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The Dutch Disease Revisited: Theory and Evidence

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JEL Codes: C33; O11; O13; O15

Keywords: Natural resource; The Dutch Disease; Real exchange rate; Growth rate



The Dutch Disease Revisited: Theory and Evidence*

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Abstract

Contrary to empirical evidence, the Dutch disease hypothesis, driven by Learning By Doing (*LBD*), does not predict the steady-state real exchange rate appreciation and economic growth deceleration due to a resource boom. To do so, I first represent a simple model to fill the theory's gap, and then adopt a dynamic panel data approach for a sample of 132 countries over the period 1970-2014 to re-evaluate both symptoms of the hypothesis in systematic analysis. The main findings are threefold. First, a resource boom appreciates the real exchange rate. Second, the real exchange rate appreciation decelerates the rate of growth in both sectors such that the shrinkage is larger in the manufacturing sector than in the service sector. This, in turn, makes the relative output level of the manufacturing sector to the service sector be smaller and economic growth be slower. Third, these effects are more intensive in resource-rich countries than in resource-poor countries.

Keywords: Natural resource; The Dutch Disease; Real exchange rate; Growth rate

JEL Classification: C33; O11; O13; O15.

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1 Introduction

Why do natural resources countries tend to grow slower than countries without?, Why did Sierra Leone drop at an average rate of 37 % between 1971 and 1989 (Humphreys et al., 2007)? and why has the income per capita in Nigeria stagnated over forty years (Sala-i Martin and Subramanian, 2013)? A conventional interpretation that has attracted more attention of researchers refers to the Dutch disease hypothesis. The term of the Dutch disease was originally named in 1977 by *The Economist* to describe the unfavorable repercussions of natural gas discoveries in the late 1950s on the Dutch manufacturing sector. The seminal work identified by Corden and Neary (1982) was established based on a Salter-Swan framework to provide an explanation for the process of de-industrialization. The mechanism rests on two steps: 1) a resource boom appreciates the real exchange rate, and so 2) sectoral growth responds asymmetrically to the real exchange rate appreciation. It motivates us to make the question of whether there is strong empirical evidence to support the symptoms of the Dutch disease.

A useful starting point is to address the term “natural resources”. Over the past three decades, scholars have defined “natural resources” in dozens of ways. Natural resources are generally categorized in two classes of plantations (e.g. coffee, cocoa, rice) and minerals (e.g. oil, gas, coal). Adopting the terminology defined in Woolcock et al. (2001), the former is called diffuse resources, while the latter is called point-source resources. Considering the type of natural resources, evidence shows that point-source resources are more valuable and provide a vulnerable influence on the economy. Hence, I only address point-source resources in this study¹ (hereafter, the term "natural resource" is used to reference this specific subset of resources).

To shed light on the key question of why resource countries have usually failed to show better economic performance than others, I first clarify the mechanism of the Dutch disease. This can be illustrated in a two-sector small open economy framework², as in Nkusu (2004), in which the labor force is fully employed and can move freely across sectors. The literature on the Dutch disease highlights two different effects. The first one is the spending effect. Resource boom brings about an expansion in the total income of the economy and so increases the demand for both traded and non-traded goods. Whereas the price of traded goods is determined exogenously by the international market, the relative price of non-traded to traded goods must appreciate in order to confront the expanded demand for non-traded goods. The second one is called the resource movement effect. A relative price appreciation will increase the real wage of labor employment in the non-trade sector, with respect to those in the traded sector. It makes a signal for labor forces to shift away from the traded sector and into the non-traded sector. Consequently, the traded sector shrinks and the non-traded sector expands (i.e. de-industrialization).

¹ Furthermore, given that the empirical database for the resource rent, collected from the World Bank, refers total natural resources rents to the mineral endowments, I ignore the former class of the terminology (i.e. plantation) to keep the consistency between the theory and empirical studies.

² In the standard Dutch disease model proposed by Corden and Neary (1982), there are three sectors: the booming sector, lagging sectors producing traded goods and the non-traded sector producing services goods.

Although the framework could describe the mechanism of the Dutch disease in a short to medium-term, it would be interesting and more realistic to investigate the long-term dynamic response of a resource-dependent economy to a permanent increase in a resource rent. Evidence supports that the traded sector benefits more from learning by doing in the long-term (Ulku, 2004). Hence, the non-resource traded sector hit by worsening competitiveness is more likely to not fully recovered once the resource income runs out (Van der Ploeg, 2011). One can be demonstrated this using a Salter-Swan model in which productivity growth is driven by learning by doing (*LBD*). As an initial attempt, Van Wijnbergen (1984) studied a two-period and two-sector model in which future productivity in the traded sector depends increasingly on the current production of the traded sector. Later on, by an assumption that only labor employment in the traded sector contributes in generation of learning, Krugman (1987) proposed a model of increasing returns to scale in the traded sector. While Sachs and Warner (1995) and Gylfason et al. (1999) made an assumption that learning generated by labor employment in the traded sector spills over perfectly to the non-traded sector. These later models clarify that the learning process induces the endogenous growth in both sectors: a natural resource boom reduces labor employment share in the traded sector, hampers learning by doing (*LBD*) and thus decelerates economic growth. In recent literature, Torvik (2001) presents a general model in which both sectors can contribute to the learning process and there are imperfect learning spillovers between sectors. He demonstrates that within such a model a resource boom tends to depreciate the steady-state real exchange rate, while the steady-state economic growth is independent of a resource boom and the sectoral productivity growth depends on which one of the direct or the spillover effect is stronger. Bjørnland and Thorsrud (2016) put forward Torvik (2001) model so that the productivity spillovers between the booming resource sector and other domestic sectors. They show that a booming resource sector leads to the real exchange rate depreciation over the transition path and increasing the rate of growth in the economy and in both sectors, contrary to standard Dutch disease models. To investigate the empirical relevance of the theory model, they apply a Bayesian Dynamic Factor Model (*BDFM*) for Australia and Norway as representative cases studies. Their results are twofold: (1) a resource boom has significant and positive productivity spillovers on non-resource sectors, and (2) there is a two-speed transmission phase so that the non-traded sector expands faster than the traded sector.

The influential works by Sachs and Warner (1995, 2001) and Rodriguez and Sachs (1999) are representatives of a stream of empirical literature showing that natural resource dependence³ decelerates economic growth. In particular, in a cross-section of countries during 1970–90 Sachs and Warner (2001) show that a 10 % increase in the ratio of natural resource exports (% of GDP) is associated with as much as 0.4–0.7 % lower annual GDP per capita growth. In

³ Two different criteria used to classify the economies depending on the natural resource are (1) resource dependence referring to the value of the natural resource as a share of GDP or total national wealth and (2) resource abundance referring to per capita value of the stock of natural resource wealth. Empirical studies across a comprehensive sample of countries show that natural resource abundance has a positive effect on economic performance (see. Brunnschweiler and Bulte (2008); Alexeev and Conrad (2009); Esfahani et al. (2013); Cavalcanti et al. (2011)).

recent studies, researchers have applied panel data rather than cross-section approach to avoid the problem of omitted variables bias. A group of these studies has found that a natural resource boom retards the institutional development and this, in turn, hampers economic growth (e.g. Murshed (2004); Collier and Hoeffler (2005); Mehlum et al. (2006)). Furthermore, a study by Manzano and Rigobon (2001) dismisses the curse once one controls for fixed effects in panel data estimation. Using annual data for 81 manufacturing sectors in 90 countries over the period 1977-2004, Ismail (2010) put forward that a 10 % increase in oil price slows down, on average, the manufacturing growth rate by 3.4 %. Further, it shows that this negative effect is stronger in countries that have a more open capital market to foreign investment and also sectors that are less capital intensive. Consistent with the former work, a recent study for 41 resource exporter countries over the period 1970-2006 shows that price movement is negatively correlated with the manufacturing value-added (Harding and Venables, 2016). More evidence for 135 countries for the period 1975-2007 shows that a resource windfall income induces savings of about 30 %, shrinks non-resource exports by 35-70 %, and expands non-resource imports by 0-35 % (Harding and Venables, 2010). Furthermore, a number of studies (e.g. Rajan and Subramanian (2008)) consider a foreign aid rather than the resource rent and find that the aid leads to slower growth in the manufacturing sector relative to the service sector.

Out of this context, a growing number of studies examines only one of the symptoms of the Dutch disease. Strong evidence for a positive effect on the real exchange rate from commodity price appreciation (first step of the symptom) has been documented by Koranchelian (2005) for Algeria, Zalduendo (2006) for Venezuela, Oomes and Kalcheva (2007) for Russia, and Beine et al. (2012) for Canada. Furthermore, Cashin et al. (2004) for a panel of 58 commodity-exporting countries over the period 1980-2002, Korhonen and Juurikkala (2009) for a panel of 12 oil-exporting countries over the period 1975-2005 and Ricci et al. (2013) for a panel of 27 developing & 21 developed countries over the period 1980-2004 report a positive correlation in the commodity prices–exchange rate nexus. In contrast, others have studied the impact of the substantial exchange rate overvaluation on growth (second step of the symptom). Empirical evidence on this subject suggests that the real exchange rate appreciation decelerates growth. Perhaps among well-known of these studies is that of Rodrik (2008); Aguirre and Calderón (2005). Other studies include those of Eichengreen (2007); Williamson (2009); Habib et al. (2017)). In terms of the sectoral performance, Sekkat and Varoudakis (2000) assessed this nexus for a panel of major Sub-Saharan African countries during the period 1970-1992. Their findings indicate that the real exchange rate depreciation fosters manufacturing exports' performance. Among a few limited studies concerning both symptoms of the Dutch disease hypothesis, Javaid and Riazuddin (2009) adopted a static and dynamic panel data technique to structurally analyze the hypothesis in a sample of 6 selected South-East Asian economies over the period 1981-2007. They first investigate the response of the real exchange rate to foreign inflows and second the impact of a change in the real exchange rate on growth rate in the manufacturing and service sectors. The findings confirm an appreciation in the real exchange rate, a contraction in the

manufacturing sector and an expansion in the service sector as a foreign aid inflows.

In the same vein, Lartey et al. (2012) studied the Dutch disease effect of remittances under different exchange rate regimes in an unbalanced panel data set of 109 countries over the period 1990-2003. They pursued a dynamic estimation procedure to estimate a regression model in which the relative output of the traded to the non-traded sector was captured as the dependent variable and remittance (% GDP) was their explanatory variable of interest. Their findings show that an increase in remittances leads to an expansion in the share of the service sector and a shrinkage in the share of the manufacturing sector. The paper also suggests that the resource movement effect is stronger under fixed nominal exchange rate regimes.

To sum up, in the context of the natural resource curse, on the one hand, the theoretical models, as in Torvik (2001); Bjørnland and Thorsrud (2016), predict that the (steady-state) real exchange rate depreciates, and the rate of growth in the economy is constant or increases due to a resource boom, contrary to the empirical evidence. On the other hand, researches have estimated the impact on the real exchange rate from a commodity price rather than a resource-dependence proxy or they have studied the direct impact of a resource-dependence proxy on economic growth rather than the impact of the real exchange rate on sectoral growth. Out of the resource curse's context, the literature examines the relationship between the real exchange rate and economic growth rather than sectoral growth or they have captured this nexus in a different empirical technique and/or specification from the present paper. Hence, these reasons motivate us to fill these gaps through developing a simple dynamic theory that leads to the real exchange rate appreciation and economic growth deceleration in the long-term and also through a comprehensive systematical empirical analysis that investigates both symptoms of the Dutch disease hypothesis.

Motivated by the literature, I first develop a simple theory, driven by *LBD*, in which the productivity is generated in both manufacturing and service sectors, while there are an imperfect spillover from the manufacturing to the service sector and a technology spillover from the resource sector to the manufacturing sector. The model describes the standard Dutch disease mechanism, the same as Torvik (2001). While it shows that a resource boom results in a conditional appreciation in the (steady-state) real exchange rate and also an unconditional depreciation in the rate of growth in the economy, contrary to Torvik (2001); Bjørnland and Thorsrud (2016). I then collect an unbalanced panel data set of 132 countries from the period 1970 to 2014 to revisit the Dutch disease symptoms. Using the Generalized Method of Moments (*GMM*) technique, I adopt a dynamic estimation procedure to avoid the autocorrelation problem and the problem of reverse causality between variables of interest (endogeneity problem). Estimated results illustrate some clear evidence in supporting the positive relationship between a resource-dependence proxy and the real exchange rate. They also demonstrate that the real exchange rate appreciation causes the sectoral growth to shrink more in the manufacturing sector than in the service sector and so the economic growth to decelerate. Finally, the empirical approach suggests that these adverse effects are more intensive in resource-rich than in resource-poor countries.

The remainder of the paper is organized as follows. Section 2 presents a modified theory, Section 3 undertakes an empirical study, and Section 4 concludes the paper.

2 A model of the Dutch disease

I extend Torvik (2001) model to make theoretical predictions consistent with empirical results. Consider a two-sector economy: manufacturing and service, indexed by M and S respectively. Assume there are no assets and capital accumulation and the labor force is the only production factor. Labor, inelastically supplied by a continuum of symmetric-identical households, can move freely across sectors. I normalize the total labor force to one:

$$L_M + L_S = 1. \quad (1)$$

L_M and L_S represent the labor shares in the manufacturing and service sectors, respectively. The production function in each sector operates under decreasing returns to scale, the same as in Matsuyama (1992) and Torvik (2001),

$$X_M = A_M L_M^\alpha \quad (2a)$$

$$X_S = A_S L_S^\alpha. \quad (2b)$$

$A_J, J = \{M, S\}$ is total factor productivity in sector J . I assume labor intensity, α , is equal in both sectors to simplify the calculations. the price of manufacturing goods is normalized to unity. Thereby the price of service goods, denoted by P , represents the real exchange rate. In addition, the total income (Y) is the sum of the value of produced manufacturing and service goods plus the value of the resource rent,

$$Y = X_M + PX_S + A_M R. \quad (3)$$

An increase in R represents a natural resource boom⁴. Also, the resource rent is measured in the manufacturing goods units, as in Torvik (2001), so as to prevent it from vanishing relative to total income as the economy grows.

On the demand side, a representative household maximizes a CES utility function in his consumption of manufacturing and service goods subject to his budget constraint ($PC_S + C_M = C = Y$). The utility function is given as:

$$U(C_M, C_S) = \frac{\sigma}{\sigma-1} C_M^{\frac{\sigma-1}{\sigma}} + \frac{\sigma}{\sigma-1} C_S^{\frac{\sigma-1}{\sigma}}. \quad (4)$$

⁴ Resource boom may refer to a windfall discovery of new resources or a technical improvement in the resource sector.

