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40 Years of Dutch Disease Literature: Lessons for Developing Countries

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Abstract

This paper surveys the "Dutch disease" literature in developing and emerging countries. It describes the original model of Dutch disease and some main extensions proposed in the theoretical literature, focusing on the ones that match developing countries' conditions. It then reviews various empirical studies that have been conducted and provides evidence that the Dutch disease is still an issue for many developing countries. Finally, it discusses the gaps in the theoretical and empirical literature for understanding the suitable policy instruments to cope with Dutch disease.

Keywords: Dutch disease; Natural resources; Resource curse; Structural transformations; Real exchange rate.

JEL Codes: O13 · O14 · Q32 · Q33

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1. Introduction

Structural transformation, defined as the reallocation of productive factors across sectors in the economy and the subsequent change in the sectoral shares of value-added in GDP, has played a central role in explaining economic divergence across developing countries in recent decades (McMillan, Rodrik and Verduzco-Gallo, 2014). Nevertheless, while integration into globalization is a commonly followed process, the reasons why structural change patterns differ across countries are still not fully understood. A fairly old explanation for this difference is the exploitation and export of natural resources, which are heterogeneously distributed across the world and which can strongly influence structural change through the so-called "Dutch disease" (DD). In broad terms, DD occurs when a resource boom reduces the internal incentives to produce, and/or the international competitiveness of, domestically produced non-resource tradable (exportable and importable) goods. It can be defined as "the resource induced revaluation of the real exchange rate" (Paldam, 2013), and the subsequent decline in the non-resource tradable sector. DD was a popular explanation for the de-industrialization process experienced by several resource-rich developed countries in the 1970s and 1980s.

However, from the 1990s, DD progressively faded in favor of the encompassing concept of "Resource Curse" (Auty, 1993) which more generally explains why many resource-rich countries experience weak economic growth. Literature reviews that specifically focus on DD remain rare, but the study of resource curse has resulted in an abundant literature and several literature reviews, which usually include a section on DD considering it to be a channel of the curse (van der Ploeg, 2011; Gilberthorpe & Papyrakis, 2015; Badeeb, Lean and Clark, 2017). The "curse" or "disease" concepts are arguably as negative as each other, but DD, contrary to resource curse, should not be analyzed as an inherently growth-reducing phenomenon but rather as a driver of structural transformation.

DD models imply that non-resource tradable sectors decline while non-tradable sectors expand. Since these effects are the consequence of increasing resource revenues, final average revenues per capita are expected to be higher after the boom even in the presence of DD. Hence, it is tempting to define DD only as a shift from one equilibrium to another, and not as a "disease" for the economy. This might explain the recent shift from the analysis of DD to the study of resource curse.

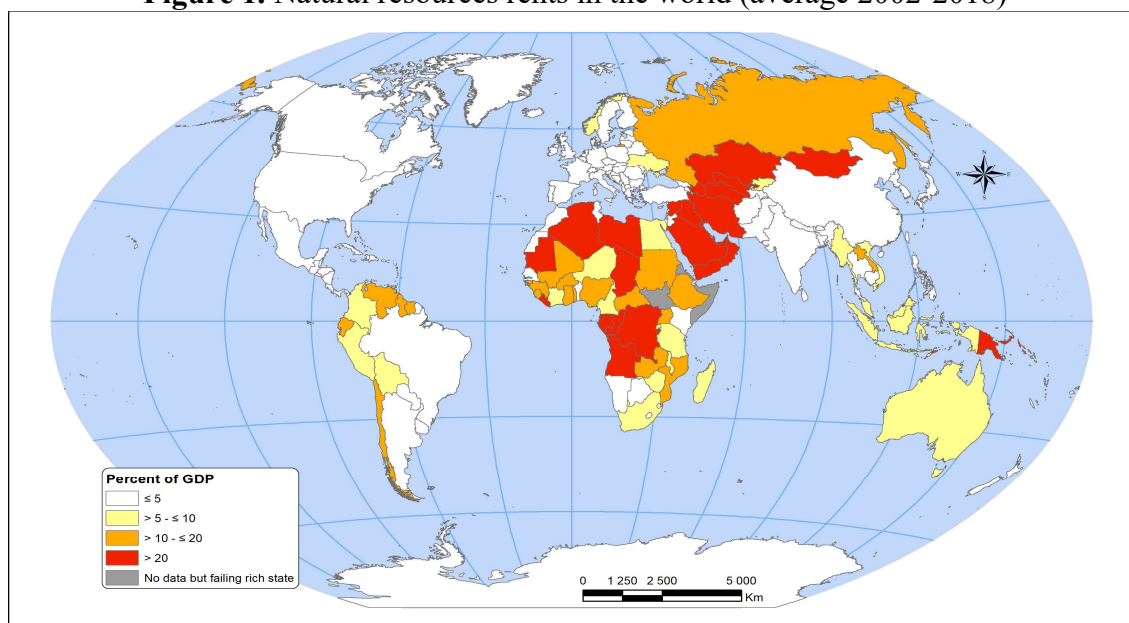
However, by transforming the structure of the economy, DD also durably affects average labor productivity (by reducing incentives to invest in human capital and in activities with potentially high productivity gains), fiscal policy (by shifting taxation from non-resource to resource sectors), inequalities (by shifting wealth from non-resource to resource sectors), and even demography (by encouraging urbanization). Therefore, there is a continuing interest in studying DD *per se*, and in understanding its main consequences and policy options. DD has been studied for 40 years but is still the object of theoretical, empirical, and policy debates. To our knowledge, Nülle and Davis (2018) is the only survey of DD literature. Our article differs from Nülle and Davis in several ways. First, we focus on developing countries, because most of the recent empirical literature on DD has targeted these countries. Then, we review the large theoretical literature that emerged at the beginning of the 1980s, the diversity of DD models, and the different sets of assumptions they use; whereas Nülle and Davis follow the initial model of Corden and Neary (1982) and the model of learning-by-doing effects proposed by Torvik (2001). Finally, while they argue that DD is the exception rather than the rule, we find more mixed conclusions. We also consider the conditions which allow or prevent DD, and the public policies that can be implemented against it.

There is a large theoretical and empirical literature on DD, much more than can be covered in a single review of literature. Thus, we made two choices in this survey. First, we restrict the empirical sections to cover only developing countries. Due to a renewed interest in structural

transformation issues and the observation of some cases of growth without industrialization, the DD hypothesis has regained relevance in the study of the development process, particularly in sub-Saharan Africa and Latin America (Orvoty & Jibrilla, 2019). Even if there is a large literature on some industrialized countries (such as Canada, Norway or the United Kingdom), DD appears to be more prevalent in developing countries. This is explained by the fact that natural resources represent a higher share of total revenues in these countries and that they often lack political or economic institutions that can effectively prevent DD. Second, we focus on the DD caused by natural resources only. In the 1990s, other sources of revenues were studied as drivers of DD, for instance international aid, migrants' remittances, or tourism. However, the mechanisms behind DD can vary according to the source of the revenue inflows. Focusing on DD caused by natural resources booms allows consistent comparisons across countries, and so proposals for policy recommendations for resource-rich developing countries. Moreover, the 2000s and 2010s have seen big changes in international prices of natural resources and a multiplication of mineral and oil discoveries. This has led to new entries of small and developing countries into the group of resource-rich economies (see Figure 1), making the need to understand the impact of natural resources even more acute.

Our aim is to survey the theoretical and empirical literature related to DD caused by natural resources revenues in developing countries, outline the main policy options and present the unresolved issues. This paper is organized as follows: Section 2 sums up the history of the DD issues, recalls the difference between DD and resource curse, and explains why DD remains relevant in understanding structural transformation. Section 3 describes the basic Corden-Neary model and its relevant variations for the study of small developing countries. Section 4 presents the evidence for DD in the empirical literature on developing countries. Section 5 presents the main lessons and policy implications.

Figure 1. Natural resources rents in the world (average 2002-2018)



Source: WDI. Natural resources rents are the sum of oil, gas, coal, mineral, and forest rents (in % GDP).

2. Brief History

The term “Dutch disease” was first used by the Journal *The Economist* (1977) to explain the industrial decline observed in the Netherlands after gas reserves discoveries in the North Sea during the 1960s, then in the United Kingdom and Australia, and afterwards in many other countries. Despite the early interest in DD from journalists and policy makers, theoretical economic models only emerged at the beginning of the 1980s to explain this apparent paradox. Corden and Neary (1982) is often referred to as the seminal paper of DD but there was a burgeoning theoretical literature on the topic at that time (see Section 3). Despite the heterogeneity in assumptions and focuses, the models of DD generally state that a resource boom will increase national expenditure (both public and private), leading to an appreciation of the real exchange rate, which in return causes non-resource tradable sectors to decline, either in outputs or in exports. This latter effect explains why DD is often defined as a cause of the “de-industrialization” process. However, Corden (1984) underlines that the tradable sector is not restricted to manufacturing industries and can include agricultural products. He argues that DD could result in “de-agriculturalization” rather than “de-industrialization”. This is of crucial

importance for several developing countries that, while weakly industrialized, are specialized in export crops. On the other hand, some agricultural (subsistence agriculture) and industrial activities (construction) are mainly non-tradable and can benefit from DD effects. Hence, we prefer the concept of “tradables squeeze effect” used by Aoki and Edwards (1983).

2.1 Dutch Disease and Resource Curse

The concepts of DD and “Natural Resource Curse” (or “Resource Curse” - RC) are often employed interchangeably but they differ in their origins. The term RC was first used by Auty (1993) to explain the absence of high or sustained economic growth during the 1980s and 1990s in many resource-rich developing countries. So the concept of RC is more recent than DD but finally has absorbed it, since DD is now, most of the time, analyzed as one of the RC channels (Frankel, 2010; van der Ploeg, 2011; Sala-i-Martin & Subramanian, 2012).

