even with learning-by-doing that is external to the firm and localized to manufacturing, that the Dutch disease is a negative phenomenon on human capital accumulation. However, I will not extrapolate from this point beyond this, but I will test the impact of oil shocks on factor-intensity in Section IV.

This proposition does not hold however in the case of international mobility of capital as relative factor prices are exogenous in that case. However open capital markets yield results on the impact of oil price booms on capital flows, which I demonstrate in the following section.

B. The Dutch Disease with Capital Mobility across Borders

The key feature that distinguish a model with capital mobility from the previous case is that the interest rate is fixed to the world rate.

Proposition 5 *A positive windfall shock leaves marginal productivity in both sectors, wages and the real exchange rate unaffected.*

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[4] Though the Stopler-Samuelson theorem is meant for two tradable sectors, the same concept can be extended here.

The intuition of this proposition is that by fixing the factor price of capital to world prices, the value marginal product of capital is also fixed. However, since the price of tradables are also fixed to the world level, this means that the marginal product of capital in the tradable sector is unchanged. This in turn means that the factor intensity is unchanged in both sectors, and thus the marginal product of capital and labor in both sectors are unchanged. Since the maginal products are unchanged, and the rent of capital is fixed to the world level, this in turn means that the real exchange rate is unchanged. The following equations present the solution of the model (for proof, see Section A.2).

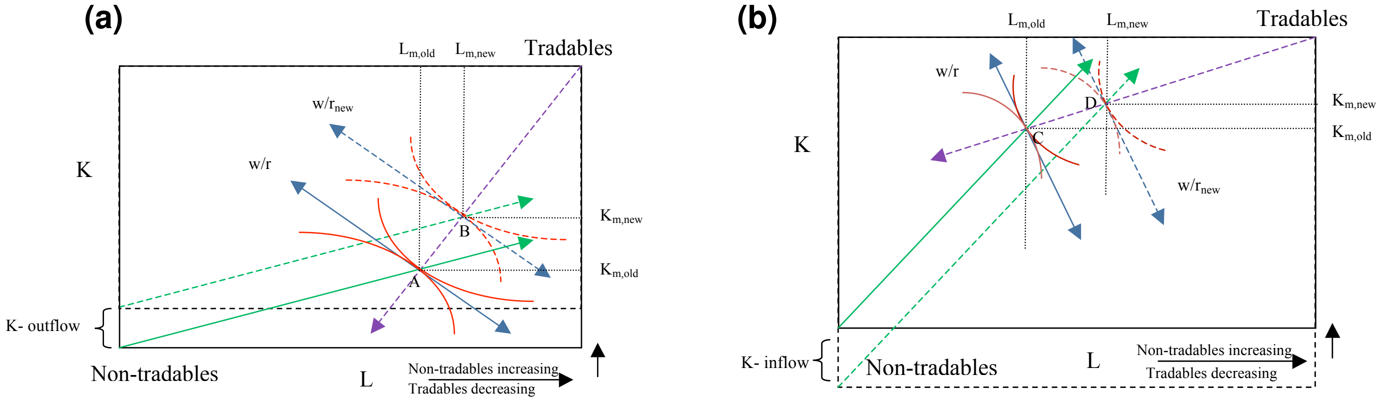
$$\begin{aligned}
\tilde{p}_{\varphi} &= 0 \\
\tilde{L}_{n\varphi} &= \frac{1}{1+\varphi} && (11) \\
\tilde{K}_{n\varphi} &= \frac{1}{1+\varphi} && (12) \\
\tilde{L}_{m\varphi} &= -\frac{L_n}{L_m}\frac{1}{1+\varphi} \\
\tilde{K}_{m\varphi} &= -\frac{L_n}{L_m}\frac{1}{1+\varphi}
\end{aligned}$$

Proposition 6 *A positive windfall shock results in net capital inflow/outflow when non-tradables are capital/labor intensive.*

This is a direct implication of Proposition 5. From equation (11) and equation (12), the Dutch disease still holds as the tradable sector sheds labor and capital in proportion to its factor intensity, which is then absorbed by the non-tradable sector at its own factor intensity. As a result capital may flow into the country if the non-tradable sector is capital-intensive and thus requires more capital to supplement the labor absorbed from the market. Alternatively, if the non-tradable sector is labor-intensive, then more capital is available than can be absorbed by the re-allocated labor and thus capital flows out (for proof, see Section A.2).

Figure 1 illustrates this proposition through two Edgeworth box examples following the effect of oil boom. In **(a)**, the economy with labor-intensive non-tradables moves from point A to point B as the oil sector Booms. The non-tradable sector absorbs labor, but is unable to accommodate all the capital shed from the tradable sector at the relative factor price w/r which remains unchanged. As a result, the return on capital declines relative to the world, and capital flows out (shrinking the Edgeworth Box in the process, by decreasing K). In **(b)**, the economy with capital-intensive non-tradables moves from point C to point D as the oil sector Booms. The non-tradable sector absorbs the labor shed by tradables but demand more capital to augment that labor than what is available domestically. As a result, the return on capital rises and capital flows in to return relative factor prices to the world level (expanding the Edgeworth Box in the process, by increasing K).

Figure 1. The Effect of Oil Booms on Capital Flows Depending on Capital Intensity of Non-tradables



Labor-intensive non-tradables

Capital-intensive non-tradables

Proposition 7 *In the case of open capital markets, the Dutch disease results in manufacturing shrinking less (more) than in the case of closed capital markets when non-tradables are capital (labor) intensive.*

This proposition describes the difference in the Dutch disease impact due to oil price shocks between open and closed capital markets.[5] While Proposition 2 holds in this case, the Dutch disease effect here compared to the case of closed capital markets depends on the factor intensity of non-tradables. If non-tradables are labor-intensive, then the case of open capital markets has a larger Dutch disease impact. That is due to the non-tradable sector being unable to accomodate all the capital shed by manufacturing and thus resulting in capital outflow. As capital markets are open, the tradable sector is unable to bid low the rent of capital and thus shrinks more than would have been the case if capital markets were closed. Alternatively, when capital markets are open and non-tradables are capital-intensive, capital inflows allow non-tradables to expand without drawing as much capital away from the tradable sector as it would if the capital markets were closed. An open capital account in this case helps cushion the lagging sector, but does not eliminate the Dutch disease altogether. It is worth noting at this point, that the conventional wisdom is that non-tradable production is more labor-intensive than tradable production. If this is indeed the case, we expect to observe a stronger Dutch disease in countries more open to Foreign Direct

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[5] While Proposition 7 illustrates the variation in the tradable sector's elasticity to oil shocks between open and closed capital markets, it does not indicate the impact of capital account liberalization itself on the level of tradable production. The effect of capital account liberalization on tradable production depends on the capital abundance of the country relative to the world. However, Proposition 7 may have normative implications through the higher exposure of the tradable sector to oil volatility through an open capital market.

