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The Dutch Disease in Reverse: Iceland's Natural Experiment

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Abstract

Abundant natural resources brought Iceland a systemically overvalued currency, with adverse effects on the secondary tradable sector. During 2003-2008 another national treasure, the sovereign's AAA rating, was used to attract foreign capital, elevating the real exchange rate even further. The financial collapse in 2008 left the country with a large foreign debt without the possibility of rollovers in international capital markets. This offset some of the effect of the natural resources on the real exchange rate; in effect, this was the Dutch disease in reverse as witnessed, in particular, by a massive increase in the number of tourists in recent years.

Keywords: Natural resource curse, Dutch disease, financial crisis.

JEL classification: F41, O23, O33

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Rarely does the opportunity arise for economists to revisit their theories using data from natural experiments. The recent history of our native country, Iceland, offers us such an opportunity. Over the years, with others, we contributed to a literature on the various aspects of the potentially adverse effects of natural resource abundance on employment and investment in the tradables sector and on economic growth.[1] Our 1999 model showed how a large and volatile primary sector would adversely affect the production of tradable goods by increasing real wages and the real exchange rate, lowering the relative price of tradable goods and hampering investment. These results have been broadly confirmed in several other studies[2] while questioned by others.[3]

The literature on the macroeconomic consequences of natural resources highlights several channels through which economic growth can be retarded. These include rent seeking,[4] the Dutch disease,[5] poor governance,[6] political or ethnic conflict,[7] corruption,[8] autocracy,[9] excessive borrowing[10] and low levels of education.[11] Ross (2011), van der Ploeg (2011) and Frankel (2014) survey the literature. If learning-by-doing occurs mostly in the secondary export sector and not in the primary sector, we also showed that natural resource booms are likely to hamper growth by discouraging employment and investment. Our earlier empirical work based on a panel of countries showed natural resource abundance, *ceteris paribus*, to be inversely correlated with growth.[12] Insofar as the trouble with abundant natural resources has to do with the real appreciation of the currency, the depreciation resulting from a financial crash can be viewed as a case of the Dutch disease in reverse.

Recent events offer us an opportunity to reassess the validity of our thesis. It has for some time been well understood that foreign aid shares an important property with natural resource

[1] See Gylfason, Herbertsson and Zoega (1999), Herbertsson, Skuladottir and Zoega (2000), Gylfason (2001), and Gylfason and Zoega (2003, 2006). The recent literature on this topic was launched by Sachs and Warner (1995).
[2] See, e.g., Sachs and Warner (2001), Collier and Goderis (2012), and Sala-i-Martin and Subramanian (2013).
[3] See Brunnschweiler and Bulte (2008), Lederman and Maloney (2008), and Alexeev and Conrad (2009).
[4] See Paldam (1997), Tornell and Lane (1999), Auty (2001), Mehlum, Moene and Torvik (2006), and Robinson, Torvik and Verdier (2006).
[5] See Corden (1984), Corden and Neary (1982), and Van Wijnbergen (1984).
[6] See Baland and Francois (2000), Tornell and Lane (1999), and Torvik (2002).
[7] See Easterly and Levine (1997) and Hodler (2006).
[8] See Arezki and Brückner (2011) and Arezki and Gylfason (2013).
[9] See Ross (2001), Collier and Hoeffler (2009), Tsui (2011) and Arezki and Gylfason (2013).
[10] See Mansurian (1991) and Manzano and Rigobon (2007).
[11] See Gylfason (2001).
[12] See Gylfason, Herbertsson and Zoega (1999).

discoveries in that aid constitutes an unrequited transfer emerging like manna from heaven.[13] In the past, aid-receiving countries such as Zambia have seen their currencies appreciate as a result of aid inflows. Further, like resource windfalls, aid inflows have about them an aura of 'other people's money' which, like lottery winnings, as well as due to their transitory and often volatile nature, may seem easier to fritter away than one's own hard-earned incomes. Like natural resource abundance that sometimes tends to attract the wrong sort of people to politics, foreign aid creates an encouragement to divert the aid inflow from its intended beneficiaries. This helps explain why natural resource abundance does less harm to growth in democracies with good policies than elsewhere (Burnside and Dollar, 2000).[14]

In this paper, we want to point out that during exuberant credit booms inflows of foreign credit can exert a similar manna-from-heaven effect on its recipients as resource windfalls and foreign aid, not least if the borrowing nation behaves as if there is no tomorrow and bankers revel in their role as rentiers.[15] In some cases, resource windfalls, foreign aid and rapid capital inflows tend to invite plunder with royal families, clerics, generals, politicians and bankers sitting in the driver's seat. Admati and Hellwig (2013, Ch. 9) describe the considerable hidden subsidies that banks deemed too big to fail (BTBFs) extract from taxpayers through implicit or explicit government guarantees. Beside explicit bailouts, these implicit bank subsidies attract generous financial contributions from bankers to politicians, encourage excessive risk taking and raise the prospect of repeated crises. Bastiat (1850) would not have been surprised: "Sometimes the law defends plunder and participates in it. Sometimes the law places the whole apparatus of judges, police, prisons and gendarmes at the service of the plunderers, and treats the victim – when he defends himself – as a criminal… This legal plunder may be only an isolated stain among the legislative measures of the people. If so, it is best to wipe it out with a minimum of speeches and denunciations – and in spite of the uproar of the vested interests."

With its gross foreign debt rising from 100 percent of GDP in 2002 to nearly 700 percent in mid-2008, Icelandic banks, aided and abetted by the government, used the sovereign's AAA rating to attract huge private capital inflows during 2003-2008 followed by a sudden

[13] See Younger (1992), Burnside and Dollar (2000), Svensson (2000) and Djankov, Montalvo, and Reynal-Querol (2008) and also Deaton (2013, Ch. 7).
[14] Gylfason and Zoega (2003) and Goderis and Malon (2011) consider the relationship between natural resources and inequality.
[15] Benigno and Fornaro (2014) use the term 'financial resource curse' to describe episodes of abundant access to foreign capital coupled with weak productivity growth.

stop and a subsequent capital outflow.[16] The inflows were accompanied and, indeed, spurred by a persistent, policy-induced appreciation of the currency intended to keep a lid on domestic inflation through a high-interest-rate policy intended also to attract foreign funds. Before and after the crash, the burden of the large foreign debt lowered the exchange rate by a half in nominal terms and a third in real terms and hence offset some of the adverse effects of the primary sector on employment, investment and output in the tradable sector. While in our earlier papers we showed how abundant natural resources (or, specifically, a heavy reliance on natural resources) had the effect of slowing down investment and growth (Gylfason and Zoega, 2006), recent events offer an opportunity to analyze the effects of a capital outflow that offset the effects of the primary sector on the real exchange rate and on tradable output and growth. It is as if foreign creditors were awarded ownership of a part of the country's natural resources leaving a smaller part of the foreign exchange earnings for the local economy.

To underline the parallel between the inflow of natural resource rents into the Icelandic economy since the advent of the individual transferable (ITQ) quota system of fisheries management in 1991 and the inflow of foreign capital during the boom years before the crash of 2008 we submit that both types of inflow were made possible by the generosity of the government to its cronies. The inflow of the resource rent was facilitated by the government's granting vessel owners free of charge valuable common-property catch quotas the macroeconomically significant rents from which were used to invest in the fisheries, diversify into unrelated business such as banks and newspapers or pledge as collateral for bank loans. The inflow of foreign capital was facilitated by the privatization of state-owned banks and other financial institutions during 1998-2003 which then went on an unprecedented borrowing spree abroad accumulating assets and liabilities equivalent ultimately to eight times annual GDP and the government went along aiming to create an international banking center.[17] In the typical corporatist fashion, collusion between business, banking and politics was the order of the day. The difference between the two processes, however, is that while the capital inflows were bound to be reversed, as always (Reinhart and Rogoff, 2011), there is no automatic reversal to be expected from the inflow of natural resource rents unless the quasi-privatization of the fisheries in this case leads to overfishing by vessel owners. In the natural resource

[16] See Gylfason *et al*. (2010), Benediktsdottir, Danielsson and Zoega (2011), Gylfason (2014) and Johnsen (2014).