Even though the concept of RC is recent, Davis (1995) notes that the idea that natural resources can have negative effects on the rest of the economy is quite old (for instance it was used to describe Argentina in the 1930s). Contrary to DD, RC primarily belongs to development economics literature. RC is in opposition to Smith and Ricardo's traditional analyses of the gains from international trade and economic specialization, and to Rostow's theories of economic development, which were dominant in the 1950s and 1960s and considered natural resources as a basis for any industrialization process (Badeed et al., 2017). RC has a resonance with the “Prebisch-Singer hypothesis”, which states that commodity prices follow a long-term declining trend, contrary to manufactured goods, implying that specializing in natural resources is a “bad deal” (Frankel, 2010). This explains why Auty's work has been followed by an abundant empirical and theoretical literature trying to disentangle the different effects (positive or negative) of the exploitation of natural resources. The seminal empirical paper which concluded that there was a negative impact of natural resources rents on economic growth was

written by Sachs and Warner (1995). Although their results have been extensively criticized, their study has served as a basis for all following RC studies.

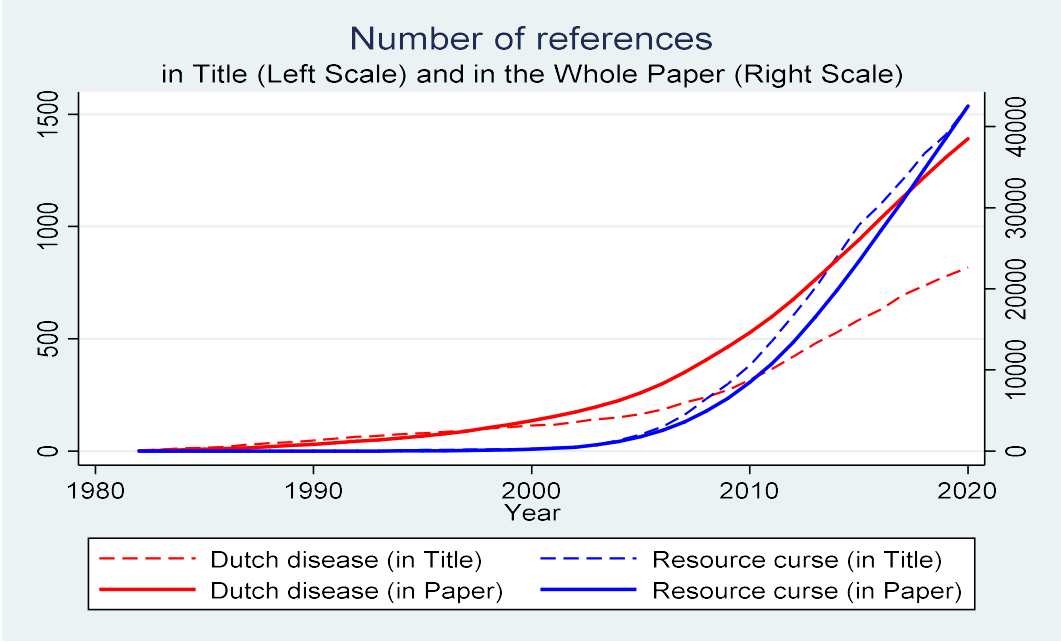
RC is a multidimensional concept. It was defined by Budina, Pang and van Wijnbergen (2007) as the fact that “resource-rich countries are characterized by slow or stagnating growth, de-industrialization, low savings, lagging human and physical capital accumulation, and stagnating or declining productivity” (pp. 10-11). The literature identifies numerous channels of RC: 3 in Sala-i-Martin and Subramanian (2012), 5 in Pegg (2010) and Badeeb et al. (2017), and 6 in Gylfason (2008) and in Frankel (2010). These channels are usually categorized as either economic or political, with the possibility that different channels may interact. As emphasized by Hausmann and Rigobon (2003), although there is general empirical evidence of a negative correlation between natural resources revenues and economic growth, the channels through which it occurs are more difficult to identify.

Arguably, the renewed interest in studying RC as an encompassing concept has partly eclipsed the analysis of DD. Figure 2 below shows the number of articles mentioning the terms “Dutch disease” and “resource curse” in their title or in the text using Google Scholar. It shows that RC has attracted much more attention in the literature since the mid-2000s (it should also be noted that while DD is restricted mainly to the economic literature, RC has also been investigated in other fields, such as political sciences). A divergence can also be observed in the number of articles with reference to “DD” in their title and in their text, which increased after the rise in studies referring to “RC”: this is in line with our previous statement that DD is today frequently referred to as a channel for RC, rather than a specific focus.

However, DD can explain structural changes, but not necessarily low economic growth, like other RC channels. Indeed, as stressed by Davis (1995): “There is nothing inherently growth-inhibiting in mineral booms and any resulting DD phenomena. The DD is simply a description of the causes and structural effects of boom-induced growth.” (p. 1768). Similarly,

Gylfason (2008) and Nülle and Davis (2018) argue that the concept of Dutch disease is a double misnomer by being "neither Dutch nor a disease". We argue here that DD is a specific concept, which could (but not necessarily) lead to a resource curse and/or interact with other RC channels.

Figure 2. Cumulated number of papers referring to “Dutch disease” and “Resource curse”



Source: Google Scholar

2.2 Should We Fear Dutch Disease?

The previous remarks do not imply that DD, as a driver of structural transformation, is losing importance for resource-rich economies. The literature has identified several reasons why DD should be considered seriously by economists and policymakers.

Whatever the exact composition of the tradable sector, it is frequent in the literature to assume that export-oriented firms are somehow “special” because they benefit from economies of scale, have "learning-by-doing" effects, or generate positive spillovers on other sectors. Therefore, a decline in tradables caused by resource revenues can be detrimental to long-term economic development. For instance, van Wijnbergen (1984b) develops a dynamic model of DD with learning-by-doing effects in the tradable sector and concludes that subsidies should

compensate for the crowding-out of non-oil traded sectors induced by DD. Torvik (2001) develops an augmented model of DD but with learning-by-doing in both traded and non-traded sectors and learning spillovers between sectors. He concludes that the final impact on long-term growth of exchange rate appreciation largely depends on the relative size of the learning-by-doing effects and spillovers in each sector (the larger the learning-by-doing effect in the traded sector or the spillovers from the traded sector the more likely a final drop in productivity and inversely for the non-tradable sector). Cherif (2013) considers learning-by-doing effects in a developing country setting with a pre-existing technological gap between developing and industrialized countries and concludes that DD tends to widen this gap at the expense of resource-rich economies. Therefore, DD is likely to be a concern for developing countries because of potential boom/bust asymmetric effects: the losses in productivity and growth in non-resource tradable sectors during the resource boom will not be recovered after the end of the boom. It should be noted that such learning-by-doing effects are not restricted to manufacturing industries. Rudel (2013) describes this phenomenon in agriculture where children are unlikely to come back and contribute to agricultural production because they have not benefited from a transfer of knowledge from their parents who left the sector during a resource boom. Lastly, manufacturing or agricultural activities tend to require more labor than extracting activities. The decline in the tradable sectors subsequent to the resource boom can be a concern for job creation and domestic unemployment. Among others, Algeria is a case which illustrates this kind of concern regarding youth unemployment and social dissatisfaction¹.

DD adverse effects can worsen, or be worsened by, other RC channels. For instance, one frequent syndrome of RC is the high volatility of international resource prices which translates into volatility of public and private revenues. Since resource revenues tend to appreciate the

¹ <https://www.reuters.com/article/algeria-economy-idUSL5N1VY41A>

exchange rate (reducing non-resource exports and encouraging imports), they generate a deterioration in the non-resource trade balance (even if the total trade balance improves due to resource exports). This makes trade balance equilibrium dependent on resource exports, implying that a fall in prices can lead to a large external deficit. This was observed in Zambia in the 1980s and 1990s, when the sudden drop in copper prices (the country's biggest export) created a large current account deficit that was solved only after the copper price increased in the mid-2000s. More recently, the COVID-19 crisis has made the utility of stable public revenues even more crucial. Indeed, the crash in international oil prices during the year 2020 led to a significant drop in export earnings and public revenues in oil-exporting countries, precisely when these countries most needed public expenditure to help them deal with the consequences of the pandemic. The conjunction of DD and commodity price volatility can also generate exchange rate volatility, reducing exports and discouraging foreign investments (Gylfason, 2008).

DD can also be linked to political dimensions of RC. For example, DD can be generated by an uncontrolled increase in public expenditure when governance is weak. It was also documented long ago that elites in authoritarian regimes tend to promote exchange rate overvaluation to favor urban consumers at the expense of rural producers, and so reduce the risk of urban revolts (Bates, 1981). Thus, more corrupt and less democratic governments may have lower incentives to implement effective policies against an overshooting appreciation of the exchange rate caused by DD, and DD can help autocratic regimes to remain in power longer. Corruption is often a major concern in resource-rich countries. It should be noted that among the 10 countries ranked bottom in 2020 in the Corruption Perception Index database, 8 countries are, or have been until recently, oil-producing countries (the Democratic Republic of the Congo, Libya, Equatorial Guinea, Sudan, Venezuela, Yemen, Syria, and South Sudan)². Paldam (2013)

² <https://www.transparency.org/en/cpi/2020/index/aze>

also links DD with political economy concerns by focusing on domestic frustration. A resource boom is assumed to increase wealth, but by reducing output and employment in other sectors through DD effects, the aggregate positive impact on the economy is likely to be lower than expected. This difference between the real rise in wealth and the expected rise is likely to create frustration and lead to the formation of special interest groups that will eventually put pressure on the government to increase public spending. In addition, DD can also encourage inequalities in resource-rich countries. By redistributing revenues from non-resource to resource sectors, DD worsens pre-existing inequalities if most of resource revenues are captured by a small elite, as is often the case in resource-rich economies. From the opposite perspective, Behzadan, Chisiki, Onder and Battaile (2017) show that an unequal distribution of resource rents can generate DD effects (see Section 3), which implies that there is a potential vicious circle between DD and inequalities. Overall, RC can occur through several channels, that may or may not be interrelated with DD. Since they all derive from natural resources, it might be difficult to disentangle these effects by attributing the decline in manufacturing to DD only, and all other potential economic or political negative consequences to other channels of RC as if they were independent.