Where C_M and C_S represent the consumption of manufacturing and service goods, respectively. While $\sigma > 0$ denotes the elasticity of substitution between two goods. Following the above assumptions, the demand for services is

$$C_S = \frac{Y}{P(1 + P^{\sigma-1})}. \quad (5)$$

Now, I compute two compositions of the real exchange rate (P) and employment share in the service sector (L_S) to determine a static equilibrium of the model. The first composition is derived from an equalization of the sectoral marginal labor productivity, representing the LL -curve and the second one is determined by the market-clearing condition in the service sector (i.e. $X_S = C_S$), representing the NN -curve. The corresponding expressions are given by

$$P = \phi \left(\frac{L_S}{1 - L_S} \right)^{1-\alpha} \quad LL - curve \quad (6a)$$

$$P = \phi^{\frac{1}{\sigma}} \left(\frac{(1 - L_S)^\alpha + R}{L_S^\alpha} \right)^{\frac{1}{\sigma}} \quad NN - curve \quad (6b)$$

where $\phi \equiv \frac{A_M}{A_S}$ is the relative productivity ratio. In a $L_S - P$ plane, the LL -curve is an upward sloping curve, while the NN -curve is a downward sloping curve.

Before moving to a description of the economy's response to a natural resource boom, it is worth investigating the long-run dynamic stability. TFP is driven by learning-by-doing (LBD). The earlier literature assumes that both sectors generate the learning but there is no spillover between them (Lucas Jr, 1988) or the productivity growth is generated in the manufacturing (traded) sector with a perfect spillover on the service (non-traded) sector (Sachs and Warner, 1995). Further, Torvik (2001) presented a more comprehensive model in which the productivity growth is generated in both sectors with an imperfect spillover between sectors. Bjørnland and Thorsrud (2016) extend Torvik (2001) model with technology spillover from the resource sector to both manufacturing and service sectors. Different from these models, I assume productivity is generated in both manufacturing and service sectors and there is an imperfect spillover from the manufacturing to the service sector and also an exogenous spillover from the resource sector to the manufacturing sector due to a technological improvement. This assumption results in theoretical predictions that are consistent with the empirical results.

$$\frac{\dot{A}_M}{A_M} = \delta_M L_M + \delta_R (R) \quad (7a)$$

$$\frac{\dot{A}_S}{A_S} = \gamma \delta_M L_M + \delta_S L_S. \quad (7b)$$

δ_M and δ_S denote respectively the direct effect on productivity growth of one worker employment in the manufacturing and service sectors. Furthermore, $0 < \gamma < 1$ measures the spillover intensity from the manufacturing to the service sector. An improvement in the exploitation of natural

resources originated from an externality such as technology transfer from abroad is more likely to spill over productivity to the manufacturing sector. For example, complicated technical processes to exploit offshore oil or to extract oil shale could generate positive knowledge externalities that, in turn, benefit the manufacturing sector. Hence, $\delta_R(R) > 0$ represents the spillover effect from resource sector to the manufacturing sector. I assume this effect is weaker than the direct generated effect in the service sector (i.e. $\delta_R(R) < \delta_S$). This assumption prevents the model from having a corner solution. It also is reasonable to assume that a technological improvement in the resource sector shifts the resource production (i.e. resource boom). In other words, an increase in the resource production can be translated as a technological improvement. Hence more resource rent, more productivity spillover to the manufacturing sector $\delta_R'(R) > 0$.

For the purpose of dynamic analysis, let me first investigate how the static equilibrium of labor allocation reacts to a change in relative productivity. In the long run, the assumption that productivity levels in both sectors are constant is relaxed. Hence, a change in relative productivity plays a crucial role in labor allocation. Two driving forces are at work in labor allocation's response to an increase in the relative productivity ratio ϕ , as in Torvik (2001). On the one hand, the level of labor requirement in the manufacturing sector falls while in the service sector goes up, as the relative productivity rises (Labor requirement effect). With an unchanged composition of the basket, labor shifts away from the manufacturing and into the service sector. Hence, higher relative productivity, more employment in the service sector. On the other hand, the relative price of manufacturing goods reduces as the relative productivity increases (Substitution effect). So the relative demand for manufacturing goods expands which, in turn, induces labor to move from the service sector to the manufacturing sector. Hence, higher relative productivity, less employments in the service sector. Briefly, two driving forces push L_S in opposite directions.

The next question is which one of these driving forces is dominant. Labor requirement effect: for a given labor allocation, an increase in the relative productivity ratio leads to an expansion faster in the manufacturing sector than in the service sector. As regards manufacturing goods relative to service goods are produced cheaper than before, the real exchange rate rises to re-establish the good market equilibrium (i.e. the NN -curve shifts up and right). The vertical shift is equal to $\frac{P}{\phi\sigma}$. Substitution effect: for a given real exchange rate, the marginal productivity of labor will be less in the service sector than in the manufacturing sector as ϕ rises. Therefore, the labor force in the service sector decreases to re-establish the labor market equilibrium (i.e. the LL -curve shifts up and left). The vertical shift is equal to $\frac{P}{\phi}$. These represent that the vertical shift is larger in the NN -curve than in the LL -curve if the elasticity of substitution is less than one (i.e. $\sigma < 1$). In conclusion, if the labor requirement effect is dominant ($\sigma < 1$), the labor force in the service sector increases as the relative productivity ratio rises (i.e. $\frac{dL_S}{d\phi} > 0$).

Now, it is worth investigating the existence of a balanced growth path along which the productivity level grow equally in both sectors. The growth rate of the relative productivity ratio is,

$$\frac{\dot{\phi}}{\phi} = \frac{\dot{A}_M}{A_M} - \frac{\dot{A}_S}{A_S} = [(1 - \gamma) \delta_M + \delta_R(R)] - [(1 - \gamma) \delta_M + \delta_S] L_S(\phi, R). \quad (8)$$

Hence, the rate of change in relative productivity ratio will be negative if and only if $\sigma < 1$ holds. Since $\sigma < 1 \Rightarrow \frac{dL_S}{d\phi} > 0 \Rightarrow \frac{d(\dot{\phi}/\phi)}{d\phi} = -[(1-\gamma)\delta_M + \delta_S] \frac{dL_S(\phi, R)}{d\phi} < 0$. This argument demonstrates that the dynamic stability of the system is satisfied and then there is a balanced growth path when $\sigma < 1$, as in Lucas Jr (1988) and Torvik (2001) ⁵.

We can now study the effect of a resource boom on the relative productivity ratio. Figure 1 shows the adjustment balanced growth path. The locus of relative productivity ratio is drawn as a downward-sloping line to satisfy the stability condition ⁶. In response to a natural resource boom, the relative demand for service goods increases and so the relative price (i.e. the real exchange rate, P) appreciates in order to come face to face with the expanded relative demand (i.e. Spending effect). It, in turn, leads to shifting labor away from the manufacturing sector and into the service sector (i.e. $\frac{dL_S}{dR} > 0$, Labor movement effect). The derivative of Equation 8 with respect to R is equal to:

$$\frac{d(\dot{\phi}/\phi)}{dR} = \delta_R'(R) - [(1-\gamma)\delta_M + \delta_S] \frac{dL_S(\phi, R)}{dR}. \quad (9)$$

Hence, an increase in employment share of the service sector induces the economy to jump vertically down from the solid line to the dotted line and from there moves towards a smaller equilibrium level of the relative productivity ratio ϕ_1^{**} if $\frac{dL_S}{dR} > \frac{\delta_R'(R)}{(1-\gamma)\delta_M + \delta_S} = \frac{dL_S^*}{dR} \Rightarrow \frac{d(\dot{\phi}/\phi)}{dR} < 0$. Otherwise, the economy first jumps up and then moves towards a larger equilibrium level of the relative productivity ratio ϕ_2^{**} (see Appendix A). For a special case in which there is no spillover effect from the resource sector to the manufacturing sector (i.e. $\delta_R(R) = 0$ and so $\delta_R'(R) = 0$), the same as Torvik (2001), a resource boom leads unconditionally to decreasing the growth rate of the relative productivity ratio.

Before attention is turned to discuss the dynamic Dutch disease, it seems to be useful to investigate the dynamic adjustment in each sector after a resource boom. Equations 7 verify that the productivity growth rate in the manufacturing sector decelerates as L_S increases, while the productivity growth rate in the service sector changes depending on the size of the direct and spillover effects of learning process. An increase in L_S decelerates the productivity growth in the service sector when the spillover effect is dominant (i.e. $\gamma\delta_M > \delta_S$) and it accelerates the productivity growth when the direct effect is stronger (i.e. $\gamma\delta_M < \delta_S$). In addition, Equations 7 indicate that a resource boom, on the one hand, tends directly to accelerate the productivity growth rate of the manufacturing sector and it, on the other hand, tends indirectly to decelerate the productivity growth rate, through making smaller the size of the labor employment share in the manufacturing sector.

⁵ When there is a Cobb-Douglas utility function (i.e. $\sigma = 1$), the vertical shifts of both LL and NN curves are equal. Therefore, the labor share in the service sector is independent of a change in ϕ (i.e. $\frac{dL_S}{d\phi} = 0$). It suggests that there is a set of growth path rather than a unique growth path.

⁶ Following Torvik (2001), assume initially $\phi > \phi^*$. Since the labor requirement effect is dominant (i.e. $\sigma < 1$), the employment in the service sector is larger than it would be at steady-state. It results in a stronger productivity growth in the service sector with respect to that in the manufacturing sector. Consequently, the relative productivity growth falls over time until it reaches its steady-state value.

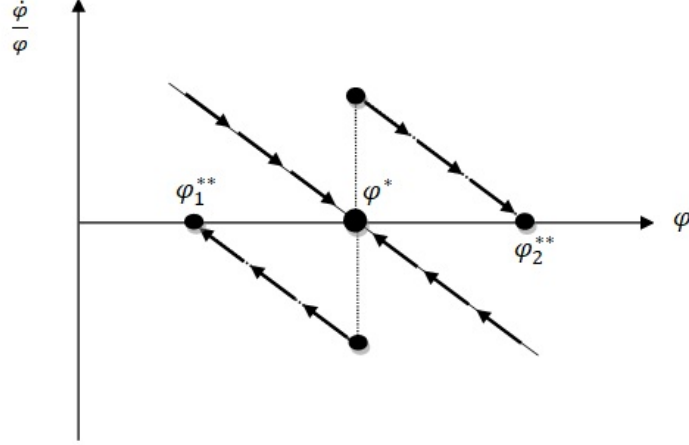


Figure 1: Adjustment balanced growth path

To have theoretical predictions relevant to the empirical findings, I assume the direct effect of the learning process is the dominant driving force in the manufacturing sector (i.e. $\delta_M \gg \delta_R$). In addition, I make the assumption that the spillover effect from the manufacturing to the service sector is stronger than the direct effect generated in the service sector, which in turn is larger than the spillover effect from the resource sector to the manufacturing sector (i.e. $\gamma\delta_M > \delta_S > \delta_R$). Torvik (2001); Bjørnland and Thorsrud (2016) models represent that the labor shares return to their steady-state level along the transition path. However, at the present dynamic model the steady-state labor employment share in the service sector changes after a shock to R ⁷,

$$L_S^*(R) = 1 - \frac{\delta_S - \delta_R}{(1 - \gamma)\delta_M + \delta_S}. \quad (10)$$

As regards the assumption of $\delta_S > \delta_R(R)$, the steady-state labor share is smaller than one ($L_S^* < 1$) ⁸. Contrary to Torvik (2001); Bjørnland and Thorsrud (2016) models in which the labor employment share in the service sector is constant at the steady-state (i.e. $L_S^* = \frac{(1-\gamma)\delta_M}{(1-\gamma)\delta_M + \delta_S}$), Equation 10 reveals that a resource boom increases the labor employment share in the service sector permanently (i.e. $\frac{dL_S^*}{dR} = \frac{\delta_R'}{(1-\gamma)\delta_M + \delta_S} > 0$). To see the equilibrium output (productivity) growth rate that is directly affected by a resource boom, insert the steady-state labor employment share in the service sector into one of the two Equations 7. The steady-state growth rate (g^*), is given by:

$$g^* = \delta_S + \frac{(\delta_S - \gamma\delta_M)(\delta_R - \delta_S)}{(1 - \gamma)\delta_M + \delta_S} > 0. \quad (11)$$

At this point, a resource boom crowds out the output (productivity). Since the size of the spillover effect from the manufacturing to the service sector is larger than that of the direct effect generated

⁷ Steady-state labor employment share in the manufacturing sector is $L_M^*(R) = \frac{\delta_S - \delta_R}{(1-\gamma)\delta_M + \delta_S}$.

⁸ It demonstrates when $\delta_S = \delta_R(R)$, the model has a corner solution.

in the service sector (i.e. $\gamma\delta_M > \delta_S$), $\frac{dg^*}{dR} = \frac{\delta_R'(\delta_S - \gamma\delta_M)}{(1-\gamma)\delta_M + \delta_S} < 0$. This is contrary to the standard Dutch disease model developed by Torvik (2001) in which there is no spillover effect from the resource sector ($\delta_R = 0$) and so the steady-state growth rate is independent of a shock in R (i.e. $g^* = \frac{\delta_S\delta_M}{(1-\gamma)\delta_M + \delta_S}$). Further, this is different from the result of the model proposed by Bjørnland and Thorsrud (2016) in which technology spillovers equally from the resource sector to other sectors and so the steady-state growth rate crowds in the sectoral output. Finally, contrary to the earlier models, the present model describes not only de-industrialization but also the slower growth rate in resource-dependent countries.

Figure 2 clarifies the dynamic Dutch disease and shows how the labor employment share in the service sector (L_S) and the real exchange rate (P) react in turn to a natural resource boom. The LL -curve (Equation 6a) and the NN -curve (Equation 6b) are respectively drawn as upward and downward sloping curves. These curves intersect initially at point E_0 . A resource rent through the real exchange rate appreciation shifts the labor employment away from the manufacturing sector and into the service sector (i.e. $\frac{dL_S}{dR} > 0$). Graphically the NN -curve shifts up, while the LL -curve doesn't affect. The new static equilibrium is set in a higher real exchange rate and a larger labor employment share in the service sector (point E_1). Assume $\frac{dL_S}{dR} > \frac{dL_S^*}{dR} = \frac{\delta_R'(R)}{(1-\gamma)\delta_M + \delta_S}$ holds and two main assumptions are taken into account (i.e. $\gamma\delta_M > \delta_S > \delta_R$ and $\delta_M \gg \delta_R$). Since L_S is now larger relative to its steady-state value L_S^* and so the relative productivity growth is negative (i.e. $\frac{\dot{\phi}}{\phi} < 0$), the productivity level shrinks faster in the manufacturing sector than in the service sector. So that the relative productivity ratio declines along the transition path. Graphically, both curves shift down. As regards the NN -curve shifts faster than the LL -curve (i.e. $\sigma < 1$ holds), falling the relative productivity ratio induces a countervailing movement of labor from the service to the manufacturing sector. The movement will continue as long as the labor employment share in the service sector converges to a new steady-state value (E_1 to E_2 in Figure 2), which is larger than value of the initial labor employment share ⁹.