[17] In the same spirit, a private company, DeCode Genetics, was in the late 1990s granted free access to public medical records to build a genetic data base to be traded on Nasdaq, but the plan generated public controversy and was not implemented. The ITQ system also generated controversy but was implemented all the same.

story, the parallel to the reversal of capital inflows is the migration of fish stocks outside the local jurisdiction for whatever reason as occurred, for example, when herring catches in Icelandic waters collapsed in the late 1960s, triggering a 50 percent devaluation of the króna from 1967 to 1969, a harbinger of the currency collapse resulting from the reversal of capital flows in 2008.

In the next section we briefly review the recent economic history of Iceland and then go back to our earlier model of the Dutch disease to set the stage for our description of the effects of the collapse of the real exchange rate surrounding the financial crash of 2008 on the non-primary sector, especially tourism.

1. Brief economic history

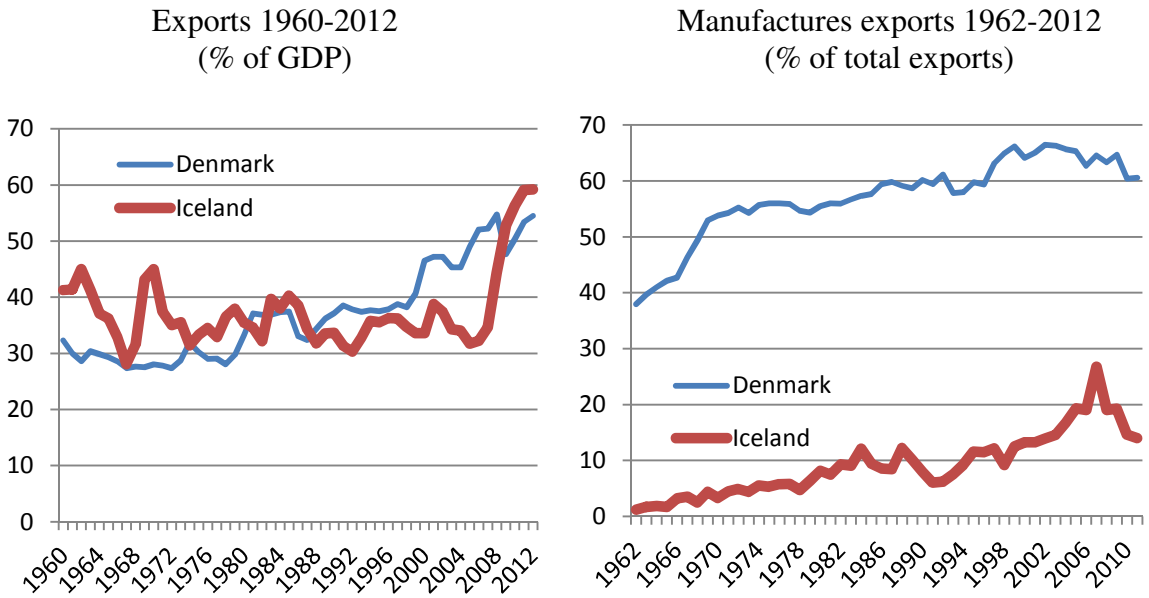
Iceland is unique among OECD countries in that the ratio of Iceland's exports of goods and services to GDP was stuck at about a third from 1870 (this is not a misprint) until 2008 when its economy collapsed with its three main banks whose sudden bankruptcy was, in dollar terms, among the largest corporate bankruptcies on record anywhere, a remarkable feat for a country with a population of 320,000. Why did Iceland's exports remain stagnant for so long at such a low level relative to GDP? All other OECD countries saw their exports grow more rapidly than GDP, especially after 1960 when liberalization of trade in goods and services gained momentum. For example, Denmark's export ratio rose from 32 percent in 1960 to 52 percent in 2007 while Iceland's export ratio remained stuck at about a third (Figure 1a).

Iceland was until 2008 a high-real-exchange-rate country, its overvalued currency holding back exports and thereby also imports except insofar as imports were financed by foreign borrowing. The systemically high real exchange rate, a condition we associate with the Dutch disease, can be traced to several causes, including high inflation[18] and an abundance of natural resources, mainly fertile fishing grounds. This link was reinforced by explicit or implicit subsidies for the fisheries, first directly from the government budget as well as through privileged access to state bank credits and then, since the mid-1980s, indirectly through gratis allocation of highly valuable and macroeconomically consequential common-property fishing rights to select vessel owners. The trendlessness of the export ratio for decades on end until 2008 seems to suggest that the change from explicit to implicit subsidization of the fisheries did not change the scope of the overvaluation of the króna. These export subsidies increased

[18] Since 1960, Iceland has had the OECD region's second highest average rate of inflation, second only to Turkey. High inflation has often been seen to go along with high real exchange rates because the government hesitates to devalue the currency to keep the currency competitive, preferring foreign borrowing to make ends meet. This has been a common scenario in Africa and Latin America, for example.

the supply of foreign exchange, lowering its price and increasing the real exchange rate. Other factors reinforced the effect of the primary sector on the real exchange rate. The overvaluation of the currency followed, in part, from the inward-looking economic policy regime, including the protection of agriculture against imported farm products, an arrangement that reduced the demand for foreign exchange, lowering its price and thereby exerting upward pressure on the real exchange rate. Further, the high real exchange rate skewed the composition of exports by hampering the development of, for example, high-tech exports industries like those that emerged in Scotland, Ireland and Norway next door. To a significant extent, Iceland's exports were, and remain, resource-based (fish and aluminum) and thus mostly low-tech, a common symptom of the Dutch disease (Figure 1b).[19]

Figure 1. Exports of goods and services and manufactures



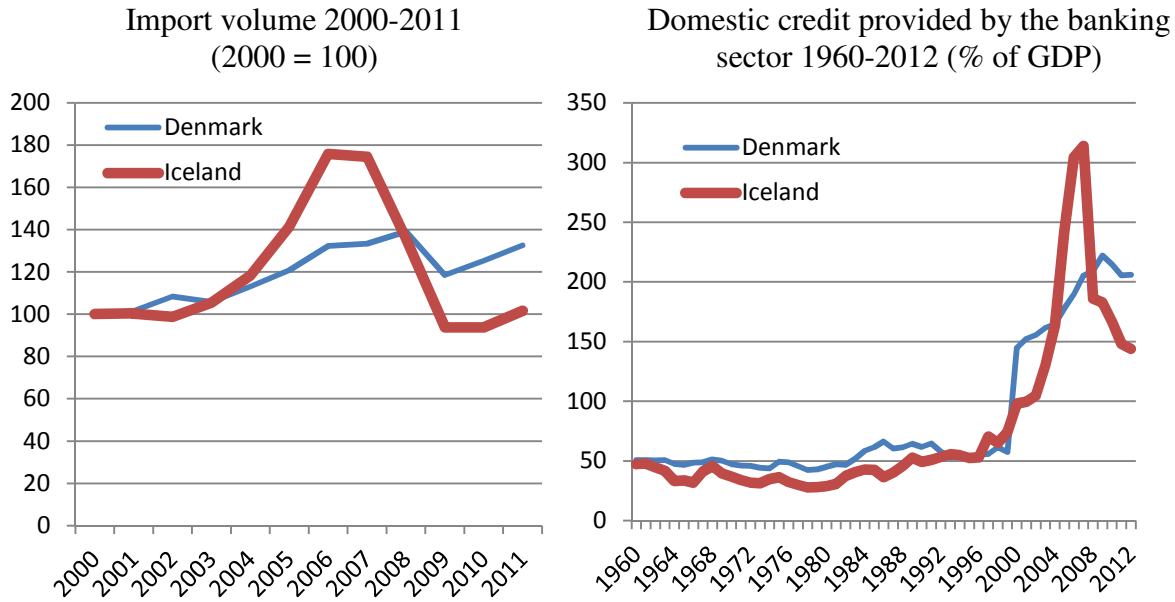
Source: World Bank, *World Development Indicators*.