Lastly, even if total output expands thanks to the boom, revenues and production decline in some sectors. When labor is imperfectly mobile across sectors, it can result in unemployment and increasing poverty in the declining sectors. Thus, DD remains a threat, at least from the point of view of the losing sectors, and must be taken into consideration by public authorities.

3. Modelling Dutch Disease

In an early paper which could be considered to be a forerunner of DD modelling, Gregory (1976) investigated the possibility that the growing mineral sector could have driven structural change in Australia. Nevertheless, Corden-Neary (1982)'s model is the one that has drawn most

of the attention and become the basis of numerous theoretical and empirical works. We first discuss this model and some refinements (Subsection 3.1), then present other early classical models (3.2), general equilibrium models (3.3) and recent new approaches to DD (3.4).

3.1 The Original Corden-Neary Model and its Extensions

The Corden-Neary model emerged from an important development of the theoretical literature at the beginning of the 1980s (Bruno & Sachs, 1982; Corden & Neary, 1982; Corden, 1984; van Wijnbergen, 1984a). The framework is that of a small open economy with three sectors: energy (traditionally oil, gas or mining resources), tradables, and non-tradables. Labor is mobile between sectors, but capital is not, and neither labor nor capital are mobile internationally. Thus, DD is a purely domestic phenomenon: it cannot be "exported" to neighboring countries through international migration or generate externalities on other countries. Three other essential assumptions are made: balanced trade (the country cannot generate surpluses or finance imports through external debt); full employment (so that the expansion of one sector draws labor out of the other sectors); and perfect flexibility of real wages. Following Corden and Neary, we call the three sectors of the economy E (energy), T (tradable manufactures) and N (non-tradable services). The real effective exchange rate is defined as the relative price of non-tradable to tradable goods (a rise in the real exchange rate is an appreciation). The movements of prices and quantities in N relative to T after a boom are generated through two effects (see Figure 3):

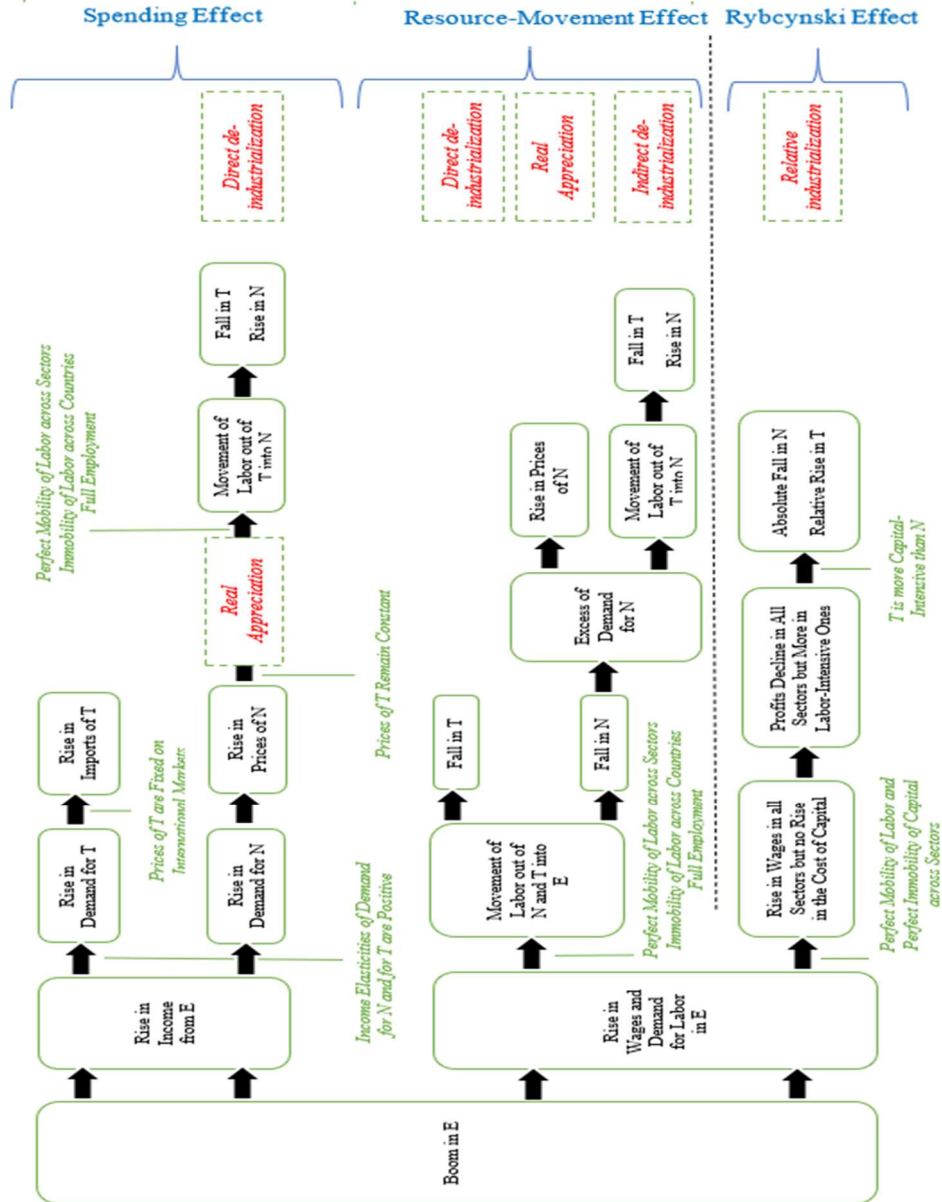
1. *The Spending Effect*: Energy exports generate additional revenues for the factor owners and for the government (through taxes), increasing the demand for both N and T. Supply being fixed in the short run (capital is not mobile), the price of N rises. However, the price of T is set on international markets (exogenous), and the increasing demand for T is compensated by additional imports. Returns to capital increase in N, whereas wages

increase in both sectors due to the perfect mobility of labor, reducing profits in T. At the end, the real exchange rate appreciates, output declines in T and increases in N.

2. *The Resource-Movements Effect*: The boom implies higher wages in E, drawing labor out of the other two sectors. This reduces the output in N and T, resulting in a gap between supply and demand for both N and T. To compensate for this difference, imports of T rise while the price of N increases, causing a real appreciation of the exchange rate, and a movement of labor from T into N: N returns to its pre-boom level while the decline in T is reinforced. At the end, output declines in T and stagnates in N.

These two effects are often put forward, yet they may not both occur, or even have different effects under different assumptions. For instance, van der Ploeg (2011) explains that, if T is more capital-intensive than N, T benefits from the resource-movement effect due to the Rybczinski theorem, because of a lower impact of the wage increase on T (see Figure 3). This assumption, that T (manufacturing) is more capital-intensive than N (services) is at first sight justified but should be moderated since some T sectors can be weakly capital-intensive (for example export crops), and some N sectors can be capital-intensive (for example construction). Corden and Neary's original model aims to explain why a NR boom may generate RER appreciation and de-industrialization. This is the first and foremost, and often only, symptom recognized by works citing this model. However, these predictions are based on specific hypotheses that can be subject to interesting variations, leading to different predictions, as Corden (1984) showed. For instance, perfect capital mobility allows capital to be drawn from T into E and N, reinforcing the fall in T and the rise in E and N, but with a lower effect on the RER appreciation. Corden also details the effect of pre-existing unemployment. The magnitude of this effect depends on the level of real wages' flexibility, but overall employment increases in N and decreases in T. Immigration lowers the increase in wages, but increases the supply and the demand for N and T, with an ambiguous effect on the RER.

Figure 3. Description of the Spending and Resource-Movement Effects



Note: Boxes are for the main explanatory and channel variables; red for the main result variables; green for the main hypotheses; E is the energy (or booming) sector; T is the tradable sector and N is the non-tradable sector. We follow Corden and Neary (1982) and use the term "de-industrialization" to describe the fall in the tradable sector even if DD can also result in "de-agriculturalization". Spending effect: there is an appreciation of RER, an absolute decline in T and an absolute increase in N. Resource-Movement effect: the output in T falls due to direct and indirect de-industrialization effects. If labor is perfectly mobile across sectors, N returns to its pre-boom equilibrium; if labor is imperfectly mobile, N falls but less than T. In both cases, there is an absolute decrease in T and a relative increase in N compared to T. Capital is supposed immobile and, if T is more capital-intensive than N, de-industrialization effects can (at least partly) be offset by the Rybczynski effect. On the contrary, if capital is mobile across sectors, capital movements follow labor movements and reinforce direct and indirect de-industrialization.

Lastly, Corden considers the case where the E product is consumed domestically. In this case, an increase in E prices encourages consumers to shift from E to N and T, reinforcing the RER appreciation. When E is an input for N and T, a rise in price reduces profitability in N and T, limiting the spending effect.

3.2 Differing Approaches for Modelling Dutch Disease

Despite the importance accorded to Corden and Neary (1982)'s article, a large literature emerged at the beginning of the 1980s to explain the various impacts of DD. The seminal model of Corden and Neary only highlights the real aspects (not the monetary ones), and focuses on the domestic economy (ignoring external competitiveness and the exchange rate of the domestic currency against foreign currencies). In addition, it was developed for industrialized countries and some of its assumptions are unlikely to be met in developing countries. Other models may differ both in their perspective and assumptions. We present here a brief overview of the diversity of approaches that have been proposed in this literature.

Bruno and Sachs (1982) use a dynamic model in which the tradable and non-tradable sectors use capital, labor, a composite input which notably includes energy, an imported good, and the output from the other sector (respectively non-tradable and tradable). They notably discuss the role of household's savings and consumption choices, assuming that some households optimize long-term consumption while others are short-term focused households. Finally, they investigate the impact of three different types of shock in an oil-exporting country: oil discovery, in international oil prices, and changes in public policies toward oil taxation and redistribution. They conclude that government budget policies and households' propensity to save current revenues from the oil sectors are key factors in mitigating DD effects.