Investment (FDI). Since we can safely assume that capital mobility across countries is not perfectly free, we also expect capital intensities and the relative factor price of labor to rise due to positive oil price shocks (Proposition 4). In Section IV, I find suggestive evidence that supports both hypotheses (for proof, see Section A.2).

C. The Case of Multiple Industrial Sectors

In these models, the assumption for clarity and simplicity is that there is only one non-resource tradable sector and one non-tradable sector. However, many of the implications of the two-sector model extend to a model with multiple tradable sectors. Given that the data incorporates a large number of manufacturing sectors, I here elaborate on what to expect theoretically in terms of Dutch disease variation across sectors in response to oil booms.

The simplest way to extend the model to cross-industry variation is to assume a closed capital market, with capital as tradable or non-tradable specific (meaning no mobility of capital between tradables and non-tradables). In this case, when an oil boom takes place, the tradable sectors collectively lose labor to non-tradables similar to Proposition 2. As a result labor-intensive sectors shrink and in the process they shed tradable-specific capital. In turn, capital-intensive sectors within tradables absorb the capital at lower rent due to the appreciation of the exchange rate. In essence, this is a direct implication of the Rybczynski theorem. Therefore, if we assume that the substitutability of capital is easier across manufacturing sectors than between manufacturing and non-tradables, and that capital markets are not perfectly open, then we expect the Dutch disease to be stronger in labor-intensive manufacturing sectors. Indeed, in Section IV , subsubsection 3 I show that such hypothesis is supported in the data.

IV. ESTIMATION OF THE STRUCTURAL IMPACT OF OIL SHOCKS

In the following, I first describe the data used in this study. Then the study presents the estimation strategy and results on measuring the Dutch disease, it's variation across countries, the impact of oil shocks on relative factor prices and factor intensity, and the variation in the Dutch disease across industries.

A. Data

I use disaggregated data from the United Nations Industrial Development Organization (UNIDO) Industrial Statistics database. The data is annual and covers years 1977–2004 on 81 manufacturing sectors. The data covers 90 countries, including 15 oil exporting countries with oil as at least

20 percent of exports on average across the sample period.[6] For estimating the Dutch disease effect (Proposition 2), and the role of open capital markets (Proposition 7), I use the revision 2 edition of the data due to the wider cross section of countries available, and I supplement the missing data with observations from revision 3 when available. For testing the impact on factor intensities and relative factor prices (Proposition 4), I use the revision 3 edition of the data because it includes more observartions on gross fixed capital formation in oil exporting countries. I construct the gross capital stock time series from gross fixed capital formation data. This study uses the perpetual inventory method with a fixed capital depreciation rate of 10 percent.[7] I use permanent oil price shocks. Thus I invoke the permanent income hypothesis by assuming that transitory shocks to oil price should have no impact on spending, and by extension should not result in a Dutch disease. I primarily use Kalman filtered estimates from Arbatli (2008), which decomposes the permanent and transitory shocks of West Texas Intermediate (WTI) crude oil spot prices (see Appendix B). For the amount of oil extracted, I use data from the International Financial Statistics by the International Monetary Fund. This study uses price levels of investment from the Penn World Tables for the estimation of capital stock and as a proxy for the return on capital. For capital market openness to FDI, I use the financial integration index from Lane and Milesi-Ferretti (2006).[8] I average this index across the sample period for oil prices to create a time-invariant index of capital market openness for each country.

B. Estimation Strategy and Results

I test the theoretical propositions from Section III using cross-sectional reduced form estimation of the effect of permanent oil price shocks on the industries across countries. I consider permanent shocks in oil windfall given by $\pi_t N_t$, where π_t is the permanent component of oil price and N_t is the level of extraction, as exogenous shocks in φ from the model. The following specifications accounts for country, industry and time effects through control dummies.

1. Measuring the Dutch Disease

I first examine the effect of windfall shocks on output in the pooled sample of manufacturing in all countries in the database using

$$\Delta \ln y_{ijt} = \alpha + \sum_{i=1}^{I} \beta_i \mathbf{1}(industry) + \sum_{j=1}^{J} \gamma_j \mathbf{1}(country) + \sum_{t=1}^{T} \zeta_t \mathbf{1}(year) + \sum_{i=1}^{4} \eta_{t-i} \Delta \ln windfall_{t-i} + u_t \tag{13}$$

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[6] For a list of the oil exporting countries in the sample, see Table 1.

[7] An issue here is the short time span of the cross section, which makes estimates sensitive to assumptions on initial capital stock.

[8] Lane and Milesi-Ferretti (2006) uses (stock of FDI assests + stock of FDI liabilities)/ Gross Domestic Product.

Where y_{ijt} is output of sector i in country j at time t, and $\mathbf{1}(industry)$, $\mathbf{1}(country)$, and $\mathbf{1}(year)$ are dummies associated with industry, country, and time respectively. Moreover, fixed-time variation across countries in that stem from varying size of the oil sector relative to the economy is captured by the fixed effects since the specification is in change of logarithms. I use a horizon of 4 years, which I find to produce the best fit using Akaike and Schwarz information criteria. The η_{t-i} coefficients correspond to the impact of oil windfall shocks i years before on industries in oil exporting countries at time t. This estimation is done on the pooled sample including both oil-exporting and non oil-exporting countries, with $\Delta \ln windfall$ taking a value of 0 for non-oil exporters. The result is reported in Table 3 column 1 for output, and column 3 for value added. I test the robustness of this pooled estimation through a fixed-effect panel estimation in columns 2 and 4. I find that the cumulative impact of permanent oil windfall shocks to be significant, with a 10 percent increase in windfall associated with a 3.4 percent reduction in value added across industries and with a 3.6 percent reduction in industrial output.[9] The results are not sensitive to whether I use a pooled least-square estimation with country, industry and time dummies, or a fixed-effect panel estimation with a fixed effect for each sector in each country and time dummies.