This pattern was reinforced by economic policies that remain inward-looking because strong local interests empowered by an electoral law that continues to grant rural interests disproportional representation in the political arena resist foreign as well as domestic competition, and have succeeded in keeping Iceland out of the European Union even if they failed to keep Iceland outside the European Economic Area that Iceland joined in 1994. The inward-looking policy regime manifests itself in many different ways: for example, through a lack of competition in banking and trade as well as one of Europe's most protective farm

[19] In 2012, fish products accounted for 27 percent of total export earnings in Iceland, aluminum for 22 percent and foreign tourism, 24 percent (source: Statistics Iceland).

policy regimes, including the afore-mentioned age-old tradition of support for the fishing industry. A long-lasting political disequilibrium biased toward an inward-looking policy stance has been sustained by the political class's ability to thwart electoral and other reforms known to be supported by the majority of the electorate. In a national referendum in 2012 on a new post-crash constitution for Iceland, 67 percent of the voters declared their support for a constitutional provision guaranteeing 'one person, one vote,' a provision that would at last put an end to excessive representation by rural areas in the political arena, but parliament has put the constitutional bill on ice despite its having received support from 67 percent of the voters in the referendum.

Figure 2. Imports and domestic credit



Source: World Bank, *World Development Indicators*.

Recent events offer us the opportunity to assess the effects of the collapse of the real exchange rate. Surrounding the financial crash of 2008 the Icelandic króna lost a half of its value in nominal terms and a third in real terms, making exports jump from a third of GDP to 60 percent of GDP (Figure 1a), and causing imports to plunge (Figure 2a) in keeping with the elasticity approach to the balance of payments. The fact that GDP fell by 10 percent after the crash shows that the hike in the export ratio stems mostly from a sharp increase in export earnings. Likewise, the fact that import volume contracted by 44 percent suggests a strong effect of the currency depreciation on imports on top of a much smaller income effect. Even so, the behavior of the real exchange rate of the króna before and after the crash accords well with the asset market approach to exchange rates (Branson, 1977) which predicts that

increased foreign borrowing to finance imports of goods and services causes the currency, on impact, to appreciate in real terms.

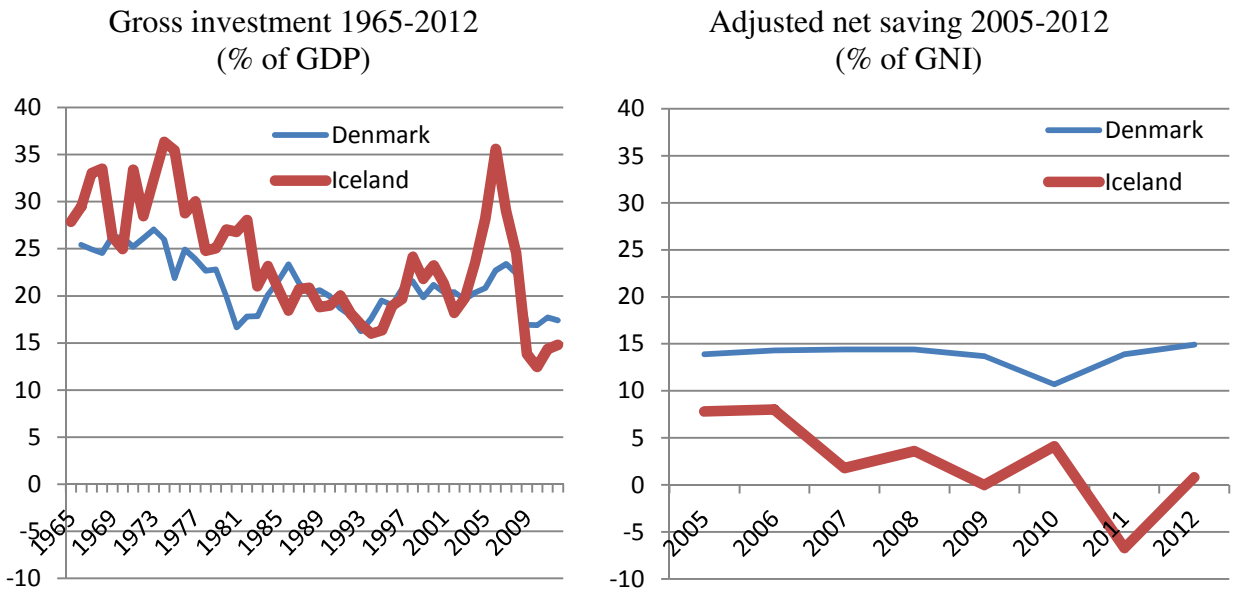
The financial crash was preceded by a capital inflow from 2003 to 2008 that propelled the real exchange rate to new heights and fuelled the stock market and the housing market as well as a boom in consumption and investment through a current account deficit averaging 14 percent of GDP. Real equity prices increased by 35 percent per year during this period, a record surpassed only by Cyprus, and real estate prices rose by 12 percent per year.[20] The current account deficit rose from five percent of GDP in 2003 to 16 percent in 2007. The growth of per capita GDP went from 1.8 percent in 2003 to 6.6 percent in 2004, 6.0 percent in 2005, 1.8 percent in 2006[21] and 3.6 percent in 2007 before turning negative three years in a row, 2008-2010. Unemployment dropped to 2.3 percent of the labor force 2007. Gross foreign debt grew from a stable level of about 60 percent of GDP in the 1990s to nearly 700 percent before the collapse in mid-2008. Because the inflow of capital was unsustainable, and also because the Central Bank's foreign exchange reserves, in a violation of the Giudotti-Greenspan rule, had fallen to seven percent of the short-term foreign liabilities of the banking system, it was only a matter of time until the expansion would end in a sudden stop. The reversal of capital flows in 2008 caused the currency to tank, consumption and GDP to fall, investment to plummet from 27 percent of GDP to 19 percent of a lower GDP,[22] real imports of goods and services to contract by more than 60 percent from 2006 to 2009 (recall Figure 2a showing the volume of merchandise imports), bank lending relative to GDP to contract by 54 percent from 2007 to 2012 (Figure 2b) and equity prices to plunge by, yes, 95 percent from peak to trough.[23,24] By 2011, real estate prices in the Reykjavík area had receded back to their 2004 level in real terms.[25]

To conclude this discussion of events in Iceland, the boom before the crash of 2008 masked an underlying structural weakness illustrated by a comparison between gross

[20] The OMX15 covering the 15 largest corporations increased by a factor of six over the same period and nearly by a factor of nine from its bottom in 2001 to its peak value in 2007. See Aliber (2011) and Halldorsson and Zoega (2010).
[21] According to their testimony before a special Court of Impeachment in 2012, senior Central Bank officials realized in 2006 that the banks could not survive, likening them to a Ponzi scheme, but this did not keep the Central Bank from continuing to lend the banks money for another two years.
[22] Net investment, i.e., gross investment minus depreciation, was negative from 2009 to 2012.
[23] Sources: *Statistics Iceland* (hagstofa.is), Central Bank of Iceland (sedlabanki.is), World Bank, *World Development Indicators*, and Trading Economics (tradingeconomics.com/iceland/stock-market). See also Halldorsson and Zoega (2010).
[24] Gylfason *et al*. (2010) and Gylfason (2014) compare economic conditions in the Nordic countries during these years.
[25] Source: Registers Iceland (skra.is/Markadurinn/Talnaefni).

investment (Figure 3a) and adjusted net saving (Figure 3b). As defined by the World Bank (2006), adjusted net saving aims to measure the real difference between production and consumption by adjusting net saving for changes in human capital (measured by spending on education and innovation) and depreciation or depletion of natural resources (e.g., through energy or mineral depletion or overfishing). A comparison of the two panels of Figure 3 shows that, before the crash, despite Iceland's investment boom, adjusted net saving in Iceland was far below that of Denmark even without including estimates of natural resource depletion, a controversial subject. This finding reflects Iceland's long-standing aversion to saving and correspondingly strong propensity to borrow, a common affliction among high-inflation countries.