Van Wijnbergen (1984a) distinguishes short- from long-term effects and introduces the possibility of short-term disequilibrium in the labor and non-traded goods markets. He

investigates three possible types of disequilibrium: repressed inflation (excess demand for labor and nontraded goods), classical unemployment (excess demand for N but not for labor because real wages adjust sluggishly to the new equilibrium), and Keynesian unemployment (excess supply of labor and of nontraded goods). The shift of the economy from equilibrium to one of these situations depends on the stickiness of prices and wages and on the public policies that are implemented.

In contrast to the model of Corden and Neary, Buiters and Purvis (1980) adopt an external perspective (focusing on the external competitiveness of exports compared to imports) rather than the internal perspective (focusing on the relative incentives to produce tradables versus non-tradables). Accordingly, they use an external RER, defined as the ratio of import (foreign) prices to domestic non-resource tradable prices. Their model stresses the role of exchange rate movements on foreign exchange markets in the presence of sticky domestic prices, which was not considered in Corden and Neary's model. Several important assumptions are made. First, oil production does not require labor, implying that starting oil production does not directly affect the other sectors' production through workers' movement (contrary to Corden-Neary's resource-movement effect). Second, consumption follows the permanent income hypothesis, meaning that oil revenues are not fully consumed during the exploitation period but partly saved to smooth consumption over time, affecting the long-term steady state of the economy. Both oil price increases and oil discoveries affect long-term non-oil tradable prices.

Neary (1982) introduces monetary aspects and shows the impact of DD on nominal variables. He uses a simple monetary model, firstly assuming flexibility of prices and wages where the real exchange rate is the relative price of N (services) to the price of T (measured by the nominal exchange rate when the foreign prices are fixed). Secondly, he assumes a boom in E leads to excess demand of N (through the spending and the resource-movement effects). However, the rise in income also raises money demand, decreasing prices if the money supply

is fixed. Neary calls this third effect the liquidity effect. Under a floating exchange rate regime, the nominal exchange rate appreciates to reach an equilibrium in the money market, together with the appreciation of the real exchange rate (the domestic price of T falls due to the appreciation of the nominal exchange rate, but the price of N may rise or fall). This causes deflationary pressures. A fixed exchange rate delays the adjustment (the domestic price of T is fixed), but the trade surplus gradually increases the money supply (if not sterilized), causing inflationary pressures. The real appreciation is now obtained through a rise in the price of N instead of a fall in the price of T.

Neary and Purvis (1982) propose a combination of the Buiters-Purvis (1980) and Corden-Neary (1982) models. In their model, non-resource tradables require capital and labor, non-tradables require only labor, and resources (in this case, benzine) require capital and another specific factor. In this model, labor is perfectly mobile between non-tradable and non-resource tradable sectors while capital is not mobile in the short term, but mobile between resource and non-resource tradable sectors in the long term. They also include the “liquidity effect”, described in Neary (1982), with similar conclusions.

Aoki and Edwards (1983) develop a dynamic model of DD focusing on the money market equilibrium. In oil-exporting countries, an exogenous rise in oil prices has two different effects on the money market. First, it creates a trade balance surplus, which increases the supply of money. Second, it increases domestic income, which increases the demand for money. Then, if supply and demand do not increase at the same rate, a short-term monetary disequilibrium occurs, but this disequilibrium is progressively eliminated in the long run. This result is important to understand how DD works, since it could imply that DD would be a “disease” only during the short-term disequilibrium period, not in the long run when the new steady state equilibrium is attained.

Also following an external perspective, but using a dynamic portfolio model, De Macedo (1982) puts forward the first known DD model specifically dedicated to analyzing a developing country, namely Egypt. He considers the specificity of a multiple foreign exchange system, with an official market rate for oil and a parallel (“grey”) market rate for other tradable goods, allowing for financial flows and holding of foreign money by the residents. The main conclusion is that the government should let the two different rates coexist to fight against DD.

Lastly, Edwards (1986) studies a coffee price boom in Colombia and develops a model composed of three different but interrelated blocks: a monetary block, an inflation block, and an exchange rate block. This model adds to the spending effect a monetary effect, and an effect on the nominal exchange rate (by omitting factors of production, the author does not model the resource movement effect). The coffee price impacts inflation through price increases in the non-tradable sector caused by the (real side) spending effect. It also generates an increase in money demand (because of higher income due to rent) and in money supply (foreign money inflows or increase in net foreign assets), which causes excess money demand (deflationary pressure) or excess money supply (inflationary pressure). Moreover, foreign money inflows appreciate the nominal exchange rate. This generates a short-term real exchange rate appreciation through an accumulation of foreign reserves, excess money supply, and non-tradable price increases, which exceed the "equilibrium" real appreciation resulting from the boom.

As shown above, the early 1980s were characterized by an extensive theoretical literature on DD modelling (see Table 1 for an overview). We discuss here briefly some key messages of this literature. First, DD can be caused by different types of resource booms. Even if most models investigate the impact of exogeneous resource price variations or surges in resource revenues, some also assess the impact of resource discoveries (Buiter and Purvis, 1980),

changes in fiscal policy towards the resource sector (Bruno and Sachs, 1982), or technological progress (Corden and Neary, 1982). Even if hydrocarbons or energy products often feature in the analyses, DD can also be driven by mining resources or agricultural commodities (such as coffee in Edwards, 1986). Second, all the models rely on some major assumptions: small open economy, full use of factors of production (i.e. no unemployment), and natural resources being fully exported. Even if the first assumption is plausible in many developing countries, the two others seem more questionable. It is also noteworthy that most models are based on an internal approach to the exchange rate defined as the ratio of tradable to non-tradable prices (e.g. Bruno and Sachs, 1982; Corden and Neary, 1982; Neary, 1982; Neary and Purvis, 1982; Aoki and Edwards, 1983; Van Wijnbergen, 1984a). This approach interprets DD as an explanation for structural transformations and differs from the external definition of exchange rates (ratio of domestic to foreign prices) which focuses on external competitiveness. While the former approach is dominant in the early theoretical literature, the latter approach is dominant in empirical studies, even when they directly refer to Corden-Neary as the seminal model (see Section 4). Lastly, three channels of DD are identified: the spending effect, the resource-movement effect, and the liquidity effect. The focus in the empirical literature on the model of Corden-Neary might explain why the liquidity effect has often been neglected.

Table 1. Main Theoretical Models of Dutch Disease

Article	Sectors	Production factors	RER	Effects
Buiter & Purvis (1980)	<i>Resource</i> : exported and consumed <i>Tradable</i> : exported and consumed <i>Importable</i> : consumed but not produced	<i>Labor</i> : T and M / mobile	$\frac{P_M}{P_T}$	Spending
Bruno & Sachs (1982)	<i>Resource</i> : exported and used as input <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Labor</i> : T and N / mobile <i>Capital</i> : T and N / not mobile in SR <i>Composite inputs</i> : T and N / mobile	$\frac{P_N}{P_T}$	Spending
Corden & Neary (1982)	<i>Resource</i> : fully exported <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Capital</i> : all sectors / not mobile <i>Labor</i> : all sectors / mobile	$\frac{P_N}{P_T}$	Spending Resource-Movement
De Macedo (1982)	<i>Resource</i> : fully exported <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Labor</i> : all sectors / mobile	$p = \frac{EP_T^*}{\bar{E}P_R^*}$ $q = \frac{P_N}{\bar{E}P_R^*}$	Spending
Neary (1982)	<i>Resource</i> : fully exported <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Labor</i> : all sectors / mobile <i>Other factor</i> : all sectors / not mobile	$\frac{P_T}{P_N}$	Spending Resource-Movement Liquidity
Neary & Purvis (1982)	<i>Resource</i> : fully exported <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Capital</i> : R and T / not mobile in SR <i>Labor</i> : T and N / mobile <i>Factor Specific to R</i>	$\frac{P_T}{P_N}$	Spending Resource-Movement
Aoki & Edwards (1983)	<i>Resource</i> : fully exported, owned by the government <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Labor</i> : T and N / mobile	$\frac{P_T}{P_N}$	Spending Resource-Movement
Van Wijnbergen (1984a)	<i>Resource</i> : fully exported <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded	<i>Capital</i> : T and N / not mobile <i>Labor</i> : T and N / mobile	$\frac{P_N}{P_T}$	Spending
Edwards (1986)	<i>Resource</i> : fully exported <i>Tradable</i> : exported and consumed <i>Non-Tradable</i> : produced but not traded		$E \frac{P_T^*}{P_N}$	Spending Money Demand/Supply Nominal Exchange Rate

3.3 General Equilibrium Models

Following these theoretical models, authors have developed general equilibrium models and applied them to real case studies. We describe here briefly two such models that have been proposed for developing countries. Benjamin, Devarajan and Weiner (1989) study the case of

Cameroon using a Computable General Equilibrium (CGE) Model with 11 sectors. Their model diverges from the original Corden-Neary (1982) on two main points. First, the authors consider three labor groups: rural, urban unskilled, and urban skilled labor. Second, they consider that tradable products are imperfect substitutes for international goods, with a coexistence within the economy of perfectly non-tradable sectors (construction and public services) and imperfectly tradable sectors (with different degrees of tradability). Given the characteristics of Cameroon, they conclude that an oil boom positively affects the sectors of construction and of capital goods, but hampers cash crop production, forestry, food processing, and public services. Kayizzi-Mugerwa (1991) also applies a multisector general equilibrium model to Zambia to estimate the impact of booms and busts in international copper prices on sectoral output and exports under different policy scenarios. He distinguishes 7 sectors (agriculture, mining, manufacturing, construction, commerce, transport and communications, and services) and concludes that a boom in copper prices has a negative impact on manufacturing and transportation, but a positive impact on services (with no strong impact on other sectors) as predicted by DD. Interestingly, he also finds that a bust in copper prices is expected to depress activity in manufacture and transportation (even if the impact is lower than with a boom), implying that rises and falls in resource prices might have asymmetrical effects.

3.4 A Recent Renewed Interest in Dutch Disease Modelling?

While the general principles of modeling DD were developed 40 years ago, the theoretical literature has continued to be active, particularly in recent years. We present here some models that try to develop new approaches to DD.