For further robustness test of Proposition 2, I estimate equation (14), which adds to equation (13) dummies for the interaction between industries and time. This may capture industry specific technological innovations. I also estimate it using the Kalman filtered permanent oil price used in the windfall for equation (13), and Hodrick-Perscott filtered spot oil price. [10]

$$\Delta \ln y_{ijt} = \alpha + \sum_{i=1}^{I} \beta_i \mathbf{1}(industry) + \sum_{j=1}^{J} \gamma_j \mathbf{1}(country) + \sum_{t=1}^{T} \zeta_t \mathbf{1}(year) + \sum_{i=1}^{4} \eta_{t-i} \Delta \ln windfall_{t-i} + \sum_{i=1}^{I}\sum_{t=1}^{T} \gamma_{it} \mathbf{1}(industry) \times \mathbf{1}(year) + u_t \tag{14}$$

The result, which is reported in Table 4, is that both the Kalman filtered permanent price shocks and the Hodrick-Prescott filtered spot price shocks deliver statistically significant results. However the Kalman filtered permanent prices show a stronger Dutch disease impact at 3.4 percent reduction in value added due to a 10 percent windfall shock, relative to only a 1.3 percent reduction observed through the Hodrick-Prescott filtered shocks. This may imply that the Kalman filtered permanent oil shocks mirror more closely the perception of persistence in shocks due to its use of future's prices to convey the market's beliefs regarding such persistence.[11] I also perform an additional robustness test using dummies for the interaction between country and time instead of the interaction dummies in equation (14). The results of this test is also supportive of a signif-

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[9] All standard errors in these estimations are clustered by sector per country for robustness.

[10] I use $\lambda = 1600$ for the H-P filter's value function.

[11] This result is consistent with Arbatli (2008) which finds a significant impact of these futures prices based Kalman filtered shocks on consumption across a sample of oil-exporting countries.

icant Dutch disease effect at the 1 percent level. For the remainder of my estimations, I use value added rather than output as a more relevant measure of the size of production.

2. The Dutch Disease in Closed versus Open Capital Markets

My index for capital market openness is based on Lane and Milesi-Ferretti (2006) and it is the average ratio of total FDI assets and liabilities to GDP over 1983-2008. Thus this index is country specific and time invariant. This methods of measuring capital market openness is capturing its most relevant aspect to Proposition 7 , which is the linkage of physical industrial capital to the world market. Measures that incorporate debt-creating capital flows are not as relevant to the Dutch disease as their effect on tradables competitiveness can be positive (for example, by providing liquidity for investment that would improve supply of both tradables and non-tradables) or may have an adverse effect (for example, by fueling consumption of non-tradables thus exacerbating the real exchange rate appreciation). FDI on the other hand more closely proxies our notion of capital from the model, and is more liable to bolster supply and thus competitiveness.

In order to test Proposition 7, I estimate the Dutch disease in each oil-exporting country in my sample. I use the estimates of the country, industry and year effects from equation (13) on the entire pool of countries, and estimate the impact of oil windfall shocks on the difference between output and these fixed effects. Thus the country-specific estimation function is

$$\Delta \ln y_{ijt} - \sum_{i=1}^{I} \hat{\beta}_i \mathbf{1}(industry) - \sum_{j=1}^{J} \hat{\gamma}_j \mathbf{1}(country) - \sum_{t=1}^{T} \hat{\zeta}_t \mathbf{1}(year) = \alpha + \sum_{i=1}^{4} \eta_{t-i} \Delta \ln windfall_{t-i} + u_t \tag{15}$$

The results are reported in Table 5. I plot the countries by these results and by their degree of financial integration in Figure 3, and run a least-squares regression on countries with statistically significant results showing the trend in Figure 4. I find the trend is that countries which are more open capital markets are impacted more strongly by permanent oil windfall shocks, even after eliminating outlier points, and countries with statistically insignificant results. This result would be consistent with Proposition 7 if non-tradables are relatively labor-intensive.

In order to test the robustness of this result, I run a pooled estimation of the Dutch disease effect using equation (15) on two groups of oil exporters with one group having a less open capital market according to my index.[12] I then contrast the results from both groups in Table 6. I find

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[12] My sample division is based on a capital market openness index cutoff of 0.2. For countries with less open capital markets, I use Colombia, Iran, Kuwait, Indonesia and Mexico. The other group includes Ecuador, Russia, Trinidad and Tobago, Malaysia, Gabon, Nigeria, and Venezuela). I eliminated Canada, Norway and the UK from this test since their Dutch disease results were weak possibly due to a high degree of windfall sterilization.

supportive evidence for Proposition 7 as the coefficient for the group with more open capital markets is much stronger in scale at -0.697 relative to the other group's coefficient at -0.352.[13] Since the consistency of these results with Proposition 7 hinges on whether non-tradables are labor-intensive, we will consider in the following the empirical evidence for Proposition 4, which also depends on the factor intensity of non-tradables. I find supportive evidence for Proposition 4 that is consistent with the a priori that non-tradables are labor-intensive. This indirectly gives more support to the evidence here for Proposition 7.