Figure 3. Investment and adjusted net saving



Source: World Bank, *World Development Indicators*.

The dramatic reversal of capital flows in 2008 offers us an opportunity to gauge the effects of a lower real exchange rate on the tradable sector. Because the stock of foreign debt is much higher than before, a significant part of exports must be used to service the debt. Before describing these effects we will review our model of the Dutch disease.

2. A prototype model

An abundance of natural resources affects secondary-sector employment, output and

investment through wages as well as the level and volatility of real exchange rates.[26] External debt also has an effect through the real exchange rate. In a way, natural resource rents have an impact similar to the inflow of foreign capital and external debt works in the opposite direction due to the outflow of interest and amortization payments. The external budget constraint equates the sum of the present discounted value of the difference between future output of primary goods Y^p and tradable goods from the secondary sector Y^S, on the one hand, and tradable goods consumption C^T, on the other hand, to the current stock of net foreign debt D. This makes clear how the accumulation of foreign-currency debt offsets some of the effect of the primary sector. There exist an infinite number of paths that satisfy the intertemporal budget constraint. Instead of solving for the optimal path, we posit a simple rule that satisfies the constraint, making saving r a function of tradable output from the primary sector, Y^P, and the secondary sector, Y^S:

$$r_t = y_t^P + y_t^S - c_t \tag{1}$$

where $y^P = \log(Y^P)$, $c = \log(C^T)$ and r is an exogenous parameter. We then choose the value of saving r so that the external budget constraint is satisfied.[27] Thus, the higher the level of external debt D, the greater is the external surplus r required to service the debt.

Primary output is stochastic and follows a Brownian motion subject to random productivity shocks described by equation (2), and is independent of the real exchange rate;

$$dy^P = \eta dt + \sigma dW \tag{2}$$

where dW represents the increment of a Wiener process $dW = \epsilon_t\sqrt{dt}$, ε having a zero mean and a unit standard deviation, i.e., $E(dW) = 0$ and $V(dW) = dt$. The drift term ηdt reflects the growth of primary output while the stochastic term σdW represents the vicissitudes of, among other things, commodity prices that make primary output rise or fall at random, thus creating uncertainty about output in the primary sector.

Secondary-sector output is deterministic, and is an increasing function of the real exchange rate $\lambda = p^T/p^N$, which is defined as the price of tradable goods in terms of nontradables, $y_t^S(\lambda_t)$, and tradable goods consumption is a decreasing function of the real

[26] The model of this section differs from our earlier one (Gylfason, Herbertsson and Zoega, 1999) in that we now have two factors of production while the earlier paper only had labor. Here, moreover, we do not derive the growth effect of the abundance of natural resources, only the effect on the output of tradable goods, employment and investment.

[27] Equation (1) implies that the sum of the growth rates of primary and secondary (tradable) output always equals the rate of growth of (tradable) consumption. The choice of this saving rule simplifies the subsequent derivations.

exchange rate, $c_t^S(\lambda_t)$. An appreciation of the currency in real terms, that is, a decrease in the relative price of tradable goods, makes λ fall.

Assuming loglinear output supply and demand functions gives

$$y^S = \alpha_0 + \alpha_1 log(\lambda)$$

$$c^T = \beta_0 - \beta_1 log(\lambda) \tag{3}$$

where α_1 and $\beta_1$are positive parameters. Combining equations (1) and (3) gives

$$log(\lambda) = \frac{\beta_0 - \alpha_0 + r}{\alpha_1 + \beta_1} - \frac{y^P}{\alpha_1 + \beta_1} \tag{4}$$

The equation shows that an increase in primary output makes the currency appreciate in real terms and that a higher level of foreign debt – requiring a higher value of saving, *r* – ultimately raises the relative price of the tradable good, countering the effect of primary output y^P on the real exchange rate.

The volatility of the primary sector also affects the real exchange rate. Using Ito's Lemma, we can write the stochastic process followed by the log of the real exchange rate as follows:

$$dlog(\lambda) = -\frac{\eta}{\alpha_1 + \beta_1} dt - \frac{\sigma}{\alpha_1 + \beta_1} dW \tag{5}$$

Again using Ito's lemma we can describe the evolution of the real exchange rate λ as

$$d\lambda = \underbrace{\left(-\frac{\eta}{\alpha_1 + \beta_1} + \frac{1}{2}\left(\frac{\sigma}{\alpha_1 + \beta_1}\right)^2\right)}_{\theta} \lambda dt - \frac{\sigma}{\alpha_1 + \beta_1} \lambda dW \tag{5'}$$

The drift term in the real exchange rate equation (5'), with $\theta < 0$ denoting appreciation – a fall in the relative price of tradable goods – is what is usually meant by the Dutch disease. Even so, the induced volatility of the real exchange rate described by the stochastic term may be no less important in its effect on investment for other export industries and import-competing industries.

Turning to the tradable secondary sector, profits measured in terms of nontradables are defined as follows

$$\Pi = \lambda_t K_t^{\alpha} (e(w_t / \overline{w_t}) N_t)^{\beta} T^{1-\alpha-\beta} - w_t N_t \tag{6}$$

where *K* is the stock of capital, *N* is employment, *T* denotes a fixed factor such as natural resources, land and infrastructure, *e* is the level of industry-wide productivity and $\alpha < 1$ and β

< 1.[28] The (strictly concave) function $e(w_t/\overline{w_t})$ measures worker effort as a function of the ratio of secondary-sector wages to wages paid in the primary sector, $\overline{w}$. We assume the following functional form for *e*, invoking Solow's elasticity condition (Solow, 1979);

$$e = \left(\frac{w-x}{x}\right)^{\kappa}, \qquad 0 < \kappa < 1 \tag{7}$$

where $x = b\overline{w}$ and *b* is a measure of the attractiveness of jobs in that sector; $b < 1$ suggests that jobs in the secondary sector are preferable to jobs in the primary sector.

The representative firm has to determine the optimal level of wages and employment at each point in time, *w* and *N*, and can costlessly hire or fire workers. This is given by the first-order condition for wages and employment. The first-order condition for wages generates the following solution for secondary sector wages

$$w = \frac{b\overline{w}}{1-\kappa} \tag{8}$$

so that a higher primary sector wage, a lower disutility of working in that sector and greater responsiveness of effort to relative wages as measured by κall make secondary sector wages go up. The first-order condition for employment follows

$$N = \lambda^{\frac{1}{1-\beta}} K^{\frac{\alpha}{1-\beta}} w^{-\frac{1}{1-\beta}} Z \tag{9}$$

with $Z = \beta^{\frac{1}{1-\beta}} T^{\frac{1-\alpha-\beta}{1-\beta}} e^{\frac{\beta}{1-\beta}}$. The equation determines optimal employment for a given stock of capital, real exchange rate and real wages, in addition to land and productivity.[29]

Equations (6) and (9) give short-run output supply as a function of the real exchange rate and primary sector wages holding the stock of capital fixed. Assuming that primary and secondary sector wages are initially equalized, the supply function is

$$Y^S = \lambda^{\frac{\beta}{1-\beta}} K^{\frac{1}{1-\beta}} w^{-\frac{\beta}{1-\beta}} B \tag{10}$$

where $B = T^{\frac{1-\alpha-\beta}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} e^{\frac{1}{1-\beta}}$. Taking the log of this equation gives the first equation in (3) with $\alpha_1 = \beta/(1-\beta)$. Looking at equations (6)-(10) together we find that both employment and output in the secondary sector depend on the real exchange rate, and hence on primary-sector output and the level of external debt, as well as primary-sector wages. A primary-sector boom has an immediate adverse effect on output in the secondary sector by increasing the real exchange rate, an essential aspect of the Dutch disease.

[28] Depreciation of capital is assumed away to simplify derivations.
[29] Paldam (1994) describes the impact of the Dutch disease in Greenland through wages.

