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The capital gains from trade are not enough: evidence from the environmental accounts of Venezuela and Mexico☆

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Abstract

In principle, a country cannot endure *negative genuine savings* for long periods of time without experiencing declining consumption. Nevertheless, theoreticians envisage two alternatives to explain how an exporter of non-renewable natural resources could experience permanent negative genuine savings and still ensure sustainability. The first one alleges that the capital gains arising from the expected improvement in the terms of trade would suffice to compensate for the negative savings of the resource exporter. The second alternative points at technological change as a way to avoid economic collapse. This paper uses the data of Venezuela and Mexico to empirically test the first of these two hypotheses. The results presented here prove that the terms of trade do not suffice to compensate the depletion of oil reserves in these two open economies.

Keywords: Exhaustible resources; Environmental accounts; Net national product; Genuine savings; Foreign trade; Oil production; Mexico; Venezuela

1. Introduction

The traditional measure of a nation's rate of accumulation of wealth is gross saving. This is calculated as a residual: GNP minus public and private consumption. Gross saving represents the total amount of produced output that is set aside for the future. Gross savings rates can say little about the sustainability of development, however, because productive assets depreciate through

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time: if this depreciation is greater than gross saving, then aggregate wealth is in decline. Net saving, total gross saving less the value of depreciation of produced assets, is one step closer to a sustainability indicator, but focuses narrowly on produced assets. Environmental economist assimilate natural resources to man made capital, since a country's consumption may be mainly supported by draining natural resources, i.e. from the depreciation of natural capital. Traditionally computed net savings ignore the depreciation of natural capital. Once natural capital depreciation is also subtracted we arrive to the concept of 'genuine savings'.

Hartwick [10] and Solow [26], building on the concepts of Hicks [13] established that in order to achieve constant real consumption through time (the lower bound of sustainability) it is necessary to keep the underlying capital stock constant. It becomes a requirement that the value of the net change in the total capital stock (that is the genuine savings) must be equal or greater than zero. In principle, a country cannot therefore endure negative genuine savings for long periods of time without experiencing declining consumption, or the total collapse of its economy as time goes to infinity.

Nevertheless, theoreticians have envisaged some possibilities that would allow an exporter of non-renewable natural resources to experience persistent negative genuine savings and still ensure sustainability. The first one alleges that the capital gains arising from the expected improvement in the terms of trade would allow the resource exporter to compensate for the negative savings. The second alternative points at technological change as a way to avoid economic collapse. The gains from trade have now been included in environmental accounting models. Some of the more representative are those of Asheim [1,2], Hartwick [12], Newmayer [19], Sefton and Weale [25] and Weale [32], while the technical change avenue remains largely unexplored excepting the contributions made by Weitzman [34].

The exercises in this paper use the historical data of Venezuela and Mexico to test ex post the validity of the predictions of the models that include capital gains from trade in modifying the genuine savings indicator. Mexico and Venezuela have been oil producers since the dawn of the oil era. Mexico started commercial production in 1901 and was the world's greatest oil exporter and second producer by 1921. Venezuela replaced Mexico in this position during the inter-war years. While Mexico nationalised its oil industry by 1938 and followed an inward-looking strategy of depleting the oil just to the extent necessary to fulfill domestic requirements, Venezuela adopted a pure export-oriented strategy, leaving her oil in foreign hands until 1976. After almost 40 years of looking at each other with a mixture of criticism and wonder, defending their own exploitation strategy as the best possible, Mexico and Venezuela ended the twentieth century as state-owned medium-sized oil exporters. The real benefit of ex post analysis is in making the most of the opportunity to improve the analytical model used as much as in understanding the path that history took.

The order of exposition in the paper is as follows. Section 2 introduces the concept and computes the value of genuine savings indicator for the Venezuelan and Mexican economies. By emphasising the level of genuine savings, we are in effect asking the question: how much of the net (environmentally adjusted) income was actually consumed? Or in other words, were the countries living beyond their means? In this first exercise Venezuela appears to have been living beyond its means for a very long period of time, yet the expected decline in well-being cannot be observed. Hence, the prediction of unsustainability implied by negative genuine savings comes into question.