3. The Dutch Disease in Relative Factor Prices and Factor Intensities

In order to test Proposition 4, I measure the effect of permanent oil price shocks on the ratio between wages in each sector and the price level of investment.[14] Here, instead of using the revision 2 edition of the dataset, which has relatively scarce observations on wages and gross fixed capital formation, I use INDSTAT revision 3 which covers 1990–2004. I consider changes in P_k, the price level of investment, to proxy changes in the rate of return on capital from the model. Additionally, I estimate the effect on the capital-labor ratio directly using the same specification as equation (16). I use my estimates of the capital stock, which I described in Subsection A together with the number of workers (number of labor hour units is not available) to proxy the capital intensity in each sector.

$$\Delta \ln(w_{ijt}/P_{k_{jt}}) = \alpha + \sum_{i=1}^{I} \beta_i \mathbf{1}(industry) + \sum_{j=1}^{J} \gamma_j \mathbf{1}(country) + \sum_{t=1}^{T} \zeta_t \mathbf{1}(year) + \sum_{i=1}^{4} \eta_{t-i} \Delta \ln \pi_{t-i} + z_t \tag{16}$$

Table 7 shows the pooled sample estimation results, which carries evidence of increasing wage-capital price ratio in response to oil price shocks. This effect is carried in turn onto the capital-labor ratio, which rises as industries follow more capital-intensive production in response to the appreciating wage. The results are consistent with the model's predictions that the Dutch disease raises the capital-labor ratio in each sector as wages appreciate relative to rent when non-tradables are labor-intensive. This, along with the supporting results for Proposition 7 in Table 6 suggest that the a priori that non-tradables are labor-intensive may be holding.

I here turn to the question of whether the Dutch disease impact varies across industries depending on their factor intensity. Indeed, I find evidence that oil price shocks affect labor-intensive

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[13] Using the Chow test, I can reject the hypothesis that the coefficient for the group with more open capital markets is equal to that of the other group at up to the 93 percent confidence interval.

[14] I use shocks to oil price rather than windfall since relative factor prices and factor intensities are unit-less ratios, whereas windfall shocks are not. Here, the oil price shock is considered as a relative price shock of oil to other goods since the permanent price shock includes only unanticipated innovations in the oil price.

industries more than capital-intensive industries.[15] Table 8 shows the Dutch disease effect by industry as estimated by the specification in equation (15). Moreover, in Figure 5, I plot industries by their Dutch disease effect and capital intensity to show a trend towards stronger Dutch disease in more labor-intensive sectors. But this does not conclude that higher capital intensity industries are more appropriate for oil-exporting countries, as the labor-intensive sectors also help absorb labor during oil busts when demand for non-tradables decline. One possible conclusion however is that a diverse industrial sector can help cushion the flow of factors of production out of manufacturing during oil booms and busts by allowing an inter-sectoral mobility of factors within tradables.

V. CONCLUSION

This study derives structural implications of the Dutch disease in oil-exporting countries due to permanent oil price shocks from a Heckscher-Ohlin factor endowment model. I then test these implications in a highly-disaggregated manufacturing sector data across a wide group of countries including oil-exporters covering 1977–2004. The results on oil-exporting countries are fourfold. First, I find that oil booms have resulted in reducing manufacturing output even after several robustness tests. Second, evidence in the data shows that windfall shocks have a stronger impact on manufacturing sectors in countries with more open capital markets to foreign investment. The model explains this result as due to outflow of investment in manufacturing following a declining marginal return on capital, which is due to the expansion of labor-intensive non-tradables. Third, I find that the relative factor price of labor to capital, and capital intensity appreciate due to windfall increases. The second and third result are consistent with the model when non-tradables are labor-intensive. Fourth, I find that manufacturing sectors with higher capital intensity are less affected by windfall shocks, possibly due to a larger share of the effect being absorbed by the labor-intensive tradable sectors. The conclusion of the fourth result is that a diverse manufacturing sector may be more cushioned from the effect of oil shocks. This is due to capital-intensive sectors being less affected by the increased demand for labor by labor-intensive non-tradables during oil boom, while labor-intensive sectors help cushion adjustment during oil busts by absorbing the labor shed by declining non-tradables. This has a direct policy implication to oil-exporters seeking to reduce the negative aspects of exposure of their tradable sector to oil volatility. A policy that promotes diversification in capital intensity within manufacturing by decreasing bias towards some sectors may help reduce the negative impact of oil boom through the Dutch disease on manufacturing, while allowing an expansion of tradable production in the case of oil busts. This is all the more relevant when we consider that subsidies in oil-exporting countries, especially in fuel, tend to promote certain sectors, which tend to be capital-intensive.

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[15] I use the revision 2 edition of the dataset.

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APPENDIX A. PROOFS

A.1. The Dutch Disease with No Capital Mobility across Borders

Proof of Proposition 1

$$\begin{aligned}
X_n &= A_n K_n^{\alpha} L_n^{1-\alpha} && (17)\\
X_m &= A_m K_m^{\beta} L_m^{1-\beta} && (18)\\
X_o &= \pi N = \Psi && (19)\\
K &= K_m + K_n && (20)\\
L &= L_m + L_n && (21)
\end{aligned}$$

This is a small open economy where X_n is non-tradables and X_m is manufacturing and both follow Cobb-Douglas production. I abstract away from materials, and factors used in the extraction of resources such that X_o is the value added of the resource sector, and is given by the exogenous windfall Ψ. A_n and A_m are Hicks-neutral productivity in each sector. Price of tradables is normalized to 1 such that price of non-tradables, p, corresponds to the real exchange rate. Wage and rent are both endogenous with labor and capital market clearing conditions given by the following.

$$\begin{aligned}
r &= pA_n\alpha K_n^{\alpha-1}L_n^{1-\alpha} = A_m\beta K_m^{\beta-1}L_m^{1-\beta} && (22)\\
w &= pA_n(1-\alpha)K_n^{\alpha}L_n^{-\alpha} = A_m(1-\beta)K_m^{\beta}L_m^{-\beta}
\end{aligned}$$

I logarithmically linearize the above with each variable $\tilde{x} = \ln x$ to get the following.

$$\begin{aligned}
\tilde{r} &= \tilde{p} + \tilde{A}_n + \tilde{\alpha} + (\alpha-1)\tilde{K}_n + (1-\alpha)\tilde{L}_n = \tilde{A}_m + \tilde{\beta} + (\beta-1)\tilde{K}_m + (1-\beta)\tilde{L}_m\\
\tilde{w} &= \tilde{p} + \tilde{A}_n + (\widetilde{1-\alpha}) + \alpha\tilde{K}_n - \alpha\tilde{L}_n = \tilde{A}_m + (\widetilde{1-\beta}) + \beta\tilde{K}_m - \beta\tilde{L}_m && (23)
\end{aligned}$$