We now turn to investment. Using Ito's lemma gives us the following stochastic process for Y^S:

$$dY^S = \left[\theta\left(\frac{\beta}{1-\beta}\right)\lambda^{\frac{\beta}{1-\beta}}K^{\frac{1}{1-\beta}}w^{-\frac{\beta}{1-\beta}}B + \frac{1}{2}\left(\frac{\beta}{1-\beta}\right)\left(\frac{2\beta-1}{1-\beta}\right)\lambda^{\frac{\beta}{1-\beta}}K^{\frac{1}{1-\beta}}w^{-\frac{\beta}{1-\beta}}B\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2\right]dt$$

$$-\left(\frac{\beta}{1-\beta}\right)K^{\frac{1}{1-\beta}}B\lambda^{\frac{\beta}{1-\beta}}w^{-\frac{\beta}{1-\beta}}\left(\frac{\sigma}{\alpha_1+\beta_1}\right)dW \tag{11}$$

Now plugging equation (10) into the profit equation (6) gives the restricted profit function

$$\pi = \lambda^{\frac{1}{1-\beta}}K^{\frac{1}{1-\beta}}w^{\frac{-\beta}{1-\beta}}\left[e - \beta K^{\frac{\alpha-1}{1-\beta}}\right]\Omega \tag{12}$$

where $\Omega = T^{\frac{1-\alpha-\beta}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}e^{\frac{1}{1-\beta}}$. Taking the derivative of profits with respect to *K* gives the marginal profit of *K*:

$$\pi_K = \lambda^{\frac{1}{1-\beta}}K^{\frac{\beta}{1-\beta}}w^{\frac{-\beta}{1-\beta}}\left[(1-\beta)^{-1}e - \left(\frac{\alpha(\beta-1)}{1-\beta}\right)K^{\frac{\alpha-1}{1-\beta}}\right]\Omega \tag{13}$$

which we denote as

$$\pi = \lambda^{\frac{1}{1-\beta}}\Upsilon \tag{14}$$

with

$$\Upsilon = K^{\frac{\beta}{1-\beta}}w^{\frac{-\beta}{1-\beta}}\left[(1-\beta)^{-1}e - \left(\frac{\alpha(\beta-1)}{1-\beta}\right)K^{\frac{\alpha-1}{1-\beta}}\right]\Omega. \tag{15}$$

It is then straight-forward to find the Bellman equation for the value of an incremental change in the stock of capital *V*:

$$rV = \lambda^{\frac{1}{1-\beta}}\Upsilon + V_\lambda\theta\lambda + \frac{1}{2}V_{\lambda\lambda}\lambda^2\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2 \tag{16}$$

Try the solution $V = \Phi\lambda^\gamma$ with $\gamma = \frac{1}{1-\beta}$. This gives the solution:

$$V = \left(\frac{\Upsilon}{r-\gamma\theta-\frac{1}{2}\gamma(\gamma-1)\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2}\right)\lambda^\gamma \tag{17}$$

The value of the investment option is then given by a function *F(λ)* which can be solved with the following Bellman equation:

$$rF = F_{\lambda}\theta\lambda + \frac{1}{2}F_{\lambda\lambda}\lambda^2\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2 \tag{18}$$

The solution takes the form

$$F(\lambda) = A\lambda^{\mu_1} \tag{19}$$

with a positive characteristic root μ_1.[30] The value matching and smooth pasting conditions for new investment are

$$\left(\frac{\gamma}{r-\gamma\theta-\frac{1}{2}\gamma(\gamma-1)\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2}\right)\lambda^{\gamma} = A\lambda^{\mu_1} + \mathrm{I} \tag{20}$$

$$\gamma\left(\frac{\gamma}{r-\gamma\theta-\frac{1}{2}\gamma(\gamma-1)\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2}\right)\lambda^{\gamma-1} = \mu_1 A\lambda^{\mu_1-1} \tag{21}$$

Using the two equations gives a value of A

$$A = \frac{\gamma\gamma\mu_1^{-1}\lambda^{\gamma-\mu_1}}{r-\gamma\theta-\frac{1}{2}\gamma(\gamma-1)\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2}$$

and a solution for the investment threshold equal to

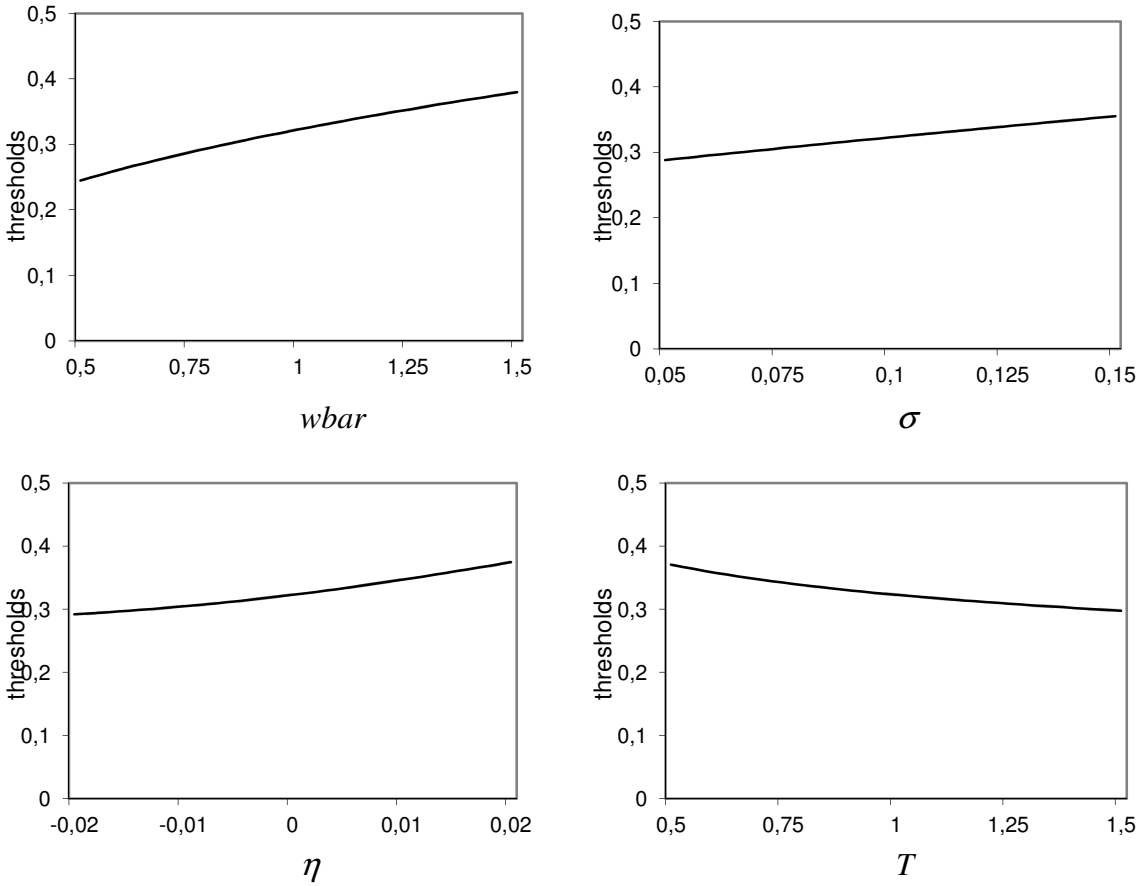
$$\left(\frac{\gamma}{r-\gamma\theta-\frac{1}{2}\gamma(\gamma-1)\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2}\right)\lambda^{\gamma}\left[1-\frac{\gamma}{\mu_1}\right] = I \tag{22}$$

The firm will decide to invest whenever the price of tradable goods λ exceeds this threshold shown below in Figure 4.

[30] The characteristic equation is

$$r-\mu_1\theta-\frac{1}{2}\mu_1(\mu_1-1)\left(\frac{\sigma}{\alpha_1+\beta_1}\right)^2 = 0$$

Figure 4. Investment thresholds



Parameter values*:* $r = 0.05$, $\beta = 0.4$, $\alpha = 0.4$, $K = 1$, $b = 0.8$, $\overline{w} = 1$, $\kappa = 0.5$, $T = 1$, $\sigma = 0.1$, $\eta = 0.0$, $\alpha_I = 0.5$, $\beta_I = 0.5$, $I = 1$.