A note on the new steady-state real exchange rate P^* can come from a close graphical investigation of the different possible slopes in the isoclines. It observes that the steady-state of P^* relative to its initial level might set, depending on the respective magnitudes of the shifts, in a higher level if the relative productivity ratio becomes larger than a critical threshold, $0 > \frac{d\phi^*}{dR} > -\frac{(1-\alpha)\phi^*}{L_M^*L_S^*}$ (see. Appendix A). Otherwise, P^* sets in a level lower than the initial level. As opposed to those, for a case in which technology doesn't spillover to the manufacturing sector ($\delta_R = 0$), shifting the labor employment away from the service and into the manufacturing sector will continue as long as the employment shares back to their initial values (i.e. E_2' in Figure 2). Consequently in this case, as in Torvik (2001), a reduction in the relative productivity ratio is accompanied by falling the real exchange rate. So that both L_S and P fall along the transition path.

⁹ It suggests that the final value of the labor employment share in the manufacturing sector is smaller than its initial value.

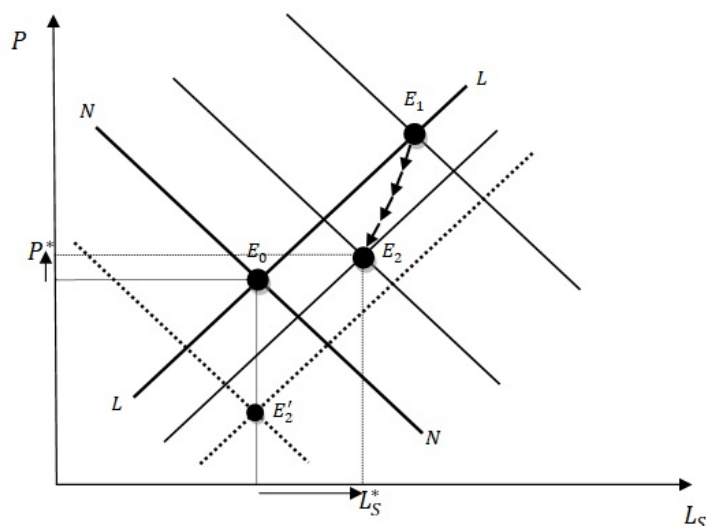


Figure 2: The Dutch disease mechanism

3 Theory meets empirical model

I specify a panel data approach to investigate the empirical relevance of the theoretical model. The main contribution of this study is to testify the symptoms of the Dutch disease. Hence, an empirical study is discussed in four stages: 1) the response of the real exchange rate to the resource-dependence proxy and the impact of the real exchange rate appreciation, respectively, on 2) the relative productivity of the manufacturing (traded) sector to the service (non-traded) sector, 3) sectoral GDP per capita growth rate, 4) economic growth rate.

3.1 Data and Methodology

The dataset consists of an unbalanced panel of 132 countries and covers 5-year periods over 1970-2014¹⁰. The list of countries included in the samples presents in Appendix D. Table 1 reports descriptive statistics. The real effective exchange rate (*REER*) estimated by *Bruegel* (Darvas, 2012) is calculated as $REER = \frac{NEER \cdot CPI^{domestic}}{CPI^{foreign}}$, where *NEER*, the nominal effective exchange rate, is a measure of the value of a currency against a weighted average of several foreign currencies and *CPI* denotes the consumer price index. This proxies the relative price of service (non-traded) to manufacturing (traded) goods. Since the relative consumer price index of domestic to foreign goods implies that an increase in *REER* tends to appreciate the relative price. I collect data of GDP per capita (Constant 2010 US dollars) as well as manufacturing (*M*) and service (*S*) value-added (Constant 2010 US dollars) from the World Bank's World Development Indicator Database (*WDI*) to construct the relative sectoral output of *M* to *S* and the natural logarithm of per capita GDP in each sector ($J = M, S$).

Following the literature, two measurements of a natural resource boom are total natural resources rents (% of GDP) (henceforth called resource-dependence index) which is sourced from *WDI*

¹⁰ 5-year periods are: 1970-1974, 1975-79, 1980-84, 1985-89, 1990-94, 1995-99, 2000-04, 2005-09, 2010-14.

and the non-agriculture commodity export price index ¹¹ which is constructed using a similar methodology to Deaton et al. (1995), Dehn (2000), Collier and Goderis (2008). Whereas the former index captures the impact of both price and quantity variations on total resource rent, the latter index which is applied as a robustness check represents only price variation (See Appendix B for more detail regarding the data, sources, and methodology used to construct the commodity price index).

Further, I collect data of the net foreign assets and GDP (both in local currency unit) from *WDI*

Table 1: Summary Statistics

	Obs.	Mean	Std Dev.	Min	Max
Real effective exchange rate	1048	1.398	4.652	0.298	136.197
Ln (relative sectoral output of M to S)	805	3.233	0.540	1.110	5.880
Ln (per capita GDP of Manufacturing)	838	6.173	1.687	2.056	9.590
Ln (per capita GDP of Service)	865	7.489	1.679	3.917	11.307
Ln (per capita GDP)	1044	8.206	1.553	5.036	11.569
Resource-dependence index	1048	7.081	9.624	0.00005	62.897
Commodity Price index)	362	1.691	1.777	1.0002	15.352
Net foreign assets	879	8.077	18.801	-62.474	117.250
Population growth	1048	1.727	1.268	-3.674	7.126
Investment ratio	858	21.426	7.857	2.812	83.787
Human Capital index	1048	2.136	0.731	1.009	3.719
Openness index	890	66.976	45.389	4.989	456.583
Terms of trade	1048	1.071	0.792	0.124	21.272
Foreign direct investment	1048	2.508	4.078	-17.505	40.409
Government spending	855	16.371	6.666	1.253	56.456
Inflation	1048	42.484	290.698	-6.628	6945.242
Institution index	1048	-0.125	0.849	-2.069	1.989

to construct the explanatory variable of net foreign assets (% GDP), and this variable is used to investigate the relationship between the resource-dependence index, the real exchange rate and the transfer problem. Other explanatory variables of interests are Population growth ¹², Investment ratio ¹³, Human Capital Index ¹⁴, Openness ratio ¹⁵, Terms of trade ¹⁶, Foreign direct investment

¹¹ Given that total natural resource rents (% of GDP) are defined as the sum of oil, natural gas, coal, mineral, and forest rents (see. *WDI*) and so the concept of reserves does not apply to many commodities, including agricultural products, I only construct a non-agriculture commodity price for as many countries as data availability allowed.

¹² The average value for the 5-year period is sourced from *WDI*.

¹³ Gross fixed capital formation in the percentage of GDP (Constant 2010 US *dollars*), is used to proxy the investment ratio. Observed values as averages for the 5-year periods are derived from *WDI*.

¹⁴ My measure of human capital is an index constructed by *Penn World Table*. This index is based on Barro and Lee (2013) database for the average years of schooling and an estimated rate of return for primary, secondary, and tertiary education, introduced by Caselli (2005).

¹⁵ I collect data of trade to GDP ratio (Constant 2010 US *dollars*), a proxy for openness level, from *WDI* database. The ratio is observed as averages for 5-year periods.

¹⁶ The net barter terms of trade index (2010=1) are calculated as the percentage ratio of the export unit value indexes to the import unit value indexes. The average value for the 5-year periods is derived from *WDI* database. Note that the base year of *WDI* database is 2005=1.

¹⁷ and Government spending ¹⁸. Moreover, GDP deflator (annual %) represents inflation and the Rule of Law indicator is considered as a proxy for quality of institution (Institution index) ¹⁹. Table 2 presents the correlation matrix for variables of interest. It reveals that the resource-dependence index is positively associated with the real exchange rate, while the real exchange rate, *per se*, is negatively correlated with per capita GDP level in each sector. In other words, it implies that the resource-dependence through the real exchange rate appreciation is likely to be accompanied by a contraction of GDP per capita in both sectors. Hence, this simple correlation matrix seems to initially clarify arising the Dutch disease and motivates us to follow the objective.

In order to verify the Dutch disease hypothesis, a dynamic panel data model is applied. The

Table 2: Correlation Matrix

	Resource dependence index	Real eff. exchange rate	Ln (per capita GDP of Manuf.)	Ln (per capita GDP of Service)
Resource-dependence index	1			
Real effective exchange rate	0.021	1		
Ln (per capita GDP of Manuf.)	-0.248	-0.017	1	
Ln (per capita GDP of Service)	-0.246	-0.042	0.949	1

general estimated equation is of the form:

$$y_{i,t} = \alpha + \delta y_{i,t-1} + X'_{i,t} \beta + \mu_i + \varepsilon_{i,t}. \quad (12)$$

where the subscripts $i = 1, \dots, N$ and $t = 1, \dots, T$ index, respectively, the countries and periods in the panel dataset. $y_{i,t}$ is the dependent variable and $X'_{i,t}$ denotes a vector of independent variables. Furthermore, α is a constant term while μ_i and $\varepsilon_{i,t}$ represent, respectively, the unobserved country-fixed effect and the error term.

The dynamic model is estimated using the first-differenced *GMM* approach suggested by Arellano and Bond (1991) and the system *GMM* developed by Blundell and Bond (1998). In the former method, the lagged level variables are used to instrument the explanatory variables, while in the latter method, both lagged levels and lagged differences are applied. Both estimators have been designed to address the potential econometric problems arising in the estimation of a dynamic regression model (Equation 12), such as a correlation between the country fixed-effect and the explanatory variables, rising autocorrelation because of including the lagged dependent

¹⁷ It is defined as the net inflows of investment divided by *GDP*. The average value for the 5-year period is collected from *WDI*.

¹⁸ It refers to General government final consumption expenditure (% of *GDP*) (constant 2010 US *dollars*). The data is an average value for the 5-year periods, sourced from *WDI*.

¹⁹ The indicators proposed by *World Bank's Governance Indicators Project* is in the range of -2.5 (weak) to $+2.5$ (strong). The data are available from 1996 to 2015. For preceding periods, I assume that the indicators are equal to the earliest value.

variable and presence of the endogenous variables.

The valid instruments for the levels of the dependent variables and the endogenous variables are lagged two or more periods, while those for the levels of the pre-determined variables are lagged one or more periods, and for the levels of exogenous variables are simply current or lagged periods. The consistency of the *GMM* estimators depends on the assessment of the proliferation of instruments which causes overidentification in the regression model and the serial autocorrelation of errors. The proliferation of instruments is checked by the *Hansen* test of over-identifying restrictions²⁰, while the second *Arellano-Bond* test²¹ is used to verify that there is no serial autocorrelation in error term and so the lagged variables are the valid instruments. Furthermore, the rule of thumb is to keep the number of instruments less than the number of country groups to avoid an overidentification (Roodman, 2009b). Finally, the regression uses a two-step system GMM (first-differenced GMM) with Windmeijer (2005) robust correction procedure²².

4 Econometric Results

4.1 Resource-dependence and the real exchange rate

The aim of this section is to investigate the response of the real exchange rate (the relative price) to an increase in a resource-dependence proxy. The dependent variable of the dynamic regression model is the real effective exchange rate and the explanatory variable of interest is total natural resource rent (% of GDP) (i.e. resource-dependence index). In addition, GDP per capita, Inflation, Government spending, Terms of trade, Openness index, and Foreign direct investment are included to control the regression model. Both dependent and independent variables are log-transformed.

Table 3 reports the empirical results. Columns (1) and (2) represent, respectively, *OLS* and the fixed effect (*FE*)²³ estimations of the baseline specification model. Although the results may not be informative, they still seem to be interesting as a benchmark. The core estimation of the regression model is reported in column (3). The coefficient on the resource-dependence enters with a positive sign and is significant at 1 percent. The estimation shows that a one percent increase in the resource-dependence index appreciates the real effective exchange rate by about 0.024%. It confirms the theory's prediction that an increase in the natural resource rent leads to an appreciation in the real exchange rate.

Now, it is worth discussing the impact of an increase in the resource-dependence index on the real effective exchange rate in terms of heterogeneity across resource-dependent countries. For this objective, I introduce a dummy variable for the natural resource-poor countries, equal to one when total natural resource rent is less than %5 of GDP, and an interaction between the dummy

²⁰ *Hansen* test is adequate when the estimation considers a *heteroscedastic* weight matrix. The null hypothesis states that the instruments, as a group, are uncorrelated with the error term.

²¹ The null hypothesis is that autocorrelation doesn't exist.

²² All results are estimated using *xtabond2* command proposed by Roodman (2009a).

²³ The *Hausman* test checking that the preferred model is random effects is rejected with a *p* – value of 0.000.

Table 3: Estimation results for the real effective exchange rate

Explanatory variable	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)			
	OLS	Full Sample	Bruegel	FE	Bruegel	Full Sample	Bruegel	Full Sample	Sys. GMM	Bruegel	Full Sample	Sys. GMM	Bruegel	Non-Europe	Sys. GMM	Bruegel	IMF	Full Sample	Sys. GMM	
Real exchange rate (lagged)	0.631*** (0.0228)	0.485*** (0.0329)	0.576*** (0.0277)	0.534*** (0.0472)	0.672*** (0.0541)	0.458*** (0.0613)	0.459*** (0.0603)	0.477*** (0.0773)	0.570*** (0.0338)											
Real exchange rate (second lagged)					-0.110** (0.0483)															
Resource-dependence (lagged)	0.00859 (0.00532)	0.00909 (0.0132)	0.0242*** (0.00894)	0.0933*** (0.0351)	0.0305*** (0.0101)	0.0278** (0.0129)	0.0315** (0.0126)	0.0223** (0.00922)	0.0359** (0.0161)											
Dummy Resource Poor countries				0.180** (0.0816)																
Dummy * Resource-dependence				-0.0785** (0.0351)																
GDP per capita	0.00580 (0.00733)	0.244*** (0.0543)	0.0179 (0.0201)	0.00356 (0.00858)	0.00263 (0.0148)	-0.00327 (0.00987)	0.00279 (0.00891)	0.0229** (0.0111)	0.0444 (0.0323)											
Inflation	-0.00595 (0.00804)	0.00103 (0.0124)	-0.00886 (0.0325)	-0.0115 (0.0224)	-0.00259 (0.0325)	-0.0192 (0.0230)	-0.0237 (0.0218)	-0.0282* (0.0171)	-0.0100 (0.0339)											
Government spending	0.0105 (0.0216)	0.0603 (0.0521)	0.0759 (0.0524)	0.0160 (0.0427)	0.141* (0.0768)	0.00821 (0.0377)	0.0109 (0.0380)	-0.0683 (0.0624)	0.0494 (0.0915)											
Terms of trade	0.114*** (0.0301)	0.182*** (0.0492)	0.198** (0.0913)	0.162* (0.0881)	0.199* (0.107)	0.141** (0.0700)	0.138** (0.0693)	0.129* (0.0704)	0.191 (0.149)											
Openness index	0.0328* (0.0170)	0.0428 (0.0417)	0.0603* (0.0310)	0.0413* (0.0219)	0.0314 (0.0434)	0.0455** (0.0223)	0.0482** (0.0215)	0.0204 (0.0179)	0.0702 (0.0489)											
Foreign Direct Investment	-0.0254*** (0.00761)	-0.0367*** (0.0101)	-0.0550 (0.0403)	-0.0305** (0.0155)	-0.0419 (0.0358)	-0.0359*** (0.0116)	-0.0367*** (0.0100)	-0.0129 (0.00974)	-0.0690 (0.0484)											
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES											
Observations	719	719	719	719	628	526	572	371	486											
Number of Countries	121	121	121	121	121	92	98	70	114											
Arellano-Bond test for AR(2) (p-value)	-	-	0.445	0.444	0.955	0.459	0.452	0.866	0.329											
Hansen OID test (p-value)	-	-	0.303	0.190	0.304	0.163	0.169	0.341	0.416											
R-squared	0.606	0.419	-	-	-	-	-	-	-											

Note: The dependent variable is the real effective exchange rate derived by *Bruegel*, while the dependent variable for estimation results reported in columns (8) is sourced by *IMF*. The real effective exchange rate (lagged) and the resource-dependence (lagged) are respectively instrumented by second lag and first lag levels in the first differences equation. Also, control variables are instrumented by second lag level in the first differences equation. To satisfy the rule of thumb some control variables are instrumented in columns (5)-(8).

Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels.

The null hypothesis of *Arellano-Bond* test is that autocorrelation doesn't exist and the null hypothesis of *Hansen* test is that the instruments, as a group, is uncorrelated with the error term.

and the resource-dependence index. The significant results reported in column (4) clarify that the real exchange rate appreciation is more intensive in resource-rich countries than resource-poor countries. Precisely, the estimation implies that this positive effect in resource-rich countries is six times larger than that in resource-poor countries.

A question now arising is whether the real exchange rate depreciates along the transition path as the resource-dependence index increases. I include the second lagged dependent variable in the regression model to address this issue. Column (5) reports both short and long-run resource-dependent's effects on the real effective exchange rate. It shows that the real exchange rate appreciation is slightly moderated over time. Nevertheless, this reduction is not to such an extent (i.e. $0.11 < 0.67$) that the long term real exchange rate is set in a level lower than the initial level²⁴. Therefore, the result may represent more consistency of the presented theory than the Torvik (2001) model.

Column (6) and (7) at Table 3 contain robustness checks of the baseline model for heterogeneity across countries. In column (6) I restrict the sample to developing countries, introduced by the International Monetary Fund's World Economic Outlook Database and in column (7) I run the regression model for sub-sample of Non-European countries to exclude the currency union's effects. The results show that the positive effect of the resource-dependence on the real exchange rate is even larger for samples of developing countries and Non-European countries so that one percent increase in the resource-dependence index leads to rising the real effective exchange rate by about 0.0278% for developing countries and 0.0315% for Non-European countries. The findings are likely to suggest that, in response to a resource boom, the relative demand for service to manufacturing goods increases more in the developing countries than others. Also, it seems to suggest that the currency union in Europe is more effective in the prevention of a resource curse. The consistency of the results is also examined by applying a different measurement approach for the dependent variable's database. I run the baseline regression model for a database of the real effective exchange rate estimated by *IMF*²⁵ to capture the robustness test. Column (8) shows the results. The available data for the real effective exchange rate of *IMF* database covers only 44 developing countries and 26 developed countries. The coefficient on the resource-dependence enters with a positive sign and its value is very close to what we found in estimation of the baseline database. However, the significance of the coefficient is weaker when *IMF* database is applied (i.e. significant in %5). The latter is more likely to be because of less number of countries' data included in *IMF* database than *Bruegel* database.

The global recession 2008-2013 has been the worst postwar recessions, both in terms of the decline in real World GDP per capita and the number of countries affected. A recession may associate with a depreciation in the real exchange rate because of falling the interest rate. Hence, it seems worthy to check the recession's effect on the consistency of the relationship between variables of interest. I run the regression model for a sample covering the period 1970-2004

²⁴ As an alternative, it implies that there are oscillations in moving up to that long-run level of the real exchange rate.

²⁵ The main difference between *Bruegel* and *IMF* databases is in the calculation of the geometrically weighted average of *CPI* indices of trading partners.

to exclude the recession's effects. Column (9) reports the estimated results. The positive and significant coefficient on the resource-dependence index supports the finding of the real exchange rate appreciation due to a resource boom. It also suggests that the great recession's effect doesn't qualitatively bias the relationship between these variables. Further, the smaller magnitude of the coefficient for the full sample than that for the restricted sample may represent the depreciation of the real exchange rate due to the falling interest rate over the recession period.

I further evaluate the sensitivity of the coefficient on the resource-dependence index to a change in sample size. Following Mihasonirina and Kangni (2011), I run the baseline regression model (column 3 of Table 3) for selected randomly 98% of the observations (without replacement). This process, repeated 250 times, gives the average value and standard deviation of the coefficient on the resource rent (% GDP). The same procedure is also used for randomly 95%, 80% and 65% of the observations. The estimated value of coefficient and standard deviation for each sample size are reported in Table 4. The results reveal when the regression runs on 98% of the sample, the estimated coefficient remains very close to the full sample's coefficient (about 3% smaller). Nevertheless, when the regression model runs on the other samples, their coefficients reduce and their distributions widen. The latter point may state that the significance of the coefficient decreases as the sample size shrinks.

The final robustness test for the first stage of the Dutch disease's analysis is a recursive estimation

Table 4: Robustness test for the sensitivity of coefficient of interest

Explanatory variable		98%	95%	80%	65%
Resource-dependence (lagged)	Coefficient	0.02343	0.02105	0.01854	0.01663
	Standard Deviation	0.00427	0.00659	0.01195	0.01435

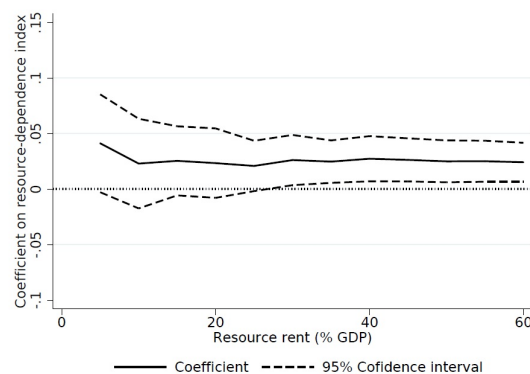


Figure 3: Recursive estimation on the coefficient of interest.

to test the stability of the coefficient of interest for cross-country heterogeneity. I first rank the observation in increasing order of the resource rent (% GDP) (i.e. resource-dependence index) and run the regression for a sample with the lowest order of resource rent (i.e. less than 5%). In

the next step, I include the subsequent observations with larger resource rent index and rerun the regression. The result, shown in Figure 3, remains positive and significant over the different levels of resource rent (% of GDP). It also represents that the coefficient on the resource-dependence index is approximately stable over increasing the resource-dependence index.

Before attention is turned to testify the impact of the real exchange rate appreciation on the relative sectoral output, sectoral growth, and economic growth, one seems to be interesting to discuss the response of the real exchange rate to resource price variations. In this respect, I next investigate the impact of the commodity price index rather than the resource-dependence index on the real exchange rate. Table 5 reports the empirical results. Columns (1) and (2) represent, respectively, *OLS* and *Sys.GMM* estimations for the sample including the commodity price index. In column (2), the insignificant and negative coefficient on the commodity price index does not support the hypothesis and is contrary to recent empirical studies (Koranchelian, 2005; Ricci et al., 2013). One might be because of the sample data set covering a shorter period and a small number of countries. An alternative may refer to heterogeneity across countries in terms of the importance of resource rent in the economy. According to the theory, a resource income boom leads to appreciating the real exchange rate. The income, in turn, depends on price and production volume. Given that the negative effect of a commodity price depreciation on the resource income may be compensated by more commodity exports, changes in commodity prices may affect the real exchange rate less intensively in resource-rich countries than in resource-poor countries. Since the commodity price presumably is the main determinant of the natural resource income in resource-poor countries where their resource productions hold constant, while the index will understate the resource income effects of the price change in resource-rich countries. To address this latter issue, I run the regression model for a sample restricted to resource-poor countries. The results are reported in column (3). The coefficient on the commodity export price index enters positive and is statistically significant at 1 percent, indicating that there is indeed a long-run real exchange rate appreciation in resource-poor countries. This contrasts with the results of the baseline model of the sample that includes the resource-dependence index (column 2 of Table 3) and suggests that the commodity price index may only describe the first symptom of the Dutch disease hypothesis in resource-poor countries and not all.

The impact of the natural resource on the real exchange rate seems to refer to the international transfer problem. The nexus between these variables rests on twofold. On the one hand, empirical evidence represents a positive long-run net foreign assets (of % GDP) in most natural resource countries (see. Lane and Milesi-Ferretti (2007)). In line with the evidence, I estimate the impact of the resource-dependence index on the net foreign assets for a sample including 114 countries' observations over the period 1970-2014. The results reported in Table 12 of Appendix C suggest that a natural resource boom leads to accumulating the net foreign assets. On the other hand, a transfer from the foreign to the home country implies an increase in global demand for home goods and hence necessitates a rise in their relative price. More precisely, in a simple Keynesian setting, countries with larger external assets, gained by exporting primary commodities (e.g. oil and gas), run a trade deficit to spend them, and achieving this trade deficit entails an appreciation

Table 5: Robustness checks for the real effective exchange rate

Explanatory variable	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		
	OLS	Bruegel Full Sample	Sys. GMM	Bruegel Full Sample	Resource-Poor Sys. GMM	Bruegel Full Sample	OLS	Bruegel Full Sample	Sys. GMM	Bruegel Full Sample	Sys. GMM	Bruegel Middle	Sys. GMM	Bruegel Low/Middle	Sys. GMM	Bruegel High/Middle	
Real exchange rate (lagged)	0.326*** (0.0278)	0.363*** (0.0810)	0.390*** (0.104)	0.649*** (0.0225)	0.390*** (0.104)	0.390*** (0.104)	0.649*** (0.0225)	0.656*** (0.0855)	0.656*** (0.0855)	0.645*** (0.0727)	0.645*** (0.0727)	0.622*** (0.0798)	0.622*** (0.0798)	0.622*** (0.0798)	0.622*** (0.0798)	0.698*** (0.0717)	0.698*** (0.0717)
Commodity Price index (lagged)	0.00694 (0.0197)	-0.00714 (0.0286)	0.591*** (0.196)		0.591*** (0.196)												
Net foreign assets (lagged)				0.216*** (0.0395)	0.216*** (0.0395)		0.216*** (0.0395)	0.265*** (0.0853)	0.265*** (0.0853)	0.238*** (0.0514)	0.238*** (0.0514)	0.241*** (0.0697)	0.241*** (0.0697)	0.241*** (0.0697)	0.241*** (0.0697)	0.285*** (0.0716)	0.285*** (0.0716)
GDP per capita	0.00777 (0.00718)	0.0151 (0.0128)	0.0158 (0.0221)	-0.00695 (0.00579)	0.0158 (0.0221)	0.0158 (0.0221)	-0.00695 (0.00579)	-0.0187 (0.0143)	-0.0187 (0.0143)	0.0108 (0.0371)	0.0108 (0.0371)	-0.0253 (0.0162)	-0.0253 (0.0162)	-0.0253 (0.0162)	-0.0253 (0.0162)	-0.0110 (0.0179)	-0.0110 (0.0179)
Inflation	-0.0299*** (0.00832)	0.0116 (0.0294)	-0.0124 (0.0193)	0.00904 (0.00687)	-0.0124 (0.0193)	-0.0124 (0.0193)	0.00904 (0.00687)	0.00904 (0.00904)	0.00904 (0.00904)	0.00473 (0.0237)	0.00473 (0.0237)	0.0116 (0.0192)	0.0116 (0.0192)	0.0116 (0.0192)	0.0116 (0.0192)	0.00749 (0.0182)	0.00749 (0.0182)
Government spending	-0.0566*** (0.0248)	-0.0314 (0.0909)	0.0636 (0.131)	0.0214 (0.0171)	0.0636 (0.131)	0.0636 (0.131)	0.0214 (0.0171)	-0.00134 (0.0561)	-0.00134 (0.0561)	-0.00922 (0.0480)	-0.00922 (0.0480)	-0.0253 (0.0545)	-0.0253 (0.0545)	-0.0253 (0.0545)	-0.0253 (0.0545)	0.0201 (0.0537)	0.0201 (0.0537)
Terms of trade	0.116*** (0.0354)	0.169* (0.0978)	0.0326 (0.232)	0.0344 (0.0230)	0.0326 (0.232)	0.0326 (0.232)	0.0344 (0.0230)	-0.00549 (0.0649)	-0.00549 (0.0649)	0.0150 (0.0780)	0.0150 (0.0780)	-0.00922 (0.0671)	-0.00922 (0.0671)	-0.00922 (0.0671)	-0.00922 (0.0671)	0.0669 (0.0947)	0.0669 (0.0947)
Openness index	0.0224 (0.0182)	0.000664 (0.0553)	-0.0121 (0.0468)	0.00521 (0.0135)	-0.0121 (0.0468)	-0.0121 (0.0468)	0.00521 (0.0135)	-0.00491 (0.0416)	-0.00491 (0.0416)	0.0297 (0.0569)	0.0297 (0.0569)	0.0180 (0.0410)	0.0180 (0.0410)	0.0180 (0.0410)	0.0180 (0.0410)	0.0162 (0.0610)	0.0162 (0.0610)
Foreign Direct Investment	-0.0105 (0.00871)	-0.0288 (0.0199)	-0.000757 (0.0261)		-0.000757 (0.0261)												
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	240	240	133	603	133	133	603	603	603	396	396	522	522	522	477	477	477
Number of Countries	66	66	41	103	41	41	103	103	103	71	71	90	90	90	84	84	84
Arellano-Bond test for AR(2) (p-value)	-	0.765	0.525	-	0.525	0.525	-	0.922	0.922	0.742	0.742	0.944	0.944	0.944	0.756	0.756	0.756
Hansen OID test (p-value)	-	0.115	0.174	-	0.174	0.174	-	0.239	0.239	0.466	0.466	0.381	0.381	0.381	0.452	0.452	0.452
R-squared	0.51	-	-	0.681	-	-	0.681	-	-	-	-	-	-	-	-	-	-

Note: The dependent variable is the real effective exchange rate derived by *Bruegel*. Commodity price (lagged) is exogenous. The real effective exchange rate (lagged) and the net foreign assets (lagged) are respectively instrumented by second lag and first lag levels in the first differences equation. The net foreign assets is normalized to avoid the cancellation of the negative value of observations in Ln form. Also, control variables are instrumented by second lag level to satisfy the rule of thumb. Foreign Direct Investment is dropped in columns (4)-(8) to avoid endogeneity problem.

Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels.

The null hypothesis of *Arellano-Bond* test is that autocorrelation doesn't exist and the null hypothesis of *Hansen* test is that the instruments, as a group, is uncorrelated with the error term.

in the real exchange rate. In this respect, using a database covering 64 industrial and middle-income developing countries between 1970 and 1998, Lane and Milesi-Ferretti (2004) show that in the long run, larger net external positions should be associated with a more appreciated real exchange rate. Accordingly, these relationships may indicate the impact of the natural resource rent on the real exchange rate through the transmission channel of the international payments (i.e. the transfer problem).