Consumption out of windfall is modeled through a representative consumer following without loss of generality an additively separable Cobb-Douglas utility in non-tradable services and manufactured goods.

$$\max_{\{c_m,c_n\}} u = (1-\gamma)\log c_m + \gamma \log c_n$$

$$pc_n + c_m \leq y$$

$$\text{where } y = w(1+\varphi)$$

Where φ is the windfall per capita measured relative to non-resource income w such that $\varphi w = \frac{\Psi}{L}$. The problem results in the following first-order condition.

$$pc_n = \gamma y$$

Consumption of non-tradables is by definition supplied domestically such that the non-tradable market clearing condition is given by.

$$pX_n = L\gamma y \tag{24}$$

I substitute the production function and log-linearize equation (24) to get

$$\tilde{p} + \tilde{A}_n + \alpha\tilde{K}_n + (1-\alpha)\tilde{L}_n = \tilde{L} + \tilde{\gamma} + \tilde{w} + (\widetilde{1+\varphi})$$

I differentiate with respect to φ to get

$$\tilde{p}_\varphi + \alpha\tilde{K}_{n\varphi} + (1-\alpha)\tilde{L}_{n\varphi} = \tilde{w}_\varphi + \frac{1}{1+\varphi} \tag{25}$$

Through partial differentiation of equation (23), I get $\tilde{w}_\varphi = \tilde{p}_\varphi + \alpha\tilde{K}_{n\varphi} - \alpha\tilde{L}_{n\varphi}$ and by substitution in equation (25) I get

$$\tilde{w}_\varphi + \tilde{L}_{n\varphi} = \tilde{w}_\varphi + \frac{1}{1+\varphi} \tag{26}$$

From equation (26)

$$\tilde{L}_{n\varphi} = \frac{1}{1+\varphi} > 0 \tag{27}$$

since $L_n + L_m = L$,

$$\tilde{L}_{m\varphi} = -\frac{L_n}{L_m}\tilde{L}_{n\varphi} = -\frac{L_n}{L_m}\frac{1}{1+\varphi} < 0 \tag{28}$$

Proof of Proposition 2 (Dutch Disease)

I differentiate the log-linearized factor market clearing conditions in equation (23) and together with equation (27) I form the following system of equations.

$$\begin{pmatrix} 1 & (\alpha-1)-(1-\beta)\frac{K_N}{K_M} & (1-\alpha)+(1-\beta)\frac{L_N}{L_M} \\ 1 & \alpha+\beta\frac{K_N}{K_M} & -(\alpha+\beta\frac{L_N}{L_M}) \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \tilde{p}_\varphi \\ \tilde{K}_{n\varphi} \\ \tilde{L}_{n\varphi} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \frac{1}{1+\varphi} \end{pmatrix} \tag{29}$$

Where the Jacobian determinant $|J| = 1 + \frac{K_n}{K_m}$. $|J|\,\tilde{K}_{n\varphi} = \frac{1+\frac{L_n}{L_m}}{1+\varphi}$, therefore

$$\tilde{K}_{n\varphi} = \frac{1+\frac{L_n}{L_m}}{(1+\varphi)(1+\frac{K_n}{K_m})} > 0$$

$$\tilde{K}_{m\varphi} = -\frac{K_n}{K_m}\tilde{K}_{n\varphi} = -\frac{K_n}{K_m}\frac{1+\frac{L_n}{L_m}}{(1+\varphi)(1+\frac{K_n}{K_m})} < 0. \tag{30}$$

This means capital flows from manufacturing to non-tradables. Along with Proposition 1, this indicates a shrinking manufacturing and expanding non-tradable sectors.

Proof of Proposition 3

From the above system, $|J|\,\tilde{p}_\varphi = \frac{1}{1+\varphi}\left[(\beta-\alpha)(\frac{L_n}{L_m}-\frac{K_n}{K_m})\right] + 1 + \frac{K_n}{K_m}$, therefore $\tilde{p}_\varphi$ is positive since when $\beta > \alpha$, non-tradables are labor-intensive, meaning $(\frac{L_n}{L_m}-\frac{K_n}{K_m}) > 0$ and vice-versa.

Proof of Proposition 4

The marginal productivity of labor in each sector is fixed to the capital-labor ratio in each industry, $a_n = \frac{K_n}{L_n}$ and $a_m = \frac{K_m}{L_m}$. Through log-linearization, I get

$$\tilde{a}_{n\varphi} = \tilde{K}_{n\varphi} - \tilde{L}_{n\varphi} = \frac{1}{|J|}\frac{1}{(1+\varphi)}\left[\frac{L_n}{L_m}-\frac{K_n}{K_m}\right] \tag{31}$$

$$\tilde{a}_{m\varphi} = \tilde{K}_{m\varphi} - \tilde{L}_{m\varphi} = \frac{1}{|J|}\frac{1}{(1+\varphi)}\left[\frac{L_n}{L_m}-\frac{K_n}{K_m}\right] \tag{32}$$

Therefore the effect of the windfall shock is given by

$$a_{n\varphi} = \frac{K_n}{L_n}\tilde{a}_{n\varphi} = \frac{K_n}{L_n}\frac{1}{|J|}\frac{1}{(1+\varphi)}\left[\frac{L_n}{L_m}-\frac{K_n}{K_m}\right] \tag{33}$$

$$a_{m\varphi} = \frac{K_m}{L_m}\tilde{a}_{m\varphi} = \frac{K_m}{L_m}\frac{1}{|J|}\frac{1}{(1+\varphi)}\left[\frac{L_n}{L_m}-\frac{K_n}{K_m}\right] \tag{34}$$

When non-tradables are labor-intensive, this in turn means an appreciation in $\frac{w}{r}$ which in turn raises $\frac{K_n}{L_n}$ and $\frac{K_m}{L_m}$ and leads to higher marginal productivity of labor as

$$\widetilde{MP}_{Ln\varphi} = \alpha\tilde{a}_{n\varphi} \tag{35}$$

$$\widetilde{MP}_{Lm\varphi} = \beta\tilde{a}_{m\varphi} \tag{36}$$

Through substitution of equation (31) and equation (32) in equation (35) and equation (36) respectively I get

$$\begin{aligned} \widetilde{MP}_{Ln\varphi} &= \alpha\frac{1}{|J|}\frac{1}{(1+\varphi)}\left[\frac{L_n}{L_m}-\frac{K_n}{K_m}\right] && (37)\\ \widetilde{MP}_{Lm\varphi} &= \beta\frac{1}{|J|}\frac{1}{(1+\varphi)}\left[\frac{L_n}{L_m}-\frac{K_n}{K_m}\right] && (38) \end{aligned}$$