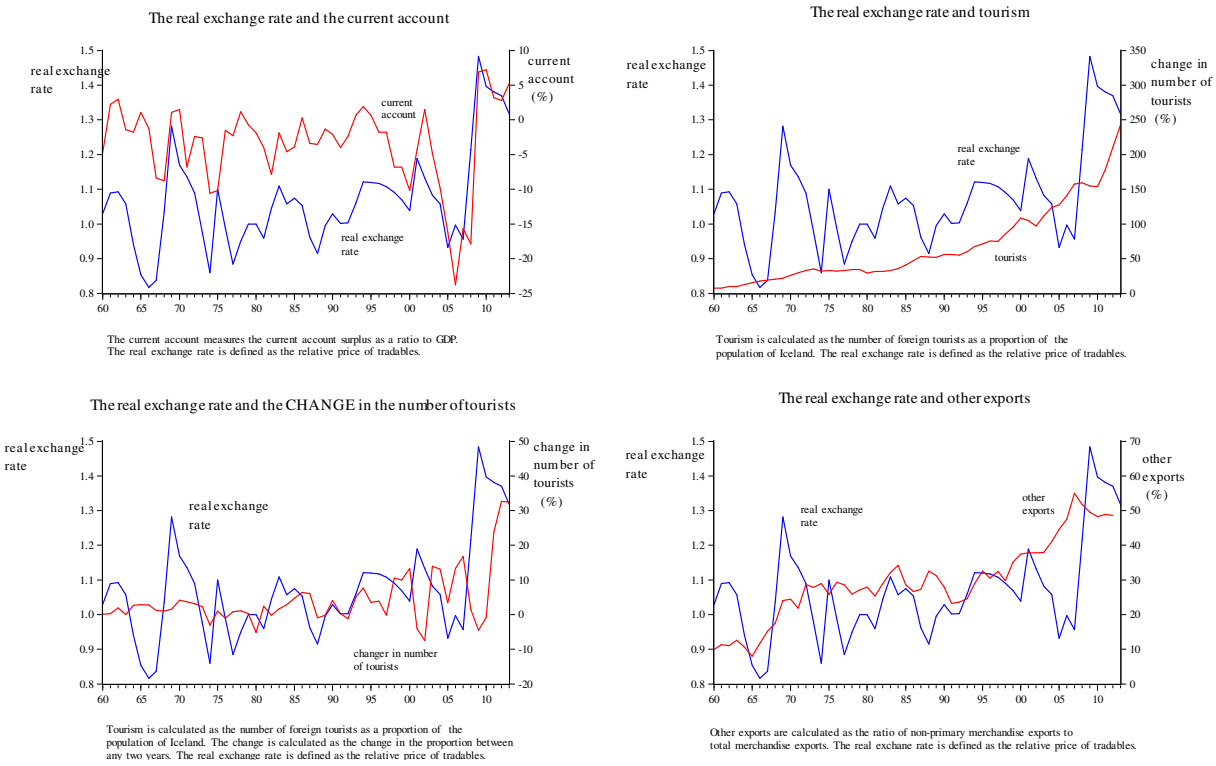
The value of the threshold depends on several variables. First, the higher the primary sector wage $\overline{w}$ or the more attractive are primary sector jobs, as measured by b, the higher are secondary sector wages, the lower are profits in equation (12) and hence the lower the value of Y in equations (17) and (22), which raises the value of the real exchange threshold, making investment less likely. Second, the volatility of the real exchange rate, created by the volatility of primary output, will raise profits due to the convexity of the profit function in equation (14) and it will also lift the threshold by increasing the option value of investment through the value of the call option in equation (19). The second effect dominates, as shown in Figure 4, so that increased primary sector volatility raises the value of the threshold making investment less likely. This is the volatility effect emphasized in some of our previous papers. A positive trend growth of primary goods production, η, has a negative effect on the trend growth of the relative price of tradable goods θ, which raises the value of the investment threshold and makes investment in new capital less likely. Finally, an increase in the endowment of the

fixed factor T raises the value of Ω and Υ, which lowers the value of the investment threshold so that firms start investing in new capital at a lower relative price of tradable output.

3. Empirical evidence

We employ a VAR to describe the relationship between the real exchange rate (E), the current account in proportion to GDP (CA), the number of tourists as a ratio of the local population (T) and non-primary exports (NP) as a share of total merchandise exports. Figure 5 shows these variables over the period 1960-2012.

Figure 5. The real exchange rate, the current account, tourism and non-primary merchandise exports



Source: Statistics Iceland (www.hagstofa.is) and the Icelandic Tourist Board (http://www.ferdamalastofa.is/is/tolur-og-utgafur/fjoldi-ferdamanna).

The upper left-hand panel shows the real exchange rate – an increase indicates depreciation – and the current account surplus. There is a positive association between the two since the early 1990s when capital became mobile: a depreciation of the currency makes the current account improve, even if foreign borrowing makes the currency appreciate on impact; there is no inconsistency involved as laid out in Branson (1977) and Gylfason and Helliwell (1983). The upper right-hand panel shows the real exchange rate and the number of tourist arrivals

where the latter series grows exponentially. Taking the first difference of the tourism variable generates the figure shown in the bottom left-hand corner. Looking at the last few years one can see an explosion in the number of foreign visitors in response to the lower real exchange rate. Tourism appears to respond to exchange rates with a lag. Finally, the bottom right-hand panel shows primary exports as a share of total merchandise exports.

Table 1. Estimation results for VAR (2) for 1960-2012

	LOG(E)	*CA*	*D(T)*	*D(N^p)*
LOG(E(-1)))	0.965*	33.278*	10.018	8.711
	(5.99)	(4.62)	(1.09)	(1.64)
LOG(E(-2))	-0.219	-30.183*	26.505*	-11.498*
	(1.26)	(3.86)	(2.65)	(2.00)
CA(-1)	-0.004	0.520*	-0.507*	-0.211
	(1.11)	(3.41)	(2.59)	(1.88)
CA(-2)	0.001	0.097	0.229	0.149
	(0.35)	(0.71)	(1.32)	(1.49)
D(T(-1))	-0.000	-0.116	0.346*	0.128
	(0.11)	(1.04)	(2.41)	(1.55)
D(T(-2))	-0.027	-11.65	0.35*	12.78
	(0.11)	(1.04)	(2.41)	(1.55)
D(N^p(-1))	0.063	11.94	-0.60*	-9.36
	(0.21)	(0.87)	(3.41)	(0.92)
D(N^p(-2))	0.005	-0.020	-0.422	-0.239
	(1.09)	(0.10)	(1.67)	(1.64)
Constant	-0.001	-1.319	1.956	0.590
	(0.04)	(1.65)	(1.91)	(1.00)
R-squared	0.60	0.65	0.58	0.26
Akaike AIC	-1.88	5.72	6.21	5.11
Schwarz SC	-1.54	6.06	6.56	5.45

Note: Maximum likelihood estimates, observations 1960-2012 (T = 51), t-values within parentheses, * denotes statistical significance at the 5% level.