The argument illustrates that the variable of the net foreign assets (% of GDP) presumably well reflects the resource-dependence index. Hence, I include the net foreign assets (% of GDP) in the base regression model (column 3 of Table 3), instead of the resource-dependence index, to address the transmission channel. Column (4) of Table 5 reports *OLS* estimation's results, while column (5) represents *Sys.GMM* estimation's results. The coefficient on the variable of interest has a positive value and is significant at 1%. In line with the literature (e.g. Lane and Milesi-Ferretti (2004); Christopoulos et al. (2012)), improving net foreign assets gained by exporting primary commodities are associated with an appreciation in the real exchange rates, providing clear evidence for the existence of a powerful transfer effect. Further, according to Lane and Milesi-Ferretti (2004), I run the regression model for the countries' subgroup, where the sample based on country size may potentially affect the magnitude of the transfer effect. In this respect, the sample is split in three groups, according to the normalized *GDP* level: *a*) low-income countries where their normalized *GDP* value is smaller than 0.25, *b*) high-income countries where their value is larger than 0.75, and *c*) middle-income countries included the rest of countries' observations. The results reported in columns (6)-(8) respectively belong to samples of middle-income, low and middle-income, and high and middle-income countries. The transfer effect remains very significant, while The coefficient magnitude in the sample including low and middle-income countries or high and middle-income countries is more intensive than the sample only including middle-income countries. This may conclude that the transfer effect is more evident in poor and rich economies.

4.2 Real exchange rate and relative sectoral output

In this sub-section, I examine the impact of the real exchange rate appreciation on the relative sectoral output to investigate the resource movement effect in the Dutch disease theory. Following the Torvik (2001) model, the labor allocation is constant at steady-state (i.e. $L_S^* = \frac{(1-\gamma)\delta_M}{(1-\gamma)\delta_M + \delta_S}$). Accordingly, the relative sectoral output, at steady-state, will be a function of the steady-state relative productivity ratio ϕ^* (i.e. $\frac{X_M}{X_S} = \phi^* \frac{(1-L_S^*)^\alpha}{(L_S^*)^\alpha}$). While, in the present theory, both increasing the steady-state labor employment share in the service sector and decreasing the steady-state relative productivity ratio tend to reduce the relative sectoral output at steady-state. Nevertheless, lack of a comprehensive dataset of sectoral productivity and also shortage data for the labor employment shares, required to estimate the productivity level in each sector, enforce us to apply another proxy that captures the impact of a natural resource boom on the relative productivity level. One seems that the relative sectoral output is a reliable and acceptable proxy to replace the relative productivity level. Therefore, the relative per capita GDP of the manufacturing to the

service sector (in constant price)²⁶ is taken into account as the dependent variable and the real effective exchange rate will be the explanatory variable of interest. I also include per capita GDP, Investment ratio, Human capital index, Openness index, Government spending, and Institution index as the control variables. I estimate the regression model using the first-differenced *GMM*. Since the system *GMM* estimator leads to arising the unit root process.

The estimated results are shown in Table 6. The first and second columns respectively report the *OLS* and the fixed effect, *FE*²⁷, estimators, while column (3) shows the results estimated by the first-differenced *GMM*. The coefficients on both the resource-dependence index and the real effective exchange rate are negative and significant at %1 percent²⁸. These imply that an increase in the resource-dependence proxy and so the real exchange rate appreciation is associated with a decrease in the relative sectoral output. More precisely, it suggests when the real exchange rate appreciates, it is more likely that the sectoral growth shrinks faster in the manufacturing sector than in the service sector and so the relative sectoral output decrease.

The finding in column (3) confirms the theory however, the values of coefficients are small. This might be because of heterogeneity across countries in terms of dependency on resource rent. Hence, I include a dummy variable of natural resource-poor countries and interaction between the dummy and the real effective exchange rate to address this issue. The estimation results reported in column (4) represent that the coefficients on the real effective exchange rate and the interaction term enter, respectively, with negative and positive signs and are significant at 5% percent. These illustrate that falling the relative sectoral output is more intensive in resource-rich countries than in resource-poor countries. The conclusion seems to be consistent with the theory and the preceding sub-section. Since the preceding section suggested that the real exchange rate appreciation is stronger in resource-rich countries than in another group. Therefore, along the transition path the relative sectoral output level (a proxy for the relative productivity) reduces more in resource-rich countries than others to induce a stronger countervailing movement of labor from the service to the manufacturing sector.

To test the robustness of the results, I first drop the resource-dependence index to satisfy lower number of instruments than the number of country groups (i.e. the rule of thumb) and then estimate the regression model for samples of developing countries, poor-institution countries, included when the value of institution index (i.e. rule of law indicator) is smaller than 1.5, and the non-European countries. The results are respectively reported in columns (5)-(7). The coefficient of interest is still negative and even their value is equal to the value estimated for the full sample (5%, at most, smaller in groups' countries than the full sample²⁹). These may suggest a negligible sensitivity of the correlation from country-group heterogeneity in terms of

²⁶ Similarly, it is a relative value-added share in constant price

²⁷ The *Hausman* test is rejected with a *p* – value of 0.002.

²⁸ The finding in the nexus between the resource-dependence index and the relative sectoral level seems to be consistent with the empirical literature. Under the panel data model of a sample including data of 28 natural resource-rich countries for the period of 2000-2016, Amiri et al. (2019) found that the relative sectoral level decreases as the natural resource income increase.

²⁹ The value of the coefficient on the real effective exchange rate for a regression model in which the resource dependence index is excluded is equal to 0.00108.

Table 6: Estimation results for the relative Sectoral GDP

Explanatory variable	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)			
	OLS	Full Sample	Bruegel	FE	Full Sample	Bruegel	Full Sample	Bruegel	Full Sample	Bruegel	Diff. GMM	Bruegel	Diff. GMM	Bruegel	non-Europe	Diff. GMM	Bruegel	Diff. GMM	Bruegel	
Relative sectoral GDP (Ln) (lagged)	0.907*** (0.0128)	0.810*** (0.0287)	0.761*** (0.0916)	0.744*** (0.0818)	0.784*** (0.0828)	0.819*** (0.106)	0.801*** (0.0901)	0.762*** (0.130)	0.635*** (0.132)											
Recourse-dependence (lagged)	0.000232 (0.000816)	0.00334* (0.00189)	-0.00925*** (0.00286)	-0.00684*** (0.00263)																
Real effective exchange rate (lagged)	-0.000618 (0.00115)	-0.00123 (0.00110)	-0.000989*** (0.000354)	-0.0638** (0.0305)	-0.00109*** (0.000313)	-0.00114** (0.000495)	-0.00110*** (0.000391)	-0.0299** (0.0148)	-0.000818** (0.000385)											
Dummy Recourse-Poor countries				-0.0568 (0.0425)																
Dummy * Real exchange rate (lagged)				0.0628** (0.0306)																
GDP per capita (Ln)	-0.00911 (0.00845)	-0.0603 (0.0385)	-0.0405 (0.122)	-0.0225 (0.121)	0.00389 (0.146)	0.0654 (0.160)	-0.0151 (0.125)	0.0593 (0.171)	-0.0913 (0.165)											
Investment ratio	0.00280*** (0.000931)	-0.00182 (0.00125)	-0.000450 (0.00252)	-0.00196 (0.00241)	-0.000948 (0.00266)	0.00143 (0.00282)	-0.00159 (0.00247)	-0.00759 (0.00689)	0.00114 (0.00397)											
Human capital index	0.0370** (0.0178)	0.140** (0.0656)	0.00734 (0.305)	-0.109 (0.286)	0.190 (0.374)	0.0960 (0.465)	-0.103 (0.320)	-0.424 (0.396)	0.312 (0.395)											
Openness index	-0.000003 (0.000166)	0.000233 (0.000426)	-0.000280 (0.00125)	-0.000335 (0.00107)	-0.00101 (0.00171)	-0.00227 (0.00181)	-0.00117 (0.00151)	-0.00276 (0.00206)	-0.000670 (0.00167)											
Government spending	-0.00204 (0.00127)	-0.00699*** (0.00249)	0.00147 (0.00625)	0.000100 (0.00532)	-0.000361 (0.00505)	-0.000711 (0.00701)	0.000534 (0.00548)	-0.0177 (0.0113)	0.00295 (0.00517)											
Institution index	-0.00779 (0.0122)	0.0338 (0.0265)	0.0301 (0.0415)	0.0297 (0.0414)	0.0655 (0.0745)	0.0924 (0.101)	0.0719 (0.0635)	-0.0156 (0.0482)	0.0546 (0.0512)											
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES											
Observations	600	600	486	486	368	289	394	263	279											
Number of Countries	114	114	104	104	76	63	81	64	87											
Arellano-Bond test for AR(2) (p-value)	-	-	0.764	0.881	0.822	0.961	0.787	0.436	0.621											
Hansen OID test (p-value)	-	-	0.357	0.620	0.520	0.477	0.471	0.158	0.340											
R-squared	0.904	0.667	-	-	-	-	-	-	-											

Note: The dependent variable is the relative GDP per capita of the manufacturing to the service sector (Ln) (in constant price). The real effective exchange rate data estimated by *Bruegel* is applied in columns (1)-(7) and (9) while the data estimated by *IMF* is used in column (8). Column (1) is regressed by *OLS* estimator, column (2) is regressed by *Fixed - Effect* estimator and other columns are regressed by first-differenced *GMM* estimator.

For estimation, the relative sectoral output (lagged), the resource-dependence index (lagged) and the real effective exchange rate (lagged) are instrumented by first and second lags in the first differences equation. Also, control variables are instrumented by second lag level in first differences equation.

Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels. The null hypothesis of *Arellano-Bond* test is that autocorrelation doesn't exist and the null hypothesis of *Hansen* test is that the instruments, as a group, is uncorrelated with the error term.

development level, quality of the institution, and currency union's effects.

I further regress the model for a sample of the real effective exchange rate estimated by *IMF* to investigate the dependency of the results in terms of a different measurement approach for the explanatory variable of interest. The results reported at column (8) still follow the theory's prediction, the same as the results estimated using *Bruegel* database. However, the absolute value of coefficient estimated by *IMF* database is much larger than that estimated by *Bruegel* database. To sum up, this demonstrates that empirical finding confirms the theoretical prediction, independent of measurement approaches for the real effective exchange rate ³⁰.

In line with the preceding subsection, I also check the consistency of the results for a sample covering the period before the great recession. The results reported in column (9) confirm the independency of the main findings from the recession's effects. The value of the coefficient on the resource-dependence index is less negative for the full sample than for the restricted sample. Regarding the theory, it may indicate that an external real exchange depreciation due to the great recession can offset a share of the negative effect of a resource boom on the relative sectoral output through the real exchange rate appreciation.

In addition, I check the sensitivity of the coefficients on the resource-dependence index and

Table 7: Robustness test for the sensitivity of coefficient of interest

Explanatory variable		98%	95%	80%	65%
Resource-dependence (lagged)	Coefficient	-0.00870	-0.00757	-0.00435	-0.00265
	Standard Deviation	0.00181	0.00257	0.00454	0.00515
Real effective exchange rate (lagged)	Coefficient	-0.00199	-0.00487	-0.01189	-0.01432
	Standard Deviation	0.00582	0.01149	0.02423	0.04195

the real exchange rate to a change in sample size the same procedure as before. The average value and standard deviation of coefficients of interest for the baseline model (i.e. column (3) in Table 6) are reported in Table 7. Although the values of both coefficients on the resource-dependence and the real exchange rate are sensitive to a shrinkage in the sample size, they keep negative signs. This may confirm that the negative correlation between the relative sectoral output and the explanatory variables of interests doesn't depend on a change in the sample size. The table further shows that the significance of the coefficient decreases along with the reduction of the sample size. Since the distribution of both coefficients widens as the sample size shrinks.

³⁰ Given that this paper aims to investigate the symptoms of the Dutch disease hypothesis systematically, I have not reported the estimated results of the impact of an increase in the commodity price index on the relative sectoral output. But the results show that the coefficient on the commodity price index is insignificant for the full sample (given data availability). This may be because of existing a sample covering a shorter period and a small number of countries. It may also refer to the fact that commodity price variation differently affects resource-groups countries depending on the importance of commodities in the economy. The estimated significant result for the sample restricted to resource-poor countries supports the latter point. This is consistent with the preceding subsection and suggests that jumping up the commodity price index through the real exchange rate appreciation and consequently the factor re-allocation only decreases the relative sectoral output level.

Following the same procedure proposed in the preceding section, I also conduct recursive

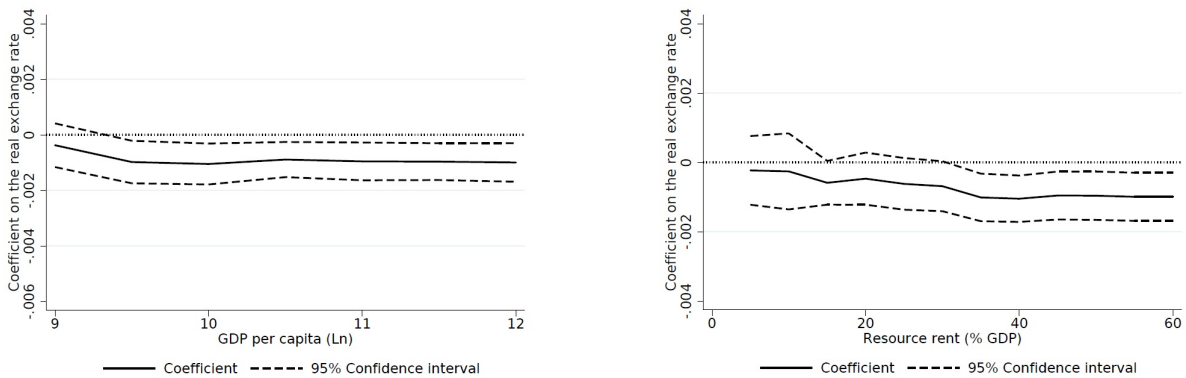


Figure 4: Recursive estimation on the real exchange rate.

estimations to evaluate the accuracy of the results. I estimate the coefficient on the real exchange rate for a sample of observations ranked in increasing orders of GDP per capita and resource rent share in GDP. Figure 4 shows the estimated results. This represents significant negative coefficients on the real exchange rate across countries and demonstrates that the value of the coefficient is approximately stable in terms of income level while it is decreasing in terms of resource rent (% GDP). The latter point is consistent with the preceding finding in column (4) of Table 6, suggesting that falling the relative sectoral output due to the real exchange rate appreciation is stronger in resource-rich countries than in resource-poor countries.

4.3 Real exchange rate and sectoral growth

So far I have analyzed the impact of the real exchange rate, appreciated by a natural resource boom, on the relative sectoral output (in constant price) as a proxy for the relative productivity ratio. But this is not the only issue of interest. It is worth conducting an investigation into the response of the sectoral economic growth, rather than the relative sectoral growth, to the real exchange rate appreciation. Sectoral GDP per capita level (in constant price) is considered as the dependent variable and the real effective exchange rate is the explanatory variable of interest. In addition, GDP per capita (Ln), Population Growth, Investment ratio, Human capital index, Openness index, Government spending, and Institution index are included to control the regression model.