A.2. The Dutch Disease with Capital Mobility across Borders

The key feature that distinguish a model with capital mobility from the previous case is that the interest rate is fixed to the world rate.

$$\begin{aligned} \tilde{r}_{\phi} &= \tilde{p}_{\varphi}+(\alpha-1)\tilde{K}_{n\varphi}+(1-\alpha)\tilde{L}_{n\varphi} && (39)\\ &= (\beta-1)\tilde{K}_{m\varphi}+(1-\beta)\tilde{L}_{m\varphi} \end{aligned}$$

The first equation yields the real exchange rate equilibrium growth rate.

$$\tilde{p}_{\varphi}=(1-\alpha)[\tilde{K}_{n\varphi}-\tilde{L}_{n\varphi}] \tag{40}$$

The second equation results in

$$\tilde{K}_{m\varphi}=\tilde{L}_{m\varphi} \tag{41}$$

Proof of Proposition 5

Through substitution in the log-linearized labor market clearing condition, I find

$$\begin{aligned} \tilde{w}_{\varphi} &= \tilde{p}_{\varphi}+\alpha\tilde{K}_{n\varphi}-\alpha\tilde{L}_{n\varphi}=\tilde{K}_{n\varphi}-\tilde{L}_{n\varphi} && (42)\\ &= \beta\tilde{K}_{m\varphi}-\beta\tilde{L}_{m\varphi} \end{aligned}$$

From equation (41) therefore $\tilde{w}_{\varphi}=0$ Wages are unchanged as capital moves across borders to leave the marginal productivity of labor unaffected in both sectors.

The non-tradables market clearing condition yields

$$\begin{aligned}
\tilde{p}_\varphi + \alpha\tilde{K}_{n\varphi} + (1-\alpha)\tilde{L}_{n\varphi} &= \tilde{w}_\varphi + \frac{1}{1+\varphi} \qquad (43)\\
\tilde{L}_{n\varphi} &= \frac{1}{1+\varphi}\\
\tilde{K}_{n\varphi} &= \frac{1}{1+\varphi}\\
\tilde{L}_{m\varphi} &= -\frac{L_n}{L_m}\frac{1}{1+\varphi} \qquad (44)\\
\tilde{K}_{m\varphi} &= -\frac{L_n}{L_m}\frac{1}{1+\varphi} \qquad (45)
\end{aligned}$$

Through substitution in equation (43) I get $\tilde{p}_\varphi = 0$, which means an unchanged real exchange rate as the influx of capital into non-tradables compensates for the excess demand. Since $\tilde{L}_{n\varphi}, \tilde{K}_{n\varphi} > 0$ and $\tilde{L}_{m\varphi}, \tilde{K}_{m\varphi} < 0$, manufacturing shrinks while non-tradables expand.

Proof of Proposition 6

When capital markets are open, the Dutch disease dynamic can have positive or negative impact on capital flow. The effect on total capital in the country is given as

$$\begin{aligned}
K_\varphi &= K_{n\varphi} + K_{m\varphi} \qquad (46)\\
&= K_n\tilde{K}_{n\varphi} + K_m\tilde{K}_{m\varphi}\\
&= \frac{L_n}{1+\varphi}\left[\frac{K_n}{L_n} - \frac{K_m}{L_m}\right]
\end{aligned}$$

Therefore when $\frac{K_n}{L_n} < \frac{K_m}{L_m}$, $K_\varphi < 0$ and vice-versa.

When non-tradables are capital-intensive, capital flows into the country to supply the excess demand of non-tradables. While when non-tradables are labor-intensive, the flow of labor out of manufacturing into non-tradables lead to a drop in the marginal productivity of capital there. This in turn results in capital flight and a loss in the total capital stock.

Proof of Proposition 7

From equation (28) and equation (44), I find that labor in manufacturing shrinks by the same proportion in the open and closed capital market cases. Thus the only differentiation in the size of the Dutch disease would come from the effect on capital stock. From equation (30) and equation (45)

$$\tilde{K}_{m\varphi,\text{open}} - \tilde{K}_{m\varphi,\text{closed}} = -\frac{L_n}{L_m}\frac{1}{1+\varphi} + \frac{K_n}{K_m}\frac{1+\frac{L_n}{L_m}}{(1+\varphi)(1+\frac{K_n}{K_m})} = \frac{K_nL_m - K_mL_n}{L_m(K_n+K_m)(1+\varphi)} \tag{47}$$

Thus the Dutch disease effect in the case of open capital markets is stronger only when $K_nL_m - K_mL_n < 0$ which is equivalent to when $\frac{K_n}{L_n} < \frac{K_m}{L_m}$ and vice-versa.

APPENDIX B. OIL PRICE DECOMPOSITIONS

Figure 2. Oil price decompositions (logs) and the WTI crude oil spot price

B.1. Kalman Filter Decomposition - Arbatli (2008)

$$p_{oil,t} = \pi_t + \chi_t$$

Where π_t is the permanent component of spot oil price, and χ_t is the transitory component. The state-space model is given by

$$y_t = A + Hx_t + v_t \tag{48}$$

$$x_t = B + Mx_{t-1} + \varepsilon_t \tag{49}$$

Where x is the state vector $[\pi_t, \chi_t]$, $B = [\mu_p, 0]$ with μ_p as the trend of the permanent component, $M = [1\ 0,\ 0\ \phi]$ with ϕ being the serial correlation of the transitory component (i.e $\chi_t = \phi\chi_{t-1} + \varepsilon_{\chi t}$), and $\varepsilon_t = [\varepsilon_{\pi t},\ \varepsilon_{\chi t}]$ is the price innovation vector. The observation vector is $y_t = [s_t, f_{t,t+n_1},$