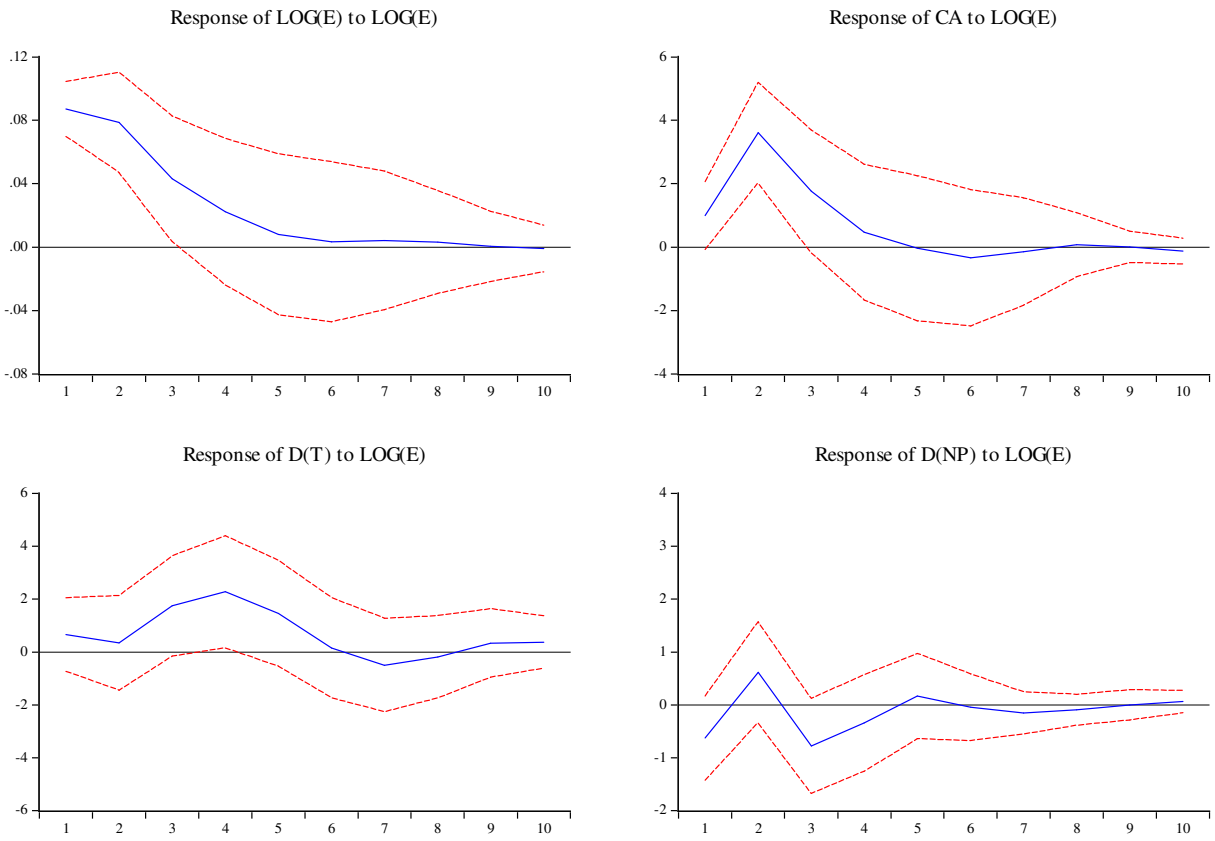
In the appendix we present unit root tests for the four series. While the real exchange rate and the current account surplus do not have a unit root, we find a unit root in the tourism variable as well as in non-primary exports. The first differences of these two variables are stationary. We can then estimate a VAR system for the four stationary variables using annual data ranging from 1960 to 2012. The general p-th order VAR is

$$\boldsymbol{y}_t = \boldsymbol{\beta}_0 + \sum_{i=1}^{p} \boldsymbol{\beta}_i \, \boldsymbol{y}_{t-i} + \boldsymbol{\nu}_t \tag{23}$$

where $\boldsymbol{y}_t' = (\log(E_t), CA, \ \Delta T, \Delta NP)$, $\boldsymbol{\beta}_0$,..., $\boldsymbol{\beta}_p$ are matrices of parameters and $\boldsymbol{\nu}_t$ a vector of error terms. The Akaike Information criterion selects two lags for the VAR, see appendix. The results of estimating the VAR(2) are shown in Table 1. The top entry in the second column suggests that a ten percent depreciation of the króna in real terms goes along with a

strengthening of the current account by the equivalent of 3.3 percent of GDP in the first year, and so on. The lag structure aims to forestall reverse causation.

Figure 6. Impulse response functions to a rise in the price of tradable goods



Note: Response to Cholesky One S.D. Innovations ± 2 S.E.

Figure 6 shows the impulse responses to a shock to the real exchange rate – that is, an increase in the relative price of tradable goods, a real depreciation.[31] The upper left-hand panel shows that the real exchange rate is stationary making it return to its initial level. The upper right-hand panel shows how higher real exchange rates improve the current account for three to four years before the effect peters out. The effect is particularly clear in the year following the depreciation of the currency. The lower left-hand panel shows the response of changes – that is, the first difference – of the number of tourist arrivals per capita. There is a positive effect that becomes significant two years after the exchange rate shock and peaks in the fourth year following the shock. This is consistent with the visual impression from Figure 5 – bottom left-hand panel – which shows that the increase in the number of tourists after the

[31] The Cholesky decomposition imposes an ordering on the variables in the VAR and attributes all of the effect of any common component to the variable that comes first in the VAR system, which in our case is the real exchange rate.

financial crash in 2008 was not instantaneous. However, we should note that the real depreciation of the currency explains only part of the increase in the number of tourists since this was on the rise even before the financial crisis and the attendant collapse of the currency. The bottom right-hand panel in Figure 6 shows the response of the ratio of non-primary merchandise exports to total merchandise exports in first differences. This last response is weak and not significantly different from zero.

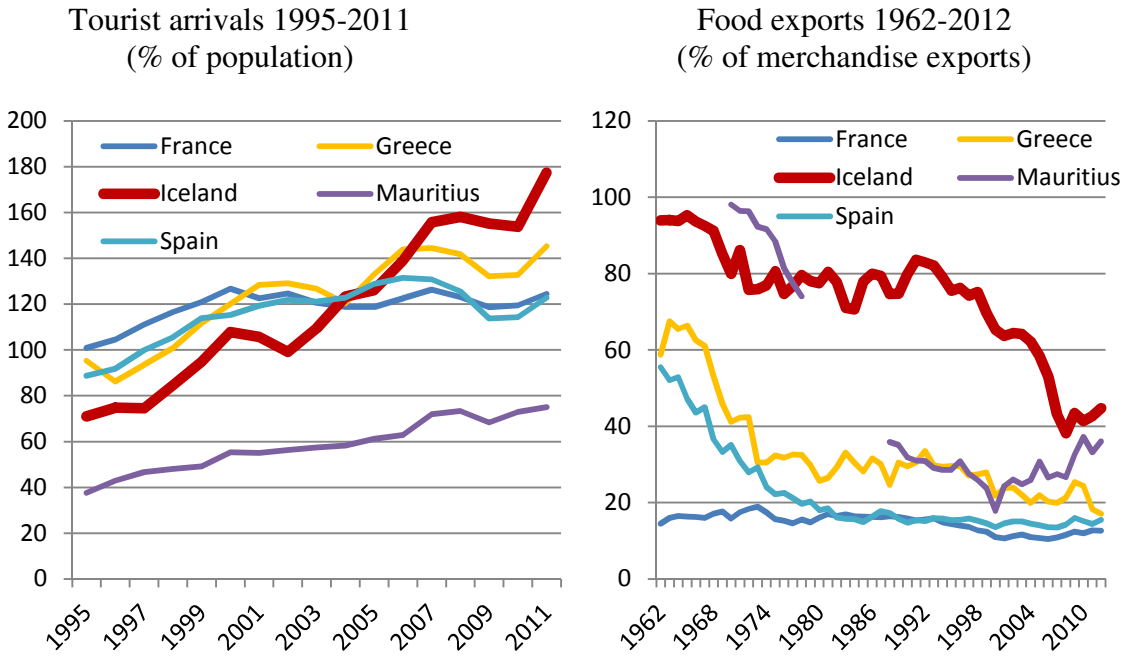
The initial impact of the real depreciation of the króna is found in the volume of imports, improving the current account in the first year after the depreciation. There follows a further positive effect on the number of foreign tourists raising export earnings. In terms of our model, tourism relies heavily on natural resources, T in the model, which may explain why it is the first sector to benefit from the low real exchange rate, see equation (6). There is no evidence of a J-curve even if tourism responds with a lag. However, in terms of non-primary merchandise exports, there is an insignificant effect. Yet, start-up firms in the technology sector initially gained from the currency collapse. However, their workers tend to be internationally mobile and several of these firms operate in many countries. For both reasons nominal wages started to rise rapidly after 2010, gradually erasing the competitive gain from the depreciation. Moreover, these firms require foreign investors who have been hesitant to invest in Iceland due to the capital controls in place since 2008. Some start-up firms have left the country for this reason and others are considering whether to do so.