Using a dynamic 2-sector model, Behzadan et al. (2017) show that DD can be fueled by a shift in demand alone with unequal distribution of the rent (as a pure windfall, or an enclave) generating a gradual fall in manufacturing. This finding implies that a higher level of pre-

existing inequalities tends to worsen DD effects, which is especially important for resource-rich countries where inequalities are often high. The main intuition behind their model is that in developing countries, non-tradables (especially services) are mainly luxury goods, implying that richer households have a higher marginal propensity to consume these goods than poorer households. If the resource rent is captured by richer households, then a high pre-existing level of inequality in the country will worsen the DD effects by increasing even more the demand for non-tradables at the expense of tradables. They test this model on a panel of 61 developing and emerging countries between 1965 and 2008 and conclude that the more equally resource rents are distributed, the less pronounced DD is.

Bahar and Santos (2018) investigate the impact of resource revenues on export diversification through a modified model of DD. They consider that some firms are more labor-intensive than others, and so include transport costs for exporting firms in their DD model. This implies that, even among the tradable sector, only the more productive firms can export. Therefore, a resource windfall raises wages and reduces profits, which leads some firms to stop exporting (because they are no longer able to pay the transport costs) and forces the more labor-intensive firms to leave the market. Therefore, the total number of exporting firms decreases, and, under a monopolistic competition framework, diversity of exports decreases. This study differs from the rest of the literature by looking at a different way through which natural resources can affect the structure of the economy based on a modified-DD mechanism.

4. Testing Dutch Disease

Since the beginning of the 2000s, a large empirical literature has investigated DD, and generated inconclusive results. Arguably, one reason is that DD, or the predictions of DD models, are conditioned by several simplifying assumptions that do not hold in the real world. Put differently, real conditions across countries are too heterogeneous to allow a homogenous

DD symptom to emerge. A second reason is that investigations are conditioned by data quality, which is sometimes questionable when studying developing countries. Also important is the length of statistical series which can be too short to properly test for long run predictions. A third reason is that, given statistical issues, test results are sensitive to the empirical methodology, the choice of the dependent and explanatory variables, or the length of the modelled lag between the boom and the DD effects.

We present here studies which aim to test DD specifically. We do not cover RC tests (based on growth regressions), except if DD is explicitly explored as a RC channel. The testable predictions which are most frequently used can be put into two groups: (1) the impact of resource price (or resource production, discoveries, or rent) on the real exchange rate; (2) the impact of resource price (or production, discoveries or rent) on non-resource tradable output.

4.1 Impact of Resource on the Real Exchange Rate

This section presents the results of a sample of empirical studies which investigate the impact of natural resource revenues on the exchange rate. One major issue when estimating Dutch disease relates to the definition of the variables selected for the analysis. Most studies exploit the real effective exchange rate defined as the ratio of domestic to foreign prices (or the opposite). Nevertheless, other indexes can be used, such as the internal exchange rate (defined as the ratio of non-tradable to tradable prices as in Corden and Neary's model), the terms of trade, or domestic inflation. Without being exhaustive, we discuss some typical works in this field.

Studying monthly time-series for Kazakhstan for the period 1996-2003, Kutan and Wyzan (2005) observe that agriculture and industry decline when oil revenues increase, and that oil prices appreciate the RER. They employ a version of the Balassa-Samuelson model of RER, which they expand to include the consumer price index and the oil price with six different time

lags (using an autoregressive conditional heteroskedasticity (ARCH) model). They find unexpected signs in their results with oil prices causing a depreciation when lagged by 1 or 3 months, and an appreciation with prices lagged by 5 months. This result is not supported by Égert and Leonard (2008) for the same country over the 1995-2005 period. They estimate the impact of oil prices and a proxy for oil rent (oil price multiplied by oil reserves) on both nominal and real bilateral exchange rates (with the USD) based on a standard monetary model (including home and foreign money supplies, real income, and interest rates). With Dynamic Ordinary Least Squares (DOLS) estimates and an Autoregressive Distributed Lag (ARDL) model, they find that only the real exchange rate of the entire tradable sector, including oil production, and not that of the tradable sector excluding oil production, appreciated following a limited rise in the oil variable in the medium term, showing the interest of using disaggregated data.

Dülger, Lopcu, Burgaç, and Balli (2013) and Mironov and Petronevich (2015) exploit quarterly data for Russia for the period 1995-2011 and monthly data for 2007-2013 respectively. Using different cointegration methods, both studies find strong evidence that an increase in oil price or oil revenues causes an RER appreciation in the long run, but weaker evidence that it causes de-industrialization. Moreover, Mironov and Petronevich (2015) find that the long-term correlation is even stronger between the RER and oil revenues (oil price multiplied by oil exports) than between the RER and oil prices. This could indicate that, while the use of resource prices is justified by its apparent exogeneity (the argument used by a vast majority of the empirical papers), resource revenue could yield better results for detecting DD.

Botswana is one of the few resource-rich African countries that has been studied for a long time, and is often viewed as having avoided DD. This argument was however challenged by Mogotsi (2002). Based on data for the period 1976 to 1995, characterized by a significant boom in diamond production in 1982, she compares the pre- and post-boom periods using OLS regression. In the RER equation, the explanatory variable is a simple dummy that equals 0 for

1976-1981 and 1 for 1982-1987. Mogotsi finds that the RER appreciated in 1982-1987 compared to the previous period, and finds a significant effect of public and private expenditure on RER.

The case of Angola is explored by Pegg (2010) who does not find any impact of mining export revenues on RER for the period 1980-2004. However, the bilateral RER appreciated against the South African Rand during the 1980s, but depreciated against the USD and European currencies, underlining the sensitivity of using bilateral rather than multilateral exchange rates.

Like Botswana, Mali is often considered to have escaped from DD following a gold boom in the 2000s. Mainguy (2011) concludes that the RER did not change differently in Mali from the rest of the Western African Economic and Monetary Union, and that the country did not show factor movements from the other sectors into mining. Although she argues that Mali experienced a mild form of DD, a similar conclusion to Mogotsi (2002) and Pegg (2010) for Botswana, the results seem to reject DD in favor of other channels of RC.

In their empirical study, Sala-i-Martin and Subramanian (2012) focus on Nigeria using a well-documented narrative and a set of descriptive statistics based on different measures of the RER, both internal and external, and making use of official and parallel exchange rate, production price and consumption price indices. Overall, they find no statistically significant correlation between oil prices and external RER, and a significant but inverse correlation between oil prices and the internal RER (i.e. an increase in oil prices generates depreciation). Based on these observations, they conclude that there was no DD in Nigeria, and turn to other explanations for the RC, such as rent-seeking behaviors.

Kablan and Loening (2012) apply two VAR Models to estimate the impact of oil production and oil price shocks on the GDP deflator in Chad. Using quarterly data covering the period

1985-2008, they observe a positive impact of oil price shocks on inflation (but an insignificant impact of oil production), and interpret these results as evidence of DD.

Based on annual data for Algeria for 1960-2016, Gasmi and Laourari (2017) test for the presence of a cointegration relationship between the Algerian real effective exchange rate and a set of parameters that includes international oil prices. Using an ARDL Bound Approach, they reject the hypothesis of a cointegration relationship among the variables, which they interpret as evidence that no spending effect occurred in Algeria, an oil-exporting country. They argue that this absence of spending effect can (partly) be attributed to the exchange rate regime which maintained a stable real exchange rate against a basket of currencies.

Khinsamone (2017) investigates two potential ways through which mining resources could have generated a long run decline in other productive sectors in the Laos economy: DD and “crowding-out” of productive investment. Applying a VAR model to the period 1980-2014, he finds that mining and utility production caused inflation in the country, consistent with the DD explanation.

The last decade has also seen the emergence of empirical studies based on panel data. For example, Égert (2012) uses the methodology of Égert and Leonard (2008) on a panel of 22 resource-rich post-soviet countries in Central and South-West Asia. This study does not support the DD theory since the relationship between oil prices and the RER is insignificant in oil-exporters in the short run. Égert however recognizes that this result may be sensitive to the number of lags in the regressions, in line with Kutan and Wyzan (2005)’s results for Kazakhstan.

Arezki and Ismail (2013) use a panel of 32 oil-producing countries for 1992-2009 to test for the DD-transmission channel of public spending. They use both static models with fixed effects and dynamic GMM estimators. They estimate first the impact of changes in the public expenditure on the real exchange rate, and then the impact of changes in international oil prices

on the changes in government spending. The authors use two measures for public current spending and public capital expenditure, then test for non-linear effects of oil price increases, oil price decreases, and oil export value. They conclude that: (i) current expenditure is positively associated with RER; (ii) oil prices are positively associated with current spending; (iii) there is a downward stickiness in current expenditure when facing oil price variations. These results imply that negative shocks on tradable sector output caused by a resource boom might persist during the bust.

In DD models, natural resources are often fully exported. However, if this assumption can hold for luxury goods like gold or diamonds, it is less likely for energy products such as gas, coal, and oil. In the case of energy prices, a discovery of resources may help reduce firms' production costs and have pro-industrialization effects if manufacturing industries are more resource-intensive than other activities. Beverelli, Dell'Erba and Rocha (2011) test the impact of an oil discovery, a variable that takes increasing values from 1 to 7 for the 7-year period from the 3 years before the discovery to the 3 years after, on RER variations in a sample of 132 countries, looking at the existence of resource-intensive industries. They find that oil discoveries have a significant positive impact on the RER, but that the higher the share of oil-intensive industries, the less prone to DD the country is. This highlights the importance of considering both (i) the use of natural resources, and (ii) the heterogeneity of these resources between the ones that are used as inputs and the others.

Lastly, Harding, Stefanski and Toews (2020) estimate the impact of giant oil and gas discoveries on the bilateral RER in a panel of 172 countries between 1970 and 2013. They investigate the impact of the net present value of the oil and gas discovery (relative to GDP), which is assumed to be more exogenous than production or prices, on three bilateral (with the USD) sector-specific RERs: for the whole economy, for tradable goods, and for non-tradable goods only. Their results show that DD is driven by its non-tradable component (consistent

with the “internal” DD with an exogenous tradable goods price). Interestingly, they also observe that appreciation begins just after the discovery and before oil production begins, which could signal significant expectations.