..., $f_{t,t+n_T}]$ where s_t is the spot WTI crude oil price, and $f_{t,t+n_i}$ are future contracts with maturities i.[16] $A = [0, \mu_p n_1 - \omega_{n_1}, ..., \mu_p n_1 - \omega_{n_1}]$ such that ω_{n_i} is the constant risk premium associated with holding a future contract with maturity i. v_T is a vector of serially uncorrelated innovations, where the covariance matrix of v_T is given by

$$VU = \begin{pmatrix} \sigma_s^2 & . & . & 0 \\ 0 & \sigma_{f_{n1}}^2 & . & 0 \\ . & . & . & . \\ 0 & . & . & \sigma_{f_{n1}}^2 \end{pmatrix} \tag{50}$$

and H is given by

$$H = \begin{pmatrix} 1 & 1 \\ 1 & \phi^{n_1} \\ . & . \\ 1 & \phi^{n_T} \end{pmatrix} \tag{51}$$

Arbatli (2008) estimates the parameters of the model using maximum likelihood, and the permanent and transitory innovations are then computed from the state-space model described in equation (48) and equation (49) using the Kalman filter.

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[16] Arbatli (2008) uses future contracts with 3, 6, 9, 12 and 15 months maturities as observations.

APPENDIX C. EMPIRICAL RESULTS

Robust standard errors in parentheses
$*** : \ p < 0.01; ** : \ p < 0.05; * : \ p < 0.1$

Table 1. List of Oil Exporting Countries in the Sample

Canada	Iran	Norway
Columbia	Kuwait	Russia
Ecuador	Malaysia	Trinidad and Tobago
Gabon	Mexico	United Kingdom
Indonesia	Nigeria	Venezuela

Table 2. Description of variables

Variable	Description	Source
y_{ijt}	real output in period t for industry i in country j—in estimations we use value added unless otherwise indicated	UNIDO-INDSTAT Rev.2
L_{ijt}	labor units (data uses number of workers) in period t for industry i in country j	UNIDO-INDSTAT Rev.2 and 3
K_{ijt}	capital units (constructed from Gross fixed Investment using PIM) in period t for industry i in country j	UNIDO-INDSTAT Rev.2 and 3
w_{ijt}	wage in period t for industry i in country j. Proxied in the data from dividing the total wage bill in each sector by the number of workers	UNIDO-INDSTAT Rev.3
$P_{k_{it}}$	weighted average price of capital goods	Penn World Tables 6.2
FDI-Open	index for capital market openness—(FDI assets+FDI liabilities)/GDP averaged over 1983-2008	Lane and Milesi-Ferretti (2007)

Table 3. The Dutch Disease Effect on Output and Value Added: Using Eqn(13)

	Output		Value Added	
	(1)	(2)	(3)	(4)
	Pooled	Fixed-Effect Panel	Pooled	Fixed-Effect Panel
η_{t-1}	-.108***	-.106***	-.116 ***	-.111***
	(.0237)	(.0238)	(.0281)	(.0285)
η_{t-2}	-.0866 ***	-.0891***	-.068***	-.0672***
	(.0221)	(.0218)	(.0236)	(.0233)
η_{t-3}	-.0966 ***	-.0966 ***	-.104***	-.101***
	(.0124)	(.0124)	(.0132)	(.0132)
η_{t-4}	-.0653***	-.0646***	-.0547***	-.0519***
	(.0133)	(.0129)	(.0158)	(.015)
$\sum_{i=1}^{4} \eta_{t-i}$	-.357***	-.356***	-.342***	-.331***
	(.0495)	(.0492)	(.0564)	(.0561)
Observations		44731		42582
Total Countries		90		83
Oil-Exporting Countries		15		15
Industries		81		81
Country FE	YES	NO	YES	NO
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
IndustryXCountry FE	NO	YES	NO	YES
R^2	0.05	0.02	0.04	0.02

Table 4. The Dutch Disease Effect showing the Cumulative Impact over 4 years of Kalman and H-P Filtered Permanent Oil Price Shocks: Using Eqn (14)

	Dutch Disease= $\sum_{i=1}^{4} \eta_{t-i}$	
Permanent Oil Shock Decomposition	Output	Value Added
Kalman filtered Oil Spot Price	-.352***	-.336***
	(.0579)	(.0643)
Hodrick-Prescott filtered Oil Spot Price	-.164 ***	-.127 ***
	(.05)	(.054)

Note: Robust standard errors in parentheses, $*** \; p < 0.01$, $** \; p < 0.05$, $* \; p < 0.1$

Table 5. The Dutch Disease and Capital Market Openness to FDI by Country: Using Eqn (15)

Country	$\sum_{i=1}^{4} \eta_{t-i}$	FDI-Open	Observations	Industries
Canada	$-.0481$ (.0573)	.470	962	74
Colombia	$-.254^{***}$ (.0401)	.159	1264	81
Ecuador	$-.0217$ (.259)	.201	801	75
Gabon	-10.42^{***} (3.749)	.236	95	26
Indonesia	1.131^{***} (.204)	.0998	1130	80
Iran	$.000832$ (.799)	.0479	206	75
Kuwait	$-.512^{***}$ (.120)	.126	762	53
Malaysia	-1.00^{***} (.146)	.529	1169	76
Mexico	$-.595^{***}$ (.206)	.169	429	63
Nigeria	-4.981 (5.420)	.450	206	75
Norway	$.0516$ (.200)	.340	809	75
Russia	-2.645^{***} (.760)	.251	234	78
Trinidad and Tobago	-3.195^{**} (1.355)	.814	290	53
United Kingdom	$-.0995^{**}$ (.0453)	.630	812	81
Venezuela	1.303^{***} (.276)	.215	748	78

Note: Robust standard errors in parentheses, $***\ p < 0.01$, $**\ p < 0.05$, $*\ p < 0.1$

Figure 3. The Dutch Disease and FDI financial integration for All Countries in Sample