A further cause of the insignificant response of non-primary exports to the depreciation is the volatility of exchange rates and uncertainty about the future level of the exchange rate. While more tourists can be accommodated with existing facilities, merchandise exports require investment in new capital which has not occurred due to the macroeconomic volatility, consistent with our model in the preceding section. Also, some local-cum-international non-primary exporters keep their accounts in euro and run their operations essentially as if they were foreign firms, and are thus impervious to the exchange rate of the króna except indirectly as victims of strict capital controls deemed necessary since the crash of 2008 to protect the króna from further depreciation if domestic and foreign capital were free to leave, especially if the controls were to be removed in a disorderly fashion.

The implication appears to be that the local labor market is dual in the sense that unskilled, low-paid workers in the tourism industry suffer a more prolonged decline in their real wages following the currency collapse than the higher-skilled workers in the technology sector. The former may face more limited opportunities when it comes to leaving the country and their employers have higher profits as a result.

Before concluding, it may be worth repeating that the increase in the number of tourists relative to population has been quite sharp in Iceland, surpassing even such popular tourist destinations as France, Greece, Spain and Mauritius (Figure 7a). The comparison with Mauritius is especially notable for historical reasons. Until the 1980s, Mauritius was a natural resource based economy, its sugar cane industry being the country's main foreign exchange earner (Frankel, 2012). As tourism gained momentum, however, the weight of the sugar industry in economic activity declined and the political clout of the plantation owners declined accordingly. Even so, limits imposed by the government on the expansion of tourism in Mauritius stemmed the decrease in the share of food exports in total exports (Figure 7b).

Figure 7. Tourism and food exports



Source: World Bank, *World Development Indicators*.

Iceland has seen a similar development with the number of tourist arrivals relative to population almost tripling since 1995 while the share of fish exports in total exports declined by a half. Notice, however, how the rapid rise of tourism in Iceland was propelled first, in part, by the banking-driven boom before the crash of 2008 and then by the collapse of the currency after the crash.[32] Unlike in Mauritius, where charter flights are not permitted, the expansion of tourism in Iceland is not kept in check on environmental or other grounds. Put differently, while the need to conserve fish stocks places a limit on the number of fish caught

[32] Recall Fig. 5 that shows how tourist arrivals rose from 180% of population in 2011 to 250% in 2013. The World Bank figures shown in Fig. 7a do not reach beyond 2011.

each year in Icelandic waters, there is as yet no corresponding limit on the number of tourist arrivals. This means that tourism, which already generates more foreign exchange each year than the once-dominant fishing industry, may in the years ahead permanently bypass the fishing industry as Iceland's main foreign exchange earner. Such a development may encourage the restitution of foreign exchange earnings to the domestic economy because, unlike fish exports, a significant part of tourism services is paid for on location. Further, like in Mauritius, the expansion of tourism may generate valuable externalities, including learning by doing, and result in significant political diversification away from government acquiescence to the densely concentrated fishing industry dominated by a few firms holding much of the catch quotas granted to them by the government virtually gratis toward diversified tourist-related services which, as experience from other countries shows, usually creates few political problems related to rent seeking and power concentration.

In essence, tourism is not that much different from the fisheries in that both industries exploit natural resources with attendant risks of overexploitation at public expense. The parallel is clear. Just as access to fishing grounds, a common-property resource by local law as well as by international human-rights covenants, needs to be restricted by market-friendly, nondiscriminatory methods in the interest of efficiency and fairness, access by tourists to public infrastructure as well as to natural wonders needs to be similarly regulated to forestall environmental degradation.[33] Specifically, just as catch quotas need to be sold or auctioned off on a level playing field to vessel operators wishing to exploit the common property resource at sea, with anything less than full price amounting to an implicit government subsidy, admission tickets need to be sold to tourists.[34] In early 2014, private landowners in Iceland began charging admission at Iceland's Geysir, on public land, something the government had been unwilling to do; charging admission to public property by private parties was subsequently ruled illegal by a local court. The violation was as basic as it was simple: only the rightful owner, the government on behalf of taxpayers, can levy a charge on tourists at Geysir. This basic principle has not, however, prevented the Icelandic government from creating a class of local oligarchs who have accumulated wealth and power by selling catch quotas that the government had allocated to them free of charge in a manner that the United Nations Human Rights Committee ruled discriminatory in a binding decision issued in

[33] Venice lost nearly two thirds of its local population before the city council decided at last, in 2011, to restrict the access of tourists to the city by levying visiting fees ('cultural donations') of up to 10 euro per hotel room per night in keeping with the user pay principle. Day trippers are exempt.

[34] The government of Bhutan requires tourists to spend a minimum of $250 per day while visiting the country. As of early 2014, Dubai charges tourists a fee of up to 20 dirhams ($5) per room per night. Other examples abound.

2007.[35] It remains to see if the government, on a smaller scale, decides to subsidize tour operators as well by not charging them for their right to sell admission to the Northern Lights (*aurora borealis*) and other local attractions in the public domain.[36]

4. Conclusion and discussion

We suggest that large capital inflows resemble natural resource windfalls in that both events flood the recipient country with easy money, triggering similar reactions among the natives, including general euphoria, real appreciation of the currency, reckless public policies in the belief that anything goes, rent seeking, even plunder. Akerlof and Romer (1995, p. 5) are quite explicit about this in their analysis of the S&L debacle in California and Texas in the 1980s: "Examinations of the operation of many such thrifts show that the owners acted as if future losses were somebody else's problem. They were right." Likewise, large capital outflows can be viewed as a cause of the Dutch disease in reverse, triggering an economic downturn accompanied by real depreciation of the currency. This is what happened in Iceland after the financial collapse of 2008 when the króna lost a third of its value in real terms, stifling imports and creating an unprecedented expansion of foreign tourism, turning it into the country's chief foreign exchange earner in lieu of the once-overwhelming fishing industry.

Further, Iceland's natural experiment before and after the crash of 2008 demonstrates the essential complementarity of the elasticities and asset market approaches to balance of payments analysis and exchange rate determination. The exchange rate of the króna climbed to unprecedented heights in response to the large capital inflows facilitated by trusting foreign bankers before the crash, an appreciation of the currency that had nothing to do with trade flows. Thereafter the currency collapsed as the capital flows were reversed, quickly turning the current account of the balance of payments to surplus and necessitating the imposition of strict capital controls as part of the IMF-supported rescue package put in place in 2008. Six years later, the controls are still firmly in place because without them and without restored confidence in the viability of the currency, it would depreciate further as capital would flee making our natural experiment even more interesting but hurting the population through a lower standard of living.

[35] See United Nations Human Rights Committee (2007), International covenant on civil and political rights, CCPR/C/91/D/1306/2004, 14 December.

[36] The idea was launched over a century ago by one of Iceland's most revered national poets, Einar Benediktsson (1864-1940), a shrewd and innovative entrepreneur instrumental in harnessing Norwegian waterfalls in the early 1900s.

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Appendix

The ADF test results, where the null hypothesis is that the process contains a unit root, are as follows:

Table A1. Augmented Dickey-Fuller Test Results

	log(E)	CA	T	N^P	ΔT	ΔN^P
Test statistic	-3.363	-3.486	2.587	-2.240	-6.939	-4.807
Asymptotic p-value	0.067	0.0511	1.00	0.46	0.00	0.00

Note: MacKinnon (1996) one-sided p-values. Constant linear trend.

Table A2. Akaike Information Criterion

No lags	25.77
1 lag	24.68
2 lags	24.27*
3 lags	24.30
4 lags	24.41
5 lags	24.50
6 lags	24.55
7 lags	24.56

Note: * indicates lag order selected by the criterion.