4.2 Impact of Resources on the Production of Tradable Goods

This section discusses a sample of empirical studies which investigate the impact of natural resource revenues on structural transformations. We assume that natural resources are associated with a decline in other tradable sectors’ outputs or exports. The empirical literature appears to have neglected the effect of resources on exports and has focused on the estimation of the impact of resources on sectoral value-added. This choice may have been motivated by the difficulty of finding accurate trade data and for developing countries, or it could be linked with the difficulty of separating and subtracting re-exports (goods imported and exported without transformation) from locally produced exports.

Some early works examined the impact of DD on the sector composition of GDP without the specific focus on manufacture found in more recent studies. For instance, Looney (1990) and Looney (1991) estimate the impact of oil resources on the value-added of several tradable and non-tradable subsectors in Saudi Arabia and Kuwait respectively. To explore channels of DD, he uses different explanatory variables such as the bilateral RER (against the USD) and the oil sector value-added, together with anticipated Non-oil GDP and government consumption. Looney (1990), for Saudi Arabia, finds that a RER appreciation hampers Agriculture, Manufacture, Mining, and Petroleum Refining (all are exportable sectors); but benefits Construction, Wholesale and Retail Trade, Transport, Storage and Communications, and Ownership of Dwellings (mainly non-tradable sectors). Looney (1991) finds a large negative impact of oil revenue on manufacture in Kuwait but a smaller impact on agriculture. However, he never discusses the small open economy assumption, in terms of oil production

and exports, which is debatable for Kuwait and Saudi Arabia. Another important article comes from Fardmanesh (1991) who investigates the impact of the share of oil revenues in total GDP on agriculture, manufacture and the non-tradable sector separately in 5 oil-exporting countries (Algeria, Ecuador, Indonesia, Nigeria and Venezuela) for the period 1966-1986. Based on OLS regressions, he observes a clear negative impact of oil revenues on agricultural output in all countries except Venezuela (where the impact is not significant), but a positive effect on the manufacturing and the non-traded sectors in all 5 countries. These results seem to support the idea that the agricultural sector is likely to be the main tradable sector in developing countries. On the contrary, manufacture appears here to be a relatively protected sector (imperfectly tradable). Despite these few articles that focus on sub-sectoral levels, most empirical analyses of DD in developing and emerging economies prefer to focus either on the de-industrialization or on the de-agriculturalization effects of the disease.

Neither Dülger et al. (2013) nor Mironov and Petronevitch (2015) could find robust evidence that oil resources generated a decline in manufacturing output in Russia, despite the obvious presence of exchange rate appreciation. In addition, Ito (2017) also rejects DD in the case of Russia for the period 2003-2013. Using a VECM, he finds that an increase in oil price and an appreciation of the RER is associated with a slight increase in manufacturing production.

Mogotsi (2002), for Botswana, finds that mining resources appreciate the RER by increasing public and private consumption. However, there is no absolute impact of the boom on wages and output in manufactures, but a relative decline in manufacturing output compared to non-tradables. This allows her to conclude that Botswana suffered from a “mild form” of DD, that can be explained by a high level of pre-existing unemployment before the boom, reducing the resource-movement effect.

While empirical studies have mostly focused on oil, gold or diamond revenues, Hodge (2015) studies the impact of metal prices on manufacturing output in South Africa for the period

1980-2010. Using a vector error correction model (VECM), he observes a negative impact of REER appreciation but a small positive impact of metal prices on manufacturing output, concluding that DD did not occur. However, since the regression includes both the REER and metal prices, and since the impact of metal prices on the RER *per se* is not modelled, this interpretation is debatable: the estimated impact of metal prices is the residual direct impact of metal price, apart from its indirect impact through RER appreciation, which is not tested.

Having concluded that there was an absence of an appreciation effect caused by international oil prices in Algeria, Gasmi and Laourari (2017) also test the direct impact of oil prices on manufacturing sector growth. Based on an ARDL model, they find a positive impact of the real effective exchange rate on the manufacturing sector, but a negative impact of oil price on the manufacturing sector, both in the short and in the long term. They explain these results by the possibility that only a resource-movement effect might have occurred, hence that Algeria suffered only from a “partial” Dutch disease. However, they remain cautious regarding this conclusion and underline that other causes than the DD can explain this negative relationship between oil price and growth in the manufacturing sector.

López González, Torres Gómez and Giraldo González (2016) investigate the industrial decline in Colombia following the mining boom at the end of the 2000s. They use OLS and Beta regressions and find a negative impact of the share of mining revenues in total non-mining GDP on the share of industry in total GDP, and a similar negative impact of the RER.

In addition to the evidence that mining resources generated inflation in Lao PDR between 1980 and 2014, Khinsamone also observes a negative long-run impact of mining resources on the manufacturing-to-services ratio with a Vector Autoregressive (VAR) model.

Taguchi and Khinsamone (2018) study five resource-rich ASEAN countries (Malaysia, Indonesia, Lao PDR, Myanmar and Vietnam) over the period 1970-2015. They estimate the impact of mining and utilities production on the manufacturing-to-services ratio using time-

series VAR models for each country separately, rather than using panel data analysis, to better account for heterogeneity. They conclude that a de-industrialization process occurred caused by mining resources for Lao PDR and Myanmar, but not for Malaysia and Vietnam. They also find that Indonesia experienced a DD before 1996, but not afterwards. The authors argue that this difference is related to the quality of institutions and policies implemented by these countries. Public expenditure management and the implementation of a resource Fund are found to be highly effective against DD, as well as strategies aimed at diversifying production structures and the quality of institutions.

A few authors have recently exploited larger panel datasets to analyze the impact of resource revenues on structural transformation. Ismail (2010) uses pooled OLS and fixed-effects estimators on a panel of 90 countries for the period 1997-2004. The results reveal a negative impact of oil price shocks on manufacturing industries, but the impact increases with the openness to foreign investments and decreases with the capital intensity of the manufacturing sector, which is consistent with the Rybczynski theorem.

De-agriculturalization has also been studied as an effect of DD in developing countries. The Corden-Neary model and its extensions allowed agriculture to be a tradable sector that DD may affect negatively, which seems relevant for many developing countries. A high share of agriculture in total production and exports characterizes Sub-Saharan African and Latin American countries. One of the first empirical studies on agriculture is Scherr (1989) who compares three oil-exporting countries: Indonesia, Mexico, and Nigeria. Based on descriptive statistics, she finds evidence that oil booms led to a decline in the agricultural sector particularly in Nigeria, but less in Indonesia, suggesting that economic policies play a key role. More recently, Orvoty and Jibrilla (2019) explore the impact of DD on agriculture in Nigeria over the period 1981-2016, arguing that Nigeria is an under-industrialized economy whose agriculture mainly relies on export crops. Based on a VECM and OLS regressions, they observe a negative

impact of crude oil prices on agricultural value-added and conclude that DD caused de-agriculturalization.

Mexico has drawn most of the attention in the empirical literature on DD in Latin America. For instance, Feltenstein (1992) analyses the different channels of the impact of oil price changes in 1986-1987 on the RER, on the wage differential between rural and urban areas, the subsequent rural-to-urban migration, and the impact on agriculture. Based on a simple two-period model, he concludes that DD effects caused by oil revenues hampered agricultural production and encouraged urbanization.

As seen previously, a boom can appreciate the RER but with no significant impact on manufacturing or agricultural production. Inversely, a decline in tradable sectors can occur with no strong evidence of RER appreciation. As an example, this result emerges from Mainguy (2011)'s study of a gold boom in Mali which was followed by a drop in cotton production, but with no specific RER appreciation (compared to the other WAEMU countries). Following Pegg (2010), Mainguy explains that Mali, like Botswana, could have suffered from DD without suffering the causal mechanisms identified in the DD literature, but also that the decline in agriculture could be explained by other causes (such as high fixed costs, low productivity, international competition, or the lack of adequate government investments).

Based on two VAR, Kablan and Loening (2012) investigate the impact of oil production and oil prices on manufacturing and on agricultural value-added in Chad. They do not observe any significant impact of oil booms or of oil price variations on the manufacturing sector, but a significant negative impact of energy booms on agriculture after one year, concluding that there was the presence of a disease only for agriculture.

Among the very few works on the impact of DD on agriculture that use panel data, Apergis, El-Montasser, Sekyere, Ajmi and Gupta (2014) study a sample of oil-dependent Middle East and North African countries for 1970-2011. Using a dynamic Error Correction Model (ECM)

they observe negative correlation between oil rent and agricultural value-added in the long term. Another panel data analysis by Abdlaziz, Naseem and Slesman (2018) estimates the impact of oil prices on 25 developing net oil-exporting countries on agricultural value-added from 1975 to 2014. Using Fully Modified OLS, Dynamic OLS and Pooled Mean-Group estimators, they conclude that there was a negative effect of oil prices on the agricultural sector.

Several lessons can be inferred from this review. First, it appears that the distinction between agriculture and manufacturing as the main exportable sector is important when investigating the presence of DD, especially in developing countries. Indeed, various studies conclude that a boom in natural resources revenues may lead to “de-agriculturalization” instead of “de-industrialization”. Second, even if both steps of DD, the RER appreciation and the decline in tradable output, have been observed, they may not occur jointly, underlying the importance of investigating the different DD channels. Many empirical studies find evidence of an appreciation effect without evidence of a decline in non-resource tradable sectors, which supports the idea that DD might not be a disease for the real economy. On the other hand, a few studies find a negative impact on tradables without exchange rate appreciation (Mainguy, 2011 for Mali; Gasmi and Laourari, 2017 for Algeria), indicating that only a resource-movement effect has occurred or that some classical assumptions of DD models are miss-specified. Finally, and paradoxically, empirical studies using large panels of countries tend to support DD, while country-case analyses generate more mixed results (see table 2). Although a publication bias cannot be excluded, this overall picture may indicate that DD is a real threat, but not a curse, and can be avoided with sound public policies. This is also confirmed by multiple time-series analyses which find evidence of DD in some countries but not others. The next section investigates the policy mix options for escaping DD.