Table 8 contains the results for both the manufacturing and service sectors. Columns (1) and (2) represent, respectively, the estimation results of growth in the manufacturing sector using *OLS* and the first-differenced *GMM* estimators. The estimated negative and significant coefficient on the real effective exchange rate, sourced from *Bruegel*, confirms that an appreciation in the real exchange rate due to a natural resource boom shrinks the manufacturing sector, as in Sekkat and Varoudakis (2000). Further, column (3) shows this result gets much stronger when the *IMF* database of the real exchange rate is applied instead. More precisely, a one-standard-deviation increase in the real exchange rate reduces the growth in the manufacturing sector by about 0.1%

Table 8: Estimation results for the Sectoral Growth

Explanatory variable	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		
	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>IMF</i>	<i>IMF</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>IMF</i>	<i>IMF</i>	<i>Bruegel</i>	<i>Bruegel</i>	
	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Service	Service	Service	Service	Service	Service	Service	Service	
	OLS	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	OLS	OLS	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	Diff. GMM	
Sectoral GDP per capita (Ln) (lagged)	0.854*** (0.0139)	0.361*** (0.0845)	0.426*** (0.107)	0.345*** (0.0658)	0.615** (0.267)	0.779*** (0.174)	0.779*** (0.174)	0.779*** (0.174)	0.717*** (0.0164)	0.268*** (0.0177)	0.828*** (0.0535)	0.828*** (0.0535)	0.843*** (0.0955)	0.843*** (0.0955)	0.153*** (0.0579)	0.153*** (0.0579)	0.149*** (0.0563)
Real effective exchange rate (lagged)	-0.00249* (0.00128)	-0.00130*** (0.000395)	-0.0388*** (0.0139)	-0.106** (0.0423)	-0.0387** (0.0160)	-0.0242* (0.0143)	-0.0242* (0.0143)	-0.0242* (0.0143)	-0.00186** (0.000769)	-0.0255*** (0.00516)	-0.000687 (0.00497)	-0.000687 (0.00497)	-0.000687 (0.00497)	-0.000687 (0.00497)	-0.000979*** (0.000131)	-0.000979*** (0.000131)	-0.00986 (0.0147)
Dummy Resource-Poor countries				-0.0907** (0.0421)													0.00346 (0.0144)
Dummy * Real exchange rate (lagged)				0.105** (0.0423)													0.00903 (0.0147)
GDP per capita (Ln)	0.114*** (0.0161)	0.747*** (0.160)	0.615** (0.267)	0.779*** (0.174)	0.615** (0.267)	0.779*** (0.174)	0.779*** (0.174)	0.779*** (0.174)	0.268*** (0.0177)	0.268*** (0.0177)	0.828*** (0.0535)	0.828*** (0.0535)	0.843*** (0.0955)	0.843*** (0.0955)	0.839*** (0.0618)	0.839*** (0.0618)	0.839*** (0.0618)
Population Growth	-0.0333*** (0.00881)	-0.0169 (0.0138)	-0.0387** (0.0160)	-0.0242* (0.0143)	-0.0387** (0.0160)	-0.0242* (0.0143)	-0.0242* (0.0143)	-0.0242* (0.0143)	-0.0255*** (0.00516)	-0.0255*** (0.00516)	-0.00687 (0.00497)	-0.00687 (0.00497)	-0.00687 (0.00497)	-0.00687 (0.00497)	-0.00954* (0.00488)	-0.00954* (0.00488)	-0.00954* (0.00488)
Investment ratio	0.00869*** (0.000992)	0.000414 (0.00402)	-0.00298 (0.00523)	-0.000181 (0.00320)	-0.00298 (0.00523)	-0.000181 (0.00320)	-0.000181 (0.00320)	-0.000181 (0.00320)	0.00366*** (0.000610)	0.00366*** (0.000610)	0.00194 (0.00168)	0.00194 (0.00168)	0.00188 (0.00271)	0.00188 (0.00271)	0.00254 (0.00185)	0.00254 (0.00185)	0.00254 (0.00185)
Human capital index	0.0418* (0.0217)	-0.190 (0.363)	-0.118 (0.365)	-0.190 (0.504)	-0.118 (0.365)	-0.190 (0.504)	-0.190 (0.504)	-0.190 (0.504)	0.0324*** (0.0123)	0.0324*** (0.0123)	-0.0631 (0.149)	-0.0631 (0.149)	0.142 (0.107)	0.142 (0.107)	-0.0804 (0.185)	-0.0804 (0.185)	-0.0804 (0.185)
Openness index	-0.00004 (0.000190)	-0.000420 (0.00135)	-0.00131 (0.00190)	0.000141 (0.00129)	-0.00131 (0.00190)	0.000141 (0.00129)	0.000141 (0.00129)	0.000141 (0.00129)	-0.00004 (0.000103)	-0.00004 (0.000103)	-0.000198 (0.000275)	-0.000198 (0.000275)	-0.000356 (0.000706)	-0.000356 (0.000706)	-0.000158 (0.000246)	-0.000158 (0.000246)	-0.000158 (0.000246)
Government spending	-0.00429*** (0.00138)	-0.00371 (0.00491)	-0.00715 (0.01000)	-0.00311 (0.00576)	-0.00715 (0.01000)	-0.00311 (0.00576)	-0.00311 (0.00576)	-0.00311 (0.00576)	-0.00114 (0.000793)	-0.00114 (0.000793)	0.000357 (0.00341)	0.000357 (0.00341)	0.0100** (0.00461)	0.0100** (0.00461)	0.00110 (0.00292)	0.00110 (0.00292)	0.00110 (0.00292)
Institution index	0.0266** (0.0130)	-0.0125 (0.0400)	-0.0224 (0.0456)	-0.0157 (0.0425)	-0.0224 (0.0456)	-0.0157 (0.0425)	-0.0157 (0.0425)	-0.0157 (0.0425)	0.0309*** (0.00757)	0.0309*** (0.00757)	-0.0296* (0.0171)	-0.0296* (0.0171)	-0.0190 (0.0245)	-0.0190 (0.0245)	-0.0272* (0.0157)	-0.0272* (0.0157)	-0.0272* (0.0157)
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	624	509	268	509	268	509	509	509	636	636	519	519	265	265	519	519	519
Number of Countries	115	106	64	106	64	106	106	106	121	121	109	109	64	64	119	119	119
Arellano-Bond test for AR(2) (p-value)	-	0.899	0.990	0.911	0.990	0.911	0.911	0.911	-	-	0.355	0.355	0.066	0.066	0.439	0.439	0.439
Hansen OID test (p-value)	-	0.148	0.364	0.309	0.364	0.309	0.309	0.309	-	-	0.177	0.177	0.395	0.395	0.218	0.218	0.218
R-squared	0.989	-	-	-	-	-	-	-	0.996	0.996	-	-	-	-	-	-	-

Note: The dependent variable is the sectoral GDP per capita level (Ln). The real effective exchange rate, used in estimation, is sourced from *Bruegel* and *IMF*. Columns (1) and (5) are regressed by *OLS*, while other columns are estimated by the first differenced *GMM* estimator. For estimation, the sectoral output level (lagged) and control variables, except Population growth and Institution index, are instrumented by second lag level, while the real effective exchange rate (lagged) is instrumented by first and prior lags in first differences equation. Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels. The null hypothesis of *Arellano-Bond* test is that autocorrelation doesn't exist and the null hypothesis of *Hansen* test is that the instruments, as a group, are uncorrelated with the error term.

for *Bruegel* database, while it is about 4% for *IMF* database.

Columns (5) and (6) report the results of growth in the service sector. The coefficients on the real exchange rate enter with a negative sign and is significant for both *OLS* and *GMM* estimators. Also, column (7), reporting the estimation results using *IMF* database, demonstrates that the coefficient on the real exchange rate is approximately much larger than that estimated by *Bruegel* database. It shows that the growth in the service sector reduces by about 2% for *IMF* database and by about 0.1% for *Bruegel* as a one-standard-deviation increase in the real exchange rate. Further, regarding the theory, a negative coefficient on the real exchange rate seems to demonstrate that the learning generated in the manufacturing sector and spilled over to the service sector is the dominant driven force of the productivity growth in the service sector. A comparison between the estimated coefficients reported in columns (2) and (6), on the one hand, and between columns (3) and (7), on the other hand, clarify that an increase in the real exchange rate makes the growth to be much slower in the manufacturing sector than in the service sector. A larger shrinkage in the manufacturing sector is in line with the empirical finding of the preceding sub-section. It states when the real exchange rate appreciates, the productivity level shrinks faster in the manufacturing sector than in the service sector and so the relative productivity growth (i.e. the relative sectoral output) reduces to re-establish the labor allocation among sectors.

Our findings in columns (2) and (6) also show that the values of coefficients on the variable of interest are negligible however are significant. This may reflect cross-country heterogeneity. Regarding the preceding sub-sections, I include the dummy variable of resource-poor countries and interaction between the dummy and the real effective exchange rate to address this problem. The results are reported in columns (4) and (8). The estimated coefficients of interest are significant for the manufacturing sector's regression, while they are insignificant for the service sector's regression. The estimated coefficients on the real effective exchange rate and the interaction term have negative and positive signs, respectively. These suggest that the adverse effect of the real exchange rate appreciation on the sectoral growth rate is more intensive in resource-rich countries than in resource-poor countries. Regarding more appreciation of the real exchange rate and so larger reduction of the relative sectoral output level in resource-rich countries than resource-poor countries (see. preceding sub-sections and the theory), these findings seem to be plausible.

Now, I conduct a sensitivity analysis for both sectors' baseline models (i.e. columns (2) and (6) in Table 8) to a change in sample size, following the same procedure as preceding sub-sections. The coefficients of the real exchange rate for both sectoral regressions are reported in Table 9. They enter with negative signs independently of the sample size however, their normal distributions are widened and their tails fall along with shrinkage in the sample size. These are more likely to suggest that the significance of the coefficients decreases as the sample size shrinks.

The final robustness test is included to test the stability of coefficients on the real exchange rate for both baseline regression models. The recursive estimation on the coefficients of interest

Table 9: Robustness test for the sensitivity of coefficients of interest

Explanatory variable		98%	95%	80%	65%	
			Manufacture			
Real effective exchange rate (lagged)	Coefficient	-0.00561	-0.00688	-0.01834	-0.01459	
	Standard Deviation	0.01771	0.01803	0.02845	0.04581	
			Service			
Real effective exchange rate (lagged)	Coefficient	-0.00160	-0.00237	-0.00747	-0.00913	
	Standard Deviation	0.00295	0.00438	0.01174	0.01490	

in terms of per capita GDP level and resource-dependence index are shown in Figure 5. The graphs demonstrate that a negative effect of the real exchange rate on the sectoral growth rate doesn't depend on heterogeneity across countries. Further, for the service sector, the value of the coefficient is stable in terms of both per capita GDP level and resource rent (% GDP), while for the manufacturing sector it is only stable in terms of per capita GDP level and decreasing in terms of resource rent (% GDP). The latter point clarifies the previous finding that a natural resource curse is more intensive in a resource-rich county than in a resource-poor country.

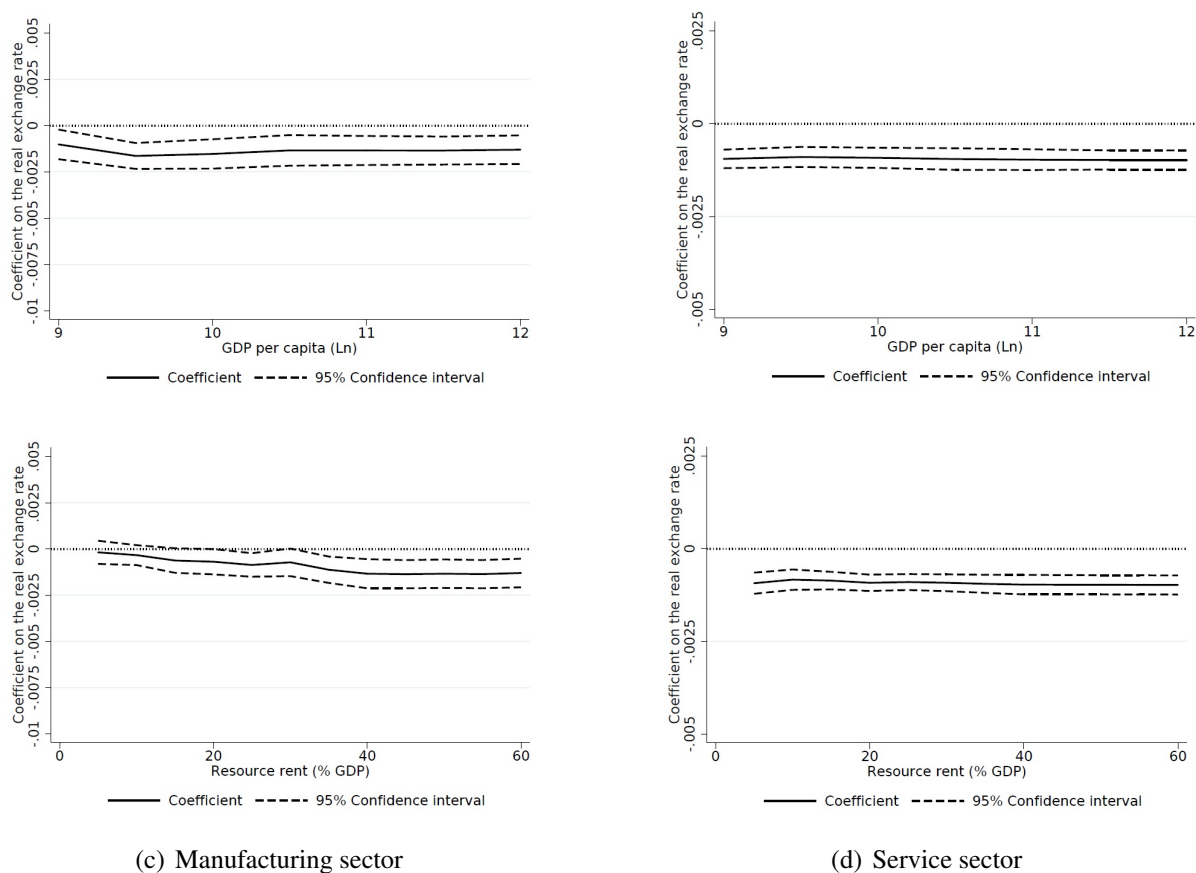


Figure 5: Recursive estimation on the real exchange rate.