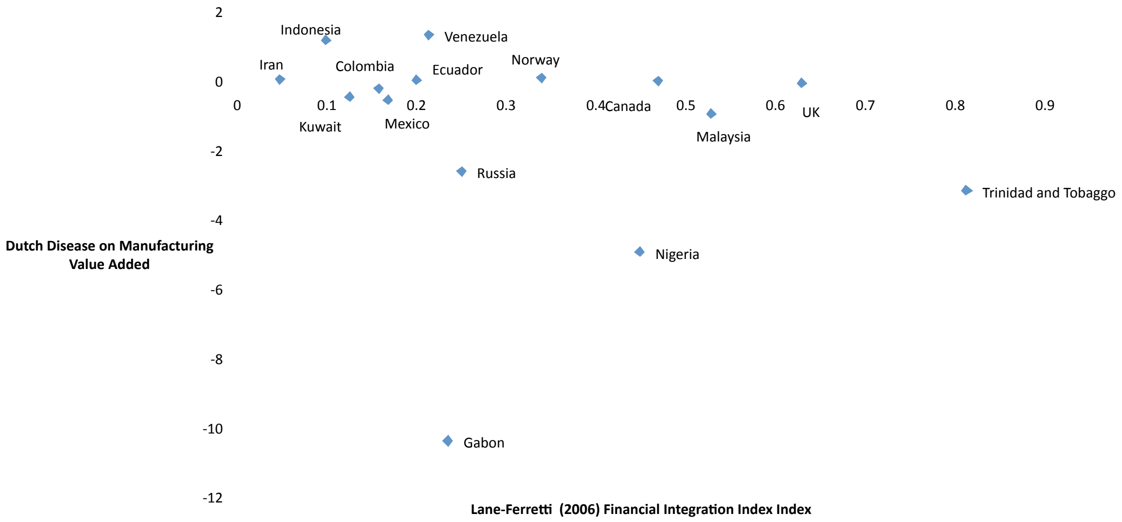

Figure 4. The Dutch Disease and FDI financial integration for Countries with Statistically Significant Dutch disease

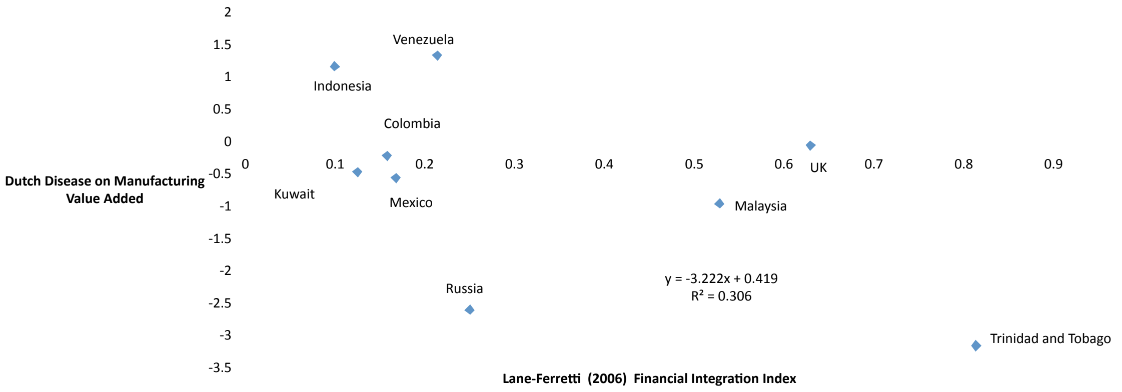

Table 6. The Dutch Disease in Countries with Open and less Open Capital markets (Proposition 7) : Using Eqn (15)

VARIABLES	Countries with High $FDI-Open$	Countries with Low $FDI-Open$
η_{t-1}	-.0458 (.0582)	-.143*** (.0294)
η_{t-2}	-.0398*** (.0700)	-.143*** (.0294)
η_{t-3}	-0.294*** (.0899)	-.112*** (.0121)
η_{t-4}	-.317*** (.087643)	-.0238 (.0155)
$\sum_{i=1}^{4}\eta_{t-i}$	-.697*** (.184)	-.352*** (.0543)
Observations	3582	3791
Countries	7	5
Total Sectors	454	352
R^2	0.0058	0.0175

Note: Robust standard errors in parentheses, $*** \ p < 0.01$, $** \ p < 0.05$, $* \ p < 0.1$

Table 7. The Dutch Disease Effect on Relative Wages and Factor Intensity: Using Eqn(16)

VARIABLES	$\Delta\ln(w/P_k)$	$\Delta\ln(K/L)$
η_{t-1}	2.315^{***} (.823)	-3.601^{**} (1.460)
η_{t-2}	5.025^{***} (.819)	4.077^{***} (1.441)
η_{t-3}	.902 (.736)	2.124^{*} (1.252)
η_{t-4}	4.537^{***} (1.035)	6.986^{***} (2.093)
$\sum_{i=1}^{4}\eta_{t-i}$	12.778^{***} (2.071)	9.586^{***} (3.646)
Observations	22575	23400
Total Countries	57	58
Oil-Exporting Countries	9	9
Industries	149	151
R^2	.046	.114

Note: Robust standard errors in parentheses, $*** \; p < 0.01$, $** \; p < 0.05$, $* \; p < 0.1$

Table 8. The Dutch Disease Across Industries with Different Capital Intensities: Using Eqn(15)

Industry	$\sum_{i=1}^{4} \eta_{t-i}$	Mean K/L	Std dev. of K/L	Obs.	Rev 2. Classification
Cement and Glass	$-.313^{***}$ (.0899)	1.217	.214	2871	3610-3699
Chemicals	$-.224^{**}$ (.0972)	1.035	.206	6826	3511-3560
Equipment	$-.359^{***}$ (.065)	.470	.141	10149	3821-3909
Food Processing	$-.429^{***}$ (.118)	.556	.0527	7936	3113-3140
Metals	$-.387^{***}$ (.11)	.198	.0185	3479	3710-3819
Plastics	$-.341^{**}$ (.152)	.305	.0356	664	3560
Textiles	$-.280^{***}$ (.0729)	.432	.0742	5462	3211-3240
Wood Processing	$-.367^{***}$ (.099)	.179	.0215	3892	3311-3419

Note: Robust standard errors in parentheses, $***\ p < 0.01$, $**\ p < 0.05$, $*\ p < 0.1$

Figure 5. The Dutch Disease and Capital Intensity by Sector