Table 2. Main Empirical Studies on Dutch Disease

	Article	Context	Data Sources	Focus	Evidence of DD
Country-Case Studies or Multiple Time-Series	Scherr (1989)	Indonesia, Mexico, Nigeria: 1970-1982	FAO, UN, WB	Agriculture	Yes
	Looney (1990)	Saudi Arabia: 1970s-1980s	National Statistics	Manufacture	Yes
	Fardmanesh (1991)	Algeria, Ecuador, Indonesia, Nigeria, Venezuela: 1966-1986	WB	Agriculture, Manufacture	Yes (for agriculture only)
	Looney (1991)	Kuwait: 1970-1986	National Statistics	Manufacture	Yes (mild form)
	Felstenstein (1992)	Mexico: 1974-1987	IFS, WB	Agriculture	Yes
	Usui (1997)	Indonesia, Mexico: 1970s	IFS	CPI, RER	No (Indonesia) / Yes (Mexico)
	Mogotsi (2002)	Botswana: 1976-1995	IFS, National Statistics	Industry	Yes (mild form)
	Kutan & Wyzan (2005)	Kazakhstan: 1996-2003	IMF, CB, National Statistics	RER	Yes
	Égert & Leonard (2008)	Kazakhstan: 1995-2005	IMF, National Statistics	Manufacture	No
	Pegg (2010)	Botswana: 1980s-2000s	IMF	RER, Sectors	Yes (mild form)
	Mainguy (2011)	Mali: 1990s-2000s	IMF, BCEAO, French CB	RER, GDP growth	No
	Kablan & Loening (2012)	Chad: 1985-2008	IFS, WDI, Geointelligence network	Agriculture, Industry	Yes (for agriculture only)
	Sala-i-Martin & Subramanian (2012)	Nigeria: 1970-2000	WDI	Prices, GDP growth	No
	Dülger et al. (2013)	Russia: 1995-2011	National Statistics and others	RER, Industry	Yes
	Hodge (2015)	South Africa: 1980-2010	IFS, OECD, CB	Industry	No
	Mironov & Petronevitch (2015)	Russia: 1997-2003	National Statistics and others	RER, Industry	Yes
	Lopez-Gonzalez et al. (2016)	Colombia: 2000s-2010s	National Statistics	Industry	Yes
	Gasmi & Laourari (2017)	Algeria: 1960-2016	IMF, WB, National Statistics	RER, Manufacture	No (RER) / Yes (Manufacture)
	Ito (2017)	Russia: 2003-2013	EIA, IFS, National Statistics	Industry	No
Khinsamone (2017)	Lao PDR: 1980-2014	National Statistics	CPI, Manufacture	Yes	
Orvoty & Jibrilla (2019)	Nigeria: 1981-2016	WDI, CB, National Statistics	Agriculture	Yes	
Panel Data Analyses	Ismail (2010)	90 countries: 1977-2004	IFS, PWT, UNIDO	Industry	Yes
	Beverelli et al. (2011)	132 countries: 1970-2010	US Statistics, PRIO	RER	Yes
	Égert (2012)	Post-soviet Asian countries: 1992-2006	WDI	NER, RER, Manufacture	No
	Arezki & Ismail (2013)	32 countries: 1992-2009	IMF	RER	Yes
	Apergis et al. (2014)	8 MENA countries: 1970-2011	WDI	Agriculture	Yes
	Behzadan et al. (2017)	61 countries: 1965-2008	WB	GDP	Yes
	Abdlaziz et al. (2018)	25 developing countries: 1975-2014	WDI, EIA	RER, Agriculture	Yes
	Bahar & Santos (2018)	128 countries: 1984-2010	COMTRADE, WDI, GEM, Horn (2010)	Export Concentration	Yes
	Taguchi & Khinsamone (2018)	5 ASEAN countries: 1970-2015	National Statistics	Manufacture	Yes
	Harding et al. (2020)	172 countries: 1970-2013	UN, IMF, Horn (2010)	Bilateral RER	Yes

5 Responding to Dutch Disease

This empirical literature review has confirmed that the seminal theoretical models of DD can help to understand the economic processes that happened in developing resource-rich countries. However, the question remains whether appropriate public policy and efficient management of natural resource revenues might help mitigating DD. We describe in this section the lessons that can be drawn from the theoretical and empirical literature relative to the role of macroeconomic policies.

5.1 The Central Role of Fiscal Policy

There is a large literature relative to the role of fiscal policy in preventing (or at least reducing) the adverse effects of DD. The main questions are usually related either to the adequate level of resource taxation, or to the most efficient use of the revenues coming from this taxation (investment, current expenditures, subsidy for declining sectors, savings, etc). However, this literature has evolved over time, from a focus on the role of taxation of resource sectors and redistribution, to a focus on non-resource tradable sectors (compensation of DD effects) in the 1980s and early 1990s, to adequate public management of natural resource revenues (prevention of DD caused by public spending) in recent years. This section covers the evolution of this literature, by first describing the arguments in favor of public redistribution across sectors, and second by presenting the debate on the optimal equilibrium between spending and saving.

5.1.1 Can Redistribution Across Sectors Help Mitigate Dutch Disease Effects?

When looking at the seminal models of DD, it is striking that the question of fiscal policy is mostly related to the support of the tradable non-resource sector through redistribution

(elaborated as industrialization policy). Corden (1984) argues that taxation of the resource sector to subsidize the tradable sector firms and workers (compensation) can help mitigate DD. He also discusses the case of the protection of tradable sectors but shows preference for the former strategy. Indeed, protecting local industries from imports by using trade barriers might be too costly, and will protect both resource and non-resource tradable sectors. Van Wijnbergen (1984b) models the tradeoff between preventing DD by saving most of the revenues or correcting it through public redistribution (tax and subsidies) in favor of the declining sectors. According to him, subsidies should be preferred since conditions for an efficient accumulation of Net Foreign Assets (NFA) would hardly be met. Using a CGE model inspired by Benjamin et al. (1989), Levy (2007) simulates the effect of an oil boom on the Chadian real exchange rate, GDP, and sectoral production under different scenarios of public investment. She concludes that when oil revenues are partly invested by the government in agriculture (e.g., in the irrigation system), RER appreciation can be avoided, and oil revenues can be a very powerful tool to reduce poverty, boost economic growth, and enhance agricultural productivity. Even though some predictions of this model are specific to the Chadian economy (which suffers from inefficient water management and insufficient food availability), it shows that adequate public investment in the declining sector should be considered. Similarly, Indonesia is often presented as having avoided a decline in non-oil tradable sectors partly through efficient public investment in industrial and agricultural sectors, and has been used as a benchmark for many countries (Mogotsi, 2002; Pegg, 2010).

However, this strategy of public redistribution also presents some major drawbacks which are not often discussed in this literature. First, it requires an efficient tax system, able to tax the resource sector and redistribute revenues to other sectors without losses during the process, which might not be possible in countries where governance is weak. If natural resource abundance tends to encourage corruption, then the corruption channel of RC might reduce the

willingness or ability to mitigate DD effects, which in return may feed institutional corruption through redistribution of wealth and revenue across sectors. Second, redistribution requires the identification of the sectors that will suffer most from DD consequences, which necessitates an efficient information and analysis system. Otherwise, subsidies can be subject to lobbies and rent-seeking behavior in sectors that would have declined even without DD. Finally, if the level of subsidy is directly linked to the level of resource revenues, a high volatility in international commodity prices will generate a high volatility in subsidies.

5.1.2 Saving or Investing?

Instead of focusing on redistributive policy across sectors, another strategy might be to implement fiscal rules or to save a large share of resource revenues so that to prevent DD. A spending effect is partly caused by public spending (through either current consumption or investment), hence imposing rules to limit public expenditure seems an obvious strategy. In addition to limiting DD effects, saving resource revenues also has two main advantages. First, creating a liquidity buffer will help to face sudden negative shocks in resource revenues that arise from the volatility of commodity prices. Second, accumulating revenues in a fund generating interests will maintain smooth consumption even after depletion of resource reserves. Hence, savings contribute to facing the three challenges that resource-rich countries often face: revenue volatility, resource exhaustion, and DD. This explains why fiscal rules have been implemented in various contexts. The tightest fiscal rules rely on a balanced non-resource budget (government budget must be at equilibrium without accounting for resource revenues): all resource revenues are saved or used for debt repayment. But more flexible rules exist. Saving can only concern excess revenues, that is the difference between actual revenue and “minimal” revenue, which can be estimated with a low resource price. An example is provided by the Chile structural balance budget mechanism, where excess revenues, generated by an international

copper price higher than the estimated long run price, are saved to counter future negative shocks. Fiscal rules can also be based on resource wealth. For instance, Timor-Leste implemented a fiscal rule stipulating that the current non-resource public deficit cannot be more than 3% of the net present value of total natural resource wealth (AfDB/BMGF, 2015). Lastly, fiscal rules can target the non-resource primary budget including investment or specific expenditures, as in Botswana where diamond revenue can only be used to finance investment or current spending on education or health (Pegg, 2010).