4.4 Real exchange rate and economic growth

The mechanism of the model and preceding empirical findings illustrate that a resource boom through an appreciation in the real exchange rate decelerates the growth rate of both the manufacturing and service sectors. Therefore, an economy is more likely to expand slower as the resource rent booms. This refers to the natural resource curse's hypothesis, empirically supported by Sachs and Warner (1995); Rodriguez and Sachs (1999); Gylfason et al. (1999). Furthermore, as I mentioned before, recent studies reveal that the real exchange rate appreciation causes economic growth to become slower (e.g. Eichengreen (2007); Rodrik (2008); Habib et al. (2017)). These motivate us to re-investigate how the economic growth rate rather the sectoral growth rates respond to explanatory variables of interest (i.e. the real exchange rate appreciation and the resource boom) using a dynamic panel data approach.

GDP per capita level (in constant price) is considered as the dependent variable and the resource-dependence index, as well as the real exchange rate, are the explanatory variables of interest. I also include Population Growth, Investment ratio, Human capital index, Openness index, Government spending, and Institution index to control the regression model. I further use the first-differenced *GMM* to estimate the regression model. Since the estimated results by the System *GMM* is suspicious to have a unit root.

Table 10 shows the results. *OLS* and *FE*³¹ estimations are respectively reported in Columns (1) and (2) as benchmarks. The baseline model reported in column (3) suggests that both coefficients of interest enter with negative signs and are significant at 1%. More precisely, the economic growth rate, on average, decelerates by about 0.8% as a one-standard-deviation increase in the resource-dependence index and it reduces by about 0.1% as a one-standard-deviation increase in the real exchange rate. Consistent with the main empirical studies (Sachs and Warner, 2001; Rodrik, 2008) and the present theory, these findings seem to confirm the presented model's prediction and to demonstrate both the natural resource curse hypothesis and the adverse effect of the real exchange rate on economic growth.

Following the preceding sub-sections, it seems to be worth discussing the heterogeneity across countries in terms of resource dependency. I include the dummy variable of the natural resource-poor countries and an interaction term, the same as before. The estimated result, reported in column (4), reveals that GDP per capita expands slower in natural resource-rich countries than in natural resource-poor countries as the real exchange rate appreciates. This is in following the preceding empirical findings in which appreciation in the real exchange rate, reduction in the relative sectoral output, and deceleration in sectoral growth are more intensive in natural resource-rich countries than in natural resource-poor countries as the resource-dependence index increases.

As the first robustness check, I regress the baseline model (i.e. column (3)) for the developing countries, the poor-institution countries, and the non-European countries to test country-group heterogeneity. The results reported in columns (5) through (7) suggest that country-group heterogeneity doesn't affect the qualitative response of the economic growth to explanatory variables

³¹ The *Hausman* test is rejected with a *p* – value of 0.000.

Table 10: Estimation results for the Economic Growth

Explanatory variable	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		
	OLS	Full Sample	Bruegel	FE	Full Sample	Bruegel	Full Sample	Diff. GMM	Bruegel	Developing	Bruegel	Poor-Instit	Diff. GMM	Bruegel	non-Europe	Bruegel	Full Sample	IMF	Recession
GDP per capita (Ln) (lagged)	0.962*** (0.00507)	0.763*** (0.0195)	0.752*** (0.0414)	0.798*** (0.0506)	0.734*** (0.0564)	0.784*** (0.0678)	0.732*** (0.0454)	0.732*** (0.0454)	0.732*** (0.0454)	0.732*** (0.0454)	0.784*** (0.0678)	0.732*** (0.0454)	0.732*** (0.0454)	0.732*** (0.0454)	0.732*** (0.0454)	0.627*** (0.0836)	0.627*** (0.0836)	0.761*** (0.0548)	0.761*** (0.0548)
Resource-dependence (lagged)	-0.000495 (0.000575)	-0.00207* (0.00112)	-0.00767*** (0.00289)	-0.00347*** (0.00175)	-0.00701*** (0.00245)	-0.00950*** (0.00320)	-0.00763*** (0.00276)	-0.00763*** (0.00276)	-0.00763*** (0.00276)	-0.00763*** (0.00276)	-0.00950*** (0.00320)	-0.00763*** (0.00276)	-0.00763*** (0.00276)	-0.00763*** (0.00276)	-0.00763*** (0.00276)	-0.00735*** (0.00299)	-0.00735*** (0.00299)	-0.00581*** (0.00305)	-0.00581*** (0.00305)
Real effective exchange rate (lagged)	-0.00237*** (0.000809)	-0.00130* (0.000734)	-0.00110*** (0.000250)	-0.0431** (0.0175)	-0.00105*** (0.000272)	-0.000724*** (0.000253)	-0.00103*** (0.000306)	-0.00103*** (0.000306)	-0.00103*** (0.000306)	-0.00103*** (0.000306)	-0.000724*** (0.000253)	-0.00103*** (0.000306)	-0.00103*** (0.000306)	-0.00103*** (0.000306)	-0.00103*** (0.000306)	-0.0187** (0.00841)	-0.0187** (0.00841)	-0.00132*** (0.000331)	-0.00132*** (0.000331)
Dummy Resource-Poor countries				-0.0428 (0.0307)															
Dummy * Real exchange rate (lagged)				0.0420** (0.0174)															
Population Growth	-0.0260*** (0.00494)	-0.00614 (0.00681)	-0.00961 (0.0102)	-0.00921 (0.0113)	-0.00106 (0.0106)	-0.000517 (0.0107)	-0.00141 (0.0105)	-0.00141 (0.0105)	-0.00141 (0.0105)	-0.00106 (0.0106)	-0.000517 (0.0107)	-0.00141 (0.0105)	-0.00141 (0.0105)	-0.00141 (0.0105)	-0.00141 (0.0105)	0.00201 (0.0143)	0.00201 (0.0143)	-0.00729 (0.0114)	-0.00729 (0.0114)
Investment ratio	0.00684*** (0.000570)	0.00663*** (0.000736)	0.0113*** (0.00232)	0.00807*** (0.00202)	0.00669*** (0.00244)	0.00836*** (0.00280)	0.00837*** (0.00276)	0.00837*** (0.00276)	0.00837*** (0.00276)	0.00669*** (0.00244)	0.00836*** (0.00280)	0.00837*** (0.00276)	0.00837*** (0.00276)	0.00837*** (0.00276)	0.00837*** (0.00276)	0.00880*** (0.00253)	0.00880*** (0.00253)	0.00890*** (0.00254)	0.00890*** (0.00254)
Human capital index	0.0333*** (0.0116)	-0.0144 (0.0382)	0.0490 (0.143)	-0.469* (0.239)	-0.103 (0.162)	0.0253 (0.161)	0.0135 (0.219)	0.0135 (0.219)	0.0135 (0.219)	-0.103 (0.162)	0.0253 (0.161)	0.0135 (0.219)	0.0135 (0.219)	0.0135 (0.219)	0.0135 (0.219)	0.238 (0.194)	0.238 (0.194)	0.0446 (0.133)	0.0446 (0.133)
Openness index	0.000154 (0.000101)	0.000497*** (0.000177)	0.000482** (0.000220)	0.000511** (0.000247)	0.000756* (0.000422)	0.000482 (0.000294)	0.00131 (0.00105)	0.00131 (0.00105)	0.00131 (0.00105)	0.000756* (0.000422)	0.000482 (0.000294)	0.00131 (0.00105)	0.00131 (0.00105)	0.00131 (0.00105)	0.00131 (0.00105)	0.000998 (0.00119)	0.000998 (0.00119)	0.000483* (0.000249)	0.000483* (0.000249)
Government spending	-0.00318*** (0.000752)	-0.00509*** (0.00120)	-0.00396 (0.00309)	-0.00488 (0.00351)	-0.00598* (0.00346)	-0.00626* (0.00334)	-0.00548 (0.00333)	-0.00548 (0.00333)	-0.00548 (0.00333)	-0.00598* (0.00346)	-0.00626* (0.00334)	-0.00548 (0.00333)	-0.00548 (0.00333)	-0.00548 (0.00333)	-0.00548 (0.00333)	-0.00758 (0.00793)	-0.00758 (0.00793)	-0.00625*** (0.00258)	-0.00625*** (0.00258)
Institution index	0.0334*** (0.00783)	-0.0262 (0.0161)	-0.0514** (0.0247)	-0.0513* (0.0312)	0.0680 (0.0481)	0.0586 (0.0496)	0.00296 (0.0404)	0.00296 (0.0404)	0.00296 (0.0404)	0.0680 (0.0481)	0.0586 (0.0496)	0.00296 (0.0404)	0.00296 (0.0404)	0.00296 (0.0404)	0.00296 (0.0404)	-0.0388 (0.0461)	-0.0388 (0.0461)	-0.00805 (0.0370)	-0.00805 (0.0370)
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	755	755	635	635	463	370	508	508	463	463	370	508	508	508	508	320	320	401	401
Number of Countries	120	120	120	120	91	78	97	97	91	91	78	97	97	97	97	70	70	106	106
Arellano-Bond test for AR(3) (p-value)	-	-	0.833	0.577	0.573	0.393	0.688	0.688	0.573	0.573	0.393	0.688	0.688	0.688	0.688	0.167	0.167	0.229	0.229
Hansen OID test (p-value)	-	-	0.186	0.102	0.227	0.369	0.259	0.259	0.227	0.227	0.369	0.259	0.259	0.259	0.259	0.344	0.344	0.193	0.193
R-squared	0.995	0.892	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: The dependent variable is the GDP per capita level (Ln). The real effective exchange rate is sourced from Bruegel and IMF. Columns (1) and (2) are respectively regressed by OLS and FE, while other columns are estimated by the first differenced GMM estimator. For estimation, the GDP per capita level (Ln) and control variables, except Population growth and Institution index, are instrumented by second lag level, the resource-dependence index (lagged) is instrumented by second and prior lags and the real effective exchange rate (lagged) is instrumented by first and prior lags in first differences equation. Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels. The null hypothesis of Arellano-Bond test is that autocorrelation doesn't exist. I report AR(3) instead of AR(2) since the null hypothesis is rejected in AR(2). The null hypothesis of Hansen test is that the instruments, as a group, are uncorrelated with the error term.

of interest. One interesting finding is that the negative effect of the resource rent on economic growth is stronger for the sample of the poor-institution countries than for the full sample. In line with Mehlum et al. (2006), it seems to confirm that improvement in the institutional quality can moderate the adverse effect of a resource boom.

I also estimate the baseline regression model for a sample of *IMF* database to check the dependency of the results on the measurement approach for the real exchange rate. The estimated results report in column (8). Significant negative coefficients on the resource-dependence index and the real exchange rate derive the same interpretation as before and demonstrate the independence of the results from the real exchange rate databases. Further, in the last column of Table 10, the sample is restricted to periods before 2004 in order to check the consistency of the findings, regarding the great recession effects. The estimated results suggest that the recession may affect the response of the economic growth to both variables of interest quantitatively, not qualitatively.³²

The same as procedure proposed in preceding sub-sections, I check the sensitivity of coefficients on the resource-dependence index and the real exchange rate. The sensitivity analysis reported in Table 11 shows that negative relationship between the explanatory variables of interest and the economic growth is qualitatively confirmed in different sample size, however the significance of the results decreases as the sample size shrinks.

I also conduct a recursive estimation to evaluate the accuracy of the results in terms of *GDP*

Table 11: Robustness test for the sensitivity of coefficient of interest

Explanatory variable		98%	95%	80%	65%
Resource-dependence (lagged)	Coefficient	-0.00631	-0.00548	-0.00359	-0.00261
	Standard Deviation	0.00130	0.00189	0.00265	0.00353
Real effective exchange rate (lagged)	Coefficient	-0.00270	-0.00567	-0.01319	-0.01483
	Standard Deviation	0.00856	0.01351	0.02085	0.02773

per capita level and resource-dependence level. Figure 6 illustrates the stability of a negative correlation between the real exchange rate and the economic growth in terms of *GDP* per capita level. While it is slightly decreasing along increasing the resource-dependence level. The latter point suggesting that the adverse effect of the real exchange rate on economic growth is more intensive in a sample of included resource-rich countries than a sample of excluded

³² Investigation on the impact of the commodity price index on economic growth does not lead to finding a significant and strong correlation neither for the full sample nor for the restricted sample of resource-poor countries. One may be because of using a sample covering a shorter period and also a small number of countries, with respect to the base sample related to the resource-dependence index. The second reason may back to the method that is used to construct the commodity price index. Although the main advantage of the measurement of the index using shares of commodities in a given year is to avoid possible endogeneity problems arising in the event of a volume response to price changes, it seems to be far from an ideal procedure. Since the index using a constant base year does not capture the effects of resource discoveries and other quantity shocks that happen after the base year.

them may clarify the more deceleration of the economic growth in resource-rich countries than resource-poor countries.

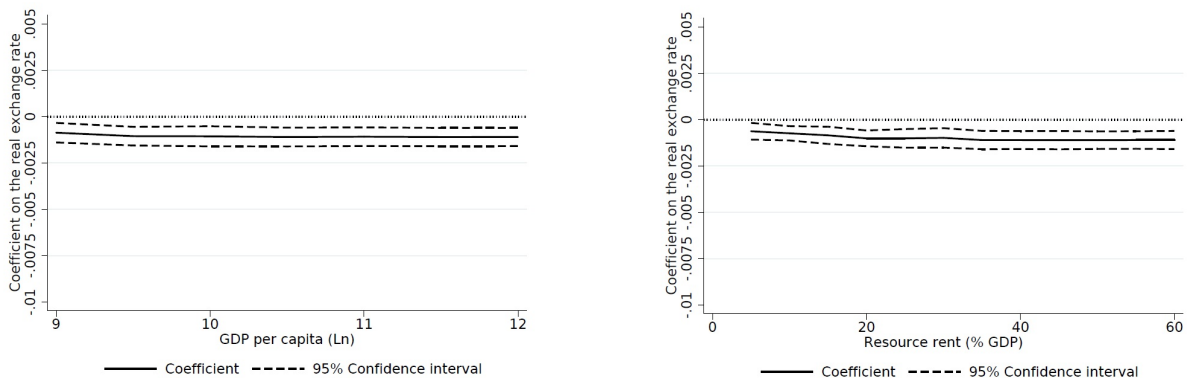


Figure 6: Recursive estimation on the real exchange rate.

5 Conclusion

In this paper, I take another look at the Dutch disease hypothesis from theoretical and also empirical perspective. Literature reveals, on the one hand, there are several limitations in the earlier theories presented to describe the Dutch disease hypothesis. Contrary to the empirical evidence, models, driven by Learning By Doing (*LBD*), predict that a resource boom tends to depreciate the steady-state real exchange rate and has no effect on the rate of economic growth in the long-term. On the other hand, less attention has been paid to systematically analyze the symptoms of Dutch disease. Hence, the first contribution, in the context of theory, is to revise the influential model so that its predictions meet the empirical evidence. In addition, the second contribution, in the context of empirical study, is to find a direct nexus between booming resource rent and the real exchange rate and then to provide a clear assessment of the response of the relative output level, sectoral growth, and economic growth to the real exchange rate appreciation.

To address the objectives, I first develop a two-sector model in which both the manufacturing and service sectors contribute to generate productivity and there are an imperfect spillover from the manufacturing to the service sector as well as a technology spillover from the resource sector to the manufacturing sector. Contrary to Torvik (2001); Bjørnland and Thorsrud (2016), the model shows that the steady-state real exchange rate appreciates conditionally and the rate of growth in the economy and in both sectors decelerates.

I then collect an unbalanced panel data set of 132 countries over a sample of five-year periods from 1970 to 2014 and estimate a dynamic regression model using the *GMM* model to investigate the empirical relevance of the theory. The empirical results, taken together, do not contradict the presented model of the Dutch disease hypothesis. The main findings can be summarized in three points. First, the empirical strategy suggests a strong and statically significant positive

effect on the real exchange rate from a natural resource boom. Second, the real exchange rate appreciation decelerates the rate of growth in both sectors such that the shrinkage is larger in the manufacturing sector than in the service sector. Accordingly, the relative output level of the manufacturing sector to the service sector diminishes and economic growth decelerates. Third, these effects are more intensive in resource-rich countries than resource-poor countries.

Appendix A Steady state response of a resource boom

Combining Equation 6, we get $\phi^* \left(\frac{L_S^*}{1-L_S^*} \right)^{1-\alpha} = \phi^{*\frac{1}{\sigma}} \left(\frac{(1-L_S^*)^\alpha + R}{L_S^{*\alpha}} \right)^{\frac{1}{\sigma}}$. Therefore we have,

$$\phi^*(R) = \left[\frac{(L_S^*)^{1-\alpha} \frac{(L_S^*)^{\frac{\alpha}{\sigma}}}{\sigma}}{(L_M^*)^{1-\alpha} \left((L_M^*)^\alpha + R \right)^{\frac{1}{\sigma}}} \right]^{\frac{\sigma}{1-\sigma}}$$

Replacing ϕ^* in one of Equations 6 gives us the steady-state value of the real exchange rate. Further, the derivative of the steady-state relative productivity ratio with respect to R is,

$$\frac{d\phi^*}{dR} = \frac{\sigma}{1-\sigma} \frac{\phi^*}{P^*} \left[\left(\frac{dP^*}{dL_S^*} \right)_{LL} - \left(\frac{dP^*}{dL_S^*} \right)_{NN} \right] \frac{dL_S^*}{dR} - \frac{\phi^*}{(1-\sigma) \left[(L_M^*)^\alpha + R \right]}.$$

Where $\left[\left(\frac{dP^*}{dL_S^*} \right)_{LL} - \left(\frac{dP^*}{dL_S^*} \right)_{NN} \right]$ denote the gap in slopes of LL and NN curves at steady-state. It represents that a resource boom reduces the relative productivity ratio, $\frac{d\phi^*}{dR} < 0$, if the following condition is satisfied.

$$\frac{dL_S^*}{dR} < \frac{\frac{P^*}{\sigma \left[(L_M^*)^\alpha + R \right]}}{\left[\left(\frac{dP^*}{dL_S^*} \right)_{LL} - \left(\frac{dP^*}{dL_S^*} \right)_{NN} \right]} = \frac{L_M^* L_S^*}{\sigma \left[(L_M^*)^\alpha + 1 - \alpha L_S^* \right]}.$$

More simplification: as regards, $(L_M^*)^\alpha < 1$ and $\alpha L_S^* > 0 \Rightarrow \frac{L_M^* L_S^*}{2\sigma} < \frac{L_M^* L_S^*}{\sigma \left[(L_M^*)^\alpha + 1 - \alpha L_S^* \right]}$. We

also know that $\frac{dL_S^*}{dR} = \frac{\delta_R'(R)}{(1-\gamma)\delta_M + \delta_S}$. Therefore, $\frac{d\phi^*}{dR} < 0$ if

$$\delta_R'(R) = \frac{\delta_S - \delta_R}{2\sigma} \frac{(1-\gamma)\delta_M + \delta_R}{(1-\gamma)\delta_M + \delta_S} \Rightarrow \frac{dL_S^*}{dR} = \frac{(\delta_S - \delta_R)((1-\gamma)\delta_M + \delta_R)}{2\sigma}.$$

The derivative of Equation 6a with respect to R at steady-state is equal to:

$$\frac{dP^*}{dR} = \frac{P^*}{\phi^*} \frac{d\phi^*}{dR} + (1-\alpha) \frac{P^*}{L_M^* L_S^*}.$$

It demonstrates that decreasing in the relative productivity ratio is accompanied by raising the real exchange rate if $0 > \frac{d\phi^*}{dR} > -\frac{(1-\alpha)\phi^*}{L_M^* L_S^*}$. While both the relative productivity ratio and the real exchange rate decrease if $\frac{d\phi^*}{dR} < -\frac{(1-\alpha)\phi^*}{L_M^* L_S^*}$.

Appendix B Commodity Price index: Data Description, Sources and Methodology

The empirical study to analyze the impact of the commodity price index on variables of interest is based on a panel dataset consisting of 73 countries over the period 1990-2014 (given data availability). To construct the composite commodity export price index, I first collect data on

world prices of 16 non-agriculture commodities³³ as well as commodity export and import values. Data for commodity price indices are extracted from the *IMF – IFS* International Financial Statistics database. While, commodity export and import data for each country over the available period are collected from the *UNCTSD* (United Nations Commodity Trade Statistics Database) database³⁴. I then construct country-commodity specific weight in 1990 by dividing the individual 1990 net export values for each commodity to the total net export value of all commodities in 1990³⁵. The weights are held fixed over periods to ignore possible endogeneity problems arising in supply responses to world prices and so to construct an exogenous index. The geometrically-weighted index of commodity export prices for country i in year t (PC_{it}) is structured as follows:

$$PC_{it} = \prod_{j=1}^J PC_{jt}^{w_{j90}},$$

where PC_{jt} represents the international market prices for commodity j in year t and w_{j90} is country-commodity specific weight in 1990. Finally, to allow the effect of commodity export prices to be larger for countries with higher commodity exports, the log of the geometrically weighted index is weighted by the 1990 share of net commodity exports in a country's GDP (see. Collier and Goderis (2008)).

Appendix C The net foreign assets and resource-dependence

In this appendix, I put forward the long-run relation between the natural resource rent and the net foreign assets. The sample consists of 114 countries for the period 1970-2014. The dependent variable is the net foreign assets and the explanatory variable of interest is the resource-dependence index. I also include a number of control variables, namely the level of GDP per capita, Foreign Direct Investment, Terms of trade, Openness index, and Institution index.

Table 12 reports the results. Column (1) represents the results estimated by *OLS* as a benchmark, while the column (2) reports the results of the baseline regression model estimated by *Sys.GMM*. These demonstrate that increasing the resource-dependence index is significantly associated with larger net foreign assets. The result confirms that the impact of the resource rent on the economic performance transmits more likely through the international transfer payment. Further, the control variables, except Openness index, are insignificant while qualitatively acceptable. As

³³ The non-agricultural commodities are aluminium, cobalt, lead, Oil crude, tin, coal, natural gas, phosphates, platinum, zinc, copper, iron ore, nickel, silver, uranium, wood. Points: 1) a normalized average prices (US dollar) of hard and soft swan-woods is given as the price of wood (2010=100), 2) a normalized average prices (US dollar) of coal for Australia and South Africa bases is given as the price of coal (2010=100), 3) a normalized average prices (US dollar) of natural gas for USA and Europe bases is given as the price of gas (2010=100), and *APSP* crude oil price that is weighted average of three crude oil spot prices (west Texas intermediate, dated Brent and Dubai Fateh) is considered as oil crude price.

³⁴ It reports dollar values of exports and imports according to the *SITC1* system.

³⁵ For countries with missing 1990 data for commodity export and import values, the analysis employs values available in the year closest to 1990.

a robustness check I run the panel regressions for country subgroups. Columns (3)-(5) show the results for sample of developing, resource-poor and resource-rich countries, respectively. The coefficient on the resource-dependence enters with a positive sign for all samples while it remains significant only for sample of developing and resource-rich countries. The larger magnitude of the coefficient of interest for the sample of resource-rich countries than for the full sample plausibly explains why most of the natural resource-rich countries are creditors.

Table 12: Estimation results for the net foreign assets

Explanatory variable	(1)	(2)	(3)	(4)	(5)
	Full Sample OLS	Full Sample Sys. GMM	Developing Sys. GMM	Resource-Poor Sys. GMM	Resource-Rich Sys. GMM
Net foreign assets (lagged)	0.736*** (0.0211)	0.699*** (0.117)	0.653*** (0.129)	0.642*** (0.198)	0.807*** (0.0837)
Resource-dependence (lagged)	0.177*** (0.0447)	0.356*** (0.112)	0.359*** (0.113)	0.997 (1.473)	0.549*** (0.196)
GDP per capita (Ln)	-0.0567 (0.388)	-0.536 (1.148)	0.557 (1.321)	-1.057 (2.826)	-2.488* (1.331)
Foreign Direct Investment	0.0396 (0.125)	-0.579 (0.371)	-0.416 (0.261)	-0.595 (0.715)	-0.185 (0.369)
Terms of trade (Ln)	-0.156 (1.082)	1.017 (2.336)	1.159 (2.299)	14.69 (16.15)	0.953 (4.702)
Openness index	0.0532*** (0.0129)	0.148*** (0.0460)	0.112*** (0.0426)	0.169** (0.0765)	0.0703 (0.0602)
Institution index	0.189 (0.675)	1.375 (1.879)	2.938 (2.384)	2.363 (4.145)	5.034 (3.488)
Time dummies	YES	YES	YES	YES	YES
Observations	763	763	682	375	313
Number of Countries	66	114	103	72	66
Arellano-Bond test for AR(2) (p-value)	-	0.136	0.199	0.178	0.585
Hansen OID test (p-value)	-	0.231	0.371	0.596	0.341
R-squared	0.727	-	-	-	-

Note: The dependent variable is the Net foreign assets. The resource-dependence (lagged) is instrumented by first lag level in the first differences equation. Also, control variables are instrumented by second lag level in the first differences equation for full and developing countries' samples, while they are instrumented by second lag level to satisfy the rule of thumb for Resource-poor and rich countries' samples.

Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels.

The null hypothesis of *Arellano-Bond* test is that autocorrelation doesn't exist and the null hypothesis of *Hansen* test is that the instruments, as a group, is uncorrelated with the error term.

Appendix D Countries included in the sample database

Table 13: List of Countries

	Period	No. Period		Period	No. Period		Period	No. Period
Albania	1985-2014	6	Gambia, The	1970-2014	9	Romania	1990-2014	5
Algeria*	1970-2014	9	Germany*	1970-2014	9	Russia*	1990-2014	5
Angola*	1980-2014	7	Ghana*	1970-2014	9	Rwanda	1970-2014	9
Argentina*	1970-2014	9	Greece*	1970-2014	9	Saudi Arabia*	1970-2014	9
Armenia	1990-2014	5	Guatemala*	1970-2014	9	Senegal*	1970-2014	9
Australia*	1970-2014	9	Haiti	1970-2014	9	Sierra Leone	1970-2014	9
Austria	1970-2014	9	Honduras*	1970-2014	9	Slovakia*	1990-2014	5
Azerbaijan	1995-2014	4	Hungary*	1990-2014	5	Slovenia*	1995-2014	4
Bahrain*	1980-2014	7	India*	1970-2014	9	South Africa	1970-2014	9
Bangladesh	1970-2014	9	Indonesia*	1970-2014	9	Spain*	1970-2014	9
Barbados	1970-2014	9	Iran*	1970-2014	9	Sri Lanka	1970-2014	9
Belarus*	1990-2014	5	Ireland	1970-2014	9	Sudan	1970-2014	9
Belgium	1970-2014	9	Italy	1970-2014	9	Suriname*	1970-2014	9
Belize	1975-2014	8	Jamaica	1970-2014	9	Swaziland	1970-2014	9
Benin*	1970-2014	9	Japan*	1970-2014	9	Switzerland*	1980-2014	7
Bhutan	1980-2014	7	Jordan*	1975-2014	8	Sweden*	1970-2014	9
Bolivia*	1970-2014	9	Kazakhstan*	1990-2014	5	Tajikistan	1995-2014	4
Botswana	1970-2014	9	Kenya	1970-2014	9	Tanzania	1990-2014	5
Brazil*	1970-2014	9	Korea south	1970-2014	9	Thailand	1970-2014	9
Brunei*	1985-2014	6	Kuwait*	1990-2014	5	Togo*	1970-2014	9
Bulgaria*	1980-2014	7	Kyrgyzstan*	1990-2014	5	Trinidad and Tobago*	1970-2014	9
Burkina Faso	1970-2014	9	Lao PDR	1980-2014	7	Turkey	1970-2014	9
Burundi	1970-2014	9	Latvia*	1995-2014	4	Tunisia*	1970-2014	9
Cambodia	1990-2014	5	Lithuania	1995-2014	4	Ukraine*	1990-2014	5
Cameron*	1970-2014	9	Luxembourg	1970-2014	9	Uganda	1980-2014	7
Canada*	1970-2014	9	Madagascar	1970-2014	9	United Kingdom*	1970-2014	9
Central Africa*	1980-2014	7	Malawi	1970-2014	9	United States*	1970-2014	9
Chad	1970-2014	9	Malaysia*	1970-2014	9	Uruguay	1970-2014	9
Chile*	1970-2014	9	Mali	1970-2014	9	Venezuela*	1970-2014	9
China*	1970-2014	9	Mauritania*	1970-2014	9	Vietnam	1985-2014	6
Colombia*	1970-2014	9	Mexico*	1970-2014	9	Yemen*	1990-2014	5
Congo, Dem.	1970-2014	9	Moldova	1995-2014	4	Zambia*	1970-2014	9
Congo, Rep.*	1970-2014	9	Mongolia	1990-2014	5			
Costa Rica	1970-2014	9	Morocco*	1970-2014	9			
Cote d'Ivoire	1970-2014	9	Mozambique	1980-2014	7			
Croatia	1995-2014	4	Namibia	1980-2014	7			
Cyprus	1975-2014	8	Nepal	1970-2014	9			
Czech*	1990-2014	5	Netherlands*	1970-2014	9			
Denmark*	1970-2014	9	New Zealand*	1970-2014	9			
Dominican Rep.	1970-2014	9	Nicaragua*	1970-2014	9			
Ecuador*	1970-2014	9	Niger*	1970-2014	9			
Egypt*	1970-2014	9	Nigeria*	1980-2014	7			
El Salvador	1970-2014	9	Norway*	1970-2014	9			
Eritrea	1990-2014	5	Pakistan	1970-2014	9			
Estonia*	1995-2014	4	Panama	1970-2014	9			
Ethiopia	1980-2014	7	Paraguay	1970-2014	9			
Fiji*	1970-2014	9	Peru*	1970-2014	9			
Finland*	1970-2014	9	Philippine*	1970-2014	9			
France*	1970-2014	9	Poland*	1990-2014	5			
Gabon*	1970-2014	9	Portugal	1970-2014	9			

Note: countries marked by (*) are included in the sample of the commodity price index.

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