The main remaining question is whether resource revenues which are not used for current expenditure should be saved or invested. If the main goal is to prevent DD, saving excess revenues might seem optimal. Sovereign Wealth Funds (SWF) have emerged over recent decades as useful institutions for saving. For instance, Anne (2019) finds a total of 63 SWFs in 39 countries (either still in operation or not). Most of them manage revenues from hydrocarbons but others are for mining resources such as diamonds (like the Pula Fund in Botswana), or copper (the Economic and Social Stabilization Fund and the Pension Reserve Fund in Chile). Wills, Senbet and Simbanegavi (2016) review the literature on SWF and conclude that fighting against DD is one of their 6 main goals³. Countries can have two or three different SWFs with different goals too. For instance, in Ghana, the Ghana Stabilization Fund (aimed at smoothing oil revenue over time), the Heritage Fund (to save revenue for future generations,) and the Ghana Infrastructure Investment Fund (to finance infrastructure projects) coexist. Regarding SWFs' performance, Raymond, Coulibaly and Omgba (2017) investigate their impact on exchange rate misalignments in 24 oil- and gas-exporting countries and conclude that having a SWF reduces the volatility of RER misalignments. Instead of creating a SWF, resource revenues can also be simply accumulated³ by the central bank. Due to high fixed costs, a SWF

³ The 5 others being intergenerational transfer (in line with the Permanent Income Hypothesis), parking motive (hold revenues until better opportunities of investment are available), stabilization motive (consumption smoothing), political accountability motive (to avoid corruption), and portfolio diversification motive. For a detailed typology of SWF, one can also refer to Anne (2019).

should be preferred only when expected future resource revenues are large enough (AfDB/BMGF, 2015).

However, many reasons exist for not saving all resource revenues. First, developing countries often suffer from capital scarcity, implying that resource revenues could be efficiently invested in sectors with high marginal returns. It is also noteworthy that if such investment is suitably made, they can help, better than external savings, to face future commodity price shocks or smooth consumption in the long run by increasing non-resource sectors' economic growth. Many governments in developing countries lack adequate fiscal systems, and face difficulties when trying to collect taxes, which implies a lower level of public expenditure than the economy would require: neglecting large inflows of revenues by saving them in an external fund might not be the optimal strategy to maximize welfare in the long term. Hence, some popular approaches such as the "Permanent Income" (perfect smoothing of consumption over time), or the "Bird-in-Hand" approach (all resource revenues are saved into an external fund and only interests are spent), applied in Norway might not be suitable in a developing country context. Overall, since resource revenues may solve many of the challenges that developing countries are facing (lack of physical or human capital, low public revenues, reduced access to financial markets etc), it is not surprising that the fight against DD is looked upon as secondary in the discussion on the optimal use of resource revenues.

Based on these observations, some authors have tried to estimate the proper tradeoff between investment and saving. Van der Ploeg (2019) argues that funds or fiscal rules should target lower consumption, but higher investment goals, in developing countries than in other economies due to the greater need for physical or human capital investment. Since these prescriptions might appear quite vague for public authorities, more complete models suited for specific countries can be used. One common approach is to use dynamic stochastic general equilibrium (DSGE) models (IMF, 2012). Using DSGE for the Central Economic and Monetary

Community (CEMAC) and Angola, Berg, Portillo, Yang and Zanna (2013) compare three fiscal approaches: the “all saving approach”, the “all investing approach”, and the “sustainable investing approach” (characterized by a stable scaling-up path of public investment). They conclude that this last approach should be preferred since it addresses both the volatility and the exhaustibility concerns. Based on a slightly different version of this model applied to Angola, Richmond, Yackovlev and Yang (2015) compare the "spending-as-you-go approach" (with no savings), the "conservative investing approach" (with constant ratios of public investment and consumption to GDP and a subsequent large accumulation of savings into a wealth fund), and the "gradual scaling-up approach" (close to the "sustainable investing approach" proposed by Berg et al., 2013). They conclude that, when resource revenues are not volatile, the "spending-as-you-go" and the "gradual scaling-up" approach are equivalent in terms of outcome, and both are better than the "conservative investing approach". However, in the presence of commodity price volatility, the gradual scaling-up approach clearly outperforms the other two approaches.

The final question is where and how to invest. A survey of the best investment strategies would be off-topic here since it is highly country-specific. However, we can briefly underline the balance between investment in physical capital (such as public infrastructure) and in human capital (education or health). It is noticeable that well-targeted public investment can largely contribute to overcome DD effects, either by boosting overall productivity (through expenditure, for instance, in education or technology) which will benefit all sectors, including both tradable and non-tradable ones, or by improving export capacity (through investment in specific infrastructures for instance), which will particularly benefit the tradable sectors.

5.2 The Role of Monetary Policy and Exchange Rate Regimes

The first models of DD noted that natural resource exports tend to affect the equilibrium in the money and exchange rate markets by affecting both demand and supply of domestic money. For instance, in the dynamic model developed by Aoki and Edwards (1983), a boom in resource revenue increases domestic income, creating an additional demand for money, but also produces a temporary trade balance surplus, which increases the domestic supply of money. Thus, there is a temporary disequilibrium in the money market, since it is unlikely that the increase in supply will perfectly match the increase in demand. This disequilibrium either results in an excess demand for non-tradable goods (if excess supply of money), reinforcing the real effects of Dutch disease, or in an excess supply of non-tradable goods (if excess demand for money), counterbalancing them. However, in the long term, the trade balance and the money market are assumed to return to their equilibrium determined by real factors. Neary (1982) also investigates this impact of resources on the money market but focuses on the role played by exchange rates. Under flexible exchange rates, the additional income generated by resource exports results in an excess demand for money, hence in a nominal exchange rate appreciation. This appreciation leads to a decrease in the price of tradable goods and to an appreciation of the real exchange rate (because the fall in prices only partially offsets the appreciation of the exchange rate). Under fixed nominal exchange rates and if central bank interventions are not sterilized, the trade surplus results in an excess supply of money, and so to an appreciation of the real exchange rate through inflation. If, on the other hand, interventions are sterilized, the trade balance surplus can be maintained without inflation. This sterilization can be achieved by raising the banking system's reserves requirement, which decreases domestic credit and compensates for the increase in the NFA-backed supply of money. It is also worth noting that a resource-movement effect can occur in every type of exchange rate regime.

Adopting a foreign currency in the domestic economy (the so-called “dollarization”), or belonging to a monetary union, does not prevent the appreciation of the real exchange rate occurring through domestic inflation (as can occur in a fixed nominal exchange rate regime). Gylfason (2008) notes that this remark also holds for subnational entities or constituent states such as Greenland (which uses the Danish Krone) with its fish exports (Note: vast mineral and hydrocarbon reserves have also been discovered in Greenland but they remain largely unexploited). Moreover, in such cases, hard constraints on monetary policy can even limit a country’s ability to prevent DD. This can be observed in Chad, which belongs to the CEMAC CFA Franc zone, where Kablan and Loening (2012) find evidence of inflationary pressures caused by oil prices and oil production, even though the impact in terms of structural transformations remain moderate. Another example is Lao PDR where the use of the U.S. dollar and the Thai Baht tends to prevail, and where Khinsamone (2017) observes an appreciation effect caused by mining output.

Finally, general equilibrium models can also contribute to understanding the impact of monetary policy and exchange rate regimes in different contexts. Allegret, Benkhodja and Razafindrabe (2018) apply a multi-sectoral medium-scale DSGE framework to the Algerian economy to compare the impact of an oil boom under three distinct monetary strategies: inflation targeting, fixed nominal exchange rate, and real oil price targeting (similar to an inflation targeting regime but based on the domestic price of oil rather than CPI). They conclude that a fixed exchange rate is the most efficient strategy against DD effects on the tradable sector. Using a DSGE model fit for Nigeria and the Western African Economic and Monetary Union (WAEMU), Batté, Bénassy-Quéré, Carton and Dufrénot (2010) estimate the potential impact of Nigerian oil revenues on Nigeria and on other WAEMU countries under the scenario of an extended regional currency union. They infer that belonging to a monetary union would not protect Nigeria from DD effects caused by a positive oil price shock, with adverse spillovers

on the other countries. In contrast, Nigeria would benefit more from a flexible exchange rate with fixed money supply, whereas WAEMU countries would benefit more from a fixed exchange rate. Finally, they conclude that setting up a Stabilization Fund in Nigeria could contribute to reducing the divergence between the countries' benefits in adopting different monetary regimes, revealing the specific issue of the impacts of DD in a monetary union.

Theoretical and empirical studies reveal the role of fiscal and monetary policies to avoid, or at least mitigate, DD, but conclusions on what these policies should be remain mixed. It is still unclear whether it is better to try to avoid DD (for instance by controlling the level of public spending and by accumulating foreign assets during the boom), or to compensate for it (by redistributive policies to the tradable non-resource sector, or by efficient public investment aimed at increasing productivity or competitiveness). Similarly, it is unclear whether fixed or flexible nominal exchange rates should be preferred to avoid real exchange rate appreciation. This difficulty in inferring clear conclusions from the literature comes partly from the variety of issues governments face when experiencing a resource boom (corruption, volatility of revenues, social, or environmental consequences). Therefore, the question of the optimal management of resource revenues and of the optimal exchange rate regime and monetary policy is rarely restricted to the fight against DD.

6 Continuing Exploring Dutch Disease

Overall, there is strong empirical evidence that DD is a reality and should be considered seriously by resource-rich developing countries. Indeed, it has been observed that several resource exporters have experienced real exchange rate appreciation and/or decline in tradable (agriculture or manufacture) outputs. However, these two effects do not always occur, and various counterexamples indicate that DD is not necessarily a “curse” for the economy. There

is also a large literature on the fiscal and monetary policies that can be implemented against DD. Yet, no consensus has been reached regarding the most efficient ways to avoid DD or even for the question of whether governments should really try to avoid DD effects. Overall, further analysis remains necessary on several points.

First, even though the seminal models are still at the theoretical core of DD analyses, they are often not suited to study developing countries, which are characterized by a large share of agriculture in total output, imperfect tradability of “tradable” goods, lack of physical and human capital, high levels of unemployment, informal economy, and international migration. Despite the growing empirical literature that has emerged in recent decades to discuss these assumptions, many unknowns remain regarding the (institutional, geographical, or demographic) determinants that can exacerbate, mitigate, or even prevent DD.

Moreover, there has been very little discussion as to the most suitable empirical strategies, and the variables to choose when investigating the presence of DD: most of the knowledge about the issues related to the explanatory variable (resource rent, revenues, prices, or reserves) comes from the RC literature, in which there is little debate on the outcome.

Finally, empirical investigations are required to understand the impact of fiscal and monetary policies and how they can prevent DD, or at least offset its most negative effects, without ignoring a major source of revenue.

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