Section 3 examines the role of the terms of trade in modifying the standard sustainability indicator in two alternative ways. First, the role of the terms of trade is analysed using the methodology of Sefton and Weale [25] (imputed income method) that takes into account the expected capital gains from trade for the adjustment of net income. This second indicator reverses the view of the previous exercise, showing that Venezuela and Mexico were never consuming beyond their means if the expected gains from the terms of trade are taken into account. In the second place, the role of the terms of trade is considered using one of the methodologies proposed in the national income literature for assessing the effect of the actual changes in the terms of trade on national income. The additions to welfare income due to the historical changes in the terms of trade differ substantially from the expected terms of trade effects derived from Sefton and Weale model resulting in the return of the paradox of negative genuine savings without observable declines in well-being. Conclusions can be found in Section 4.

The results of this paper are on line with the findings of Vincent et al. [31], who estimated that Indonesia would have to invest more in order to sustain its consumption levels when using an open economy model than using a closed economy model. These results question the view that the exporter of natural resources 'does not have to do any investing in order to maintain its level of income constant, so the whole of the revenue is available for consumption' given the expected gains in the terms of trade [32, pp. 99–100]. In the absence of technical change, consuming the whole of the revenue may be a good theoretical option but a bad economic decision.

There are wide contrasts between the historical evolution of the variables and the assumptions generally adopted in theoretical models of resource depletion. The theoretical models assume that depletion takes place under very strict assumptions (optimal depletion, homogeneous reserves, absence of technological change, etc). It would be hard to imagine a set of assumptions more at odds with the actual characteristics of resource use in most countries. Perhaps failure of these assumptions is partly responsible for the lack of evidence supporting the theoretical forecasts. In addition, the data required by the models are hardly ever readily available and best proxies need to be used. The reader should bear in mind these limitations when considering the results of this paper.

2. The standard sustainability indicator: genuine savings

The genuine savings indicator can be expressed in the form

$$Z = \frac{S}{Y} - \frac{\delta_M K_M}{Y} - \frac{\delta_N K_N}{Y}, \tag{1}$$

where S is gross savings, $\delta_M K_M$ and $\delta_N K_N$ are man-made capital and natural capital depreciation respectively and Y is total output in the economy. According to its authors, Pearce et al. [21,22], Z 'is an intuitive zero-order rule for determining whether a country is on or off a sustainable development path at any one point in time. The value of Z must be either zero or positive to ensure sustainability.'

By emphasising the level of genuine savings, we are in effect asking the question: how much of the adjusted income was actually consumed? Gross savings are GNP minus consumption. Net savings are gross savings minus depreciation of physical capital, which can also be expressed as

$(GNP - \delta_M K_M) - C = NNP - C$. Subtracting natural capital depreciation from these net savings we arrive to genuine savings, $NNP - \delta_N K_N - C = NNP_{\text{adj}} - C$. Thus the Z indicator can actually be re-expressed in the following terms:

$$Z = \frac{NNP_{\text{adj}} - C}{Y}, \tag{2}$$

where NNP_{adj} is the environmentally adjusted net income (that is, $NNP - \delta_N K_N$) and C is the sum of public and private consumption. Observe that, in the way it was originally formulated, the genuine savings indicator implies the use of the net price method of Repetto et al. [23] for adjusting the traditional NNP. This method establishes that natural capital depreciation, $\delta_N K_N$, matches the total *resource rent* (N_t) for the year.

The theoretically correct estimate of resource rent is marginal profit times quantity extracted. Given the difficulty of measuring marginal costs, empirical studies have used average cost of extraction as an approximation (the most notable exceptions to the widespread use of average costs are Hartwick [11], Vincent [30], Vincent et al. and [31] and Weitzman [35]). Consequently, the most common way to calculate N_t has been to obtain the surplus revenue accruing to the owners of the resource after accounting for the contribution of labour and capital inputs. In absence of technological change, theoreticians expect marginal costs to increase as the resource is depleted. As a consequence the total rents calculated using average costs theoretically overestimate the true value of the resource rent and therefore exaggerate asset depreciation. In historical terms, however, technological advance has driven extraction costs steadily downward [24]. This may partly offset the bias introduced by using average rather than marginal costs in the calculations of the resource rent.

Figs. 1 and 2 compare the sizes of the man-made capital depreciation ($\delta_M K_M$) as recorded in the traditional accounts, with the measure of natural capital depreciation ($\delta_N K_N$), that is N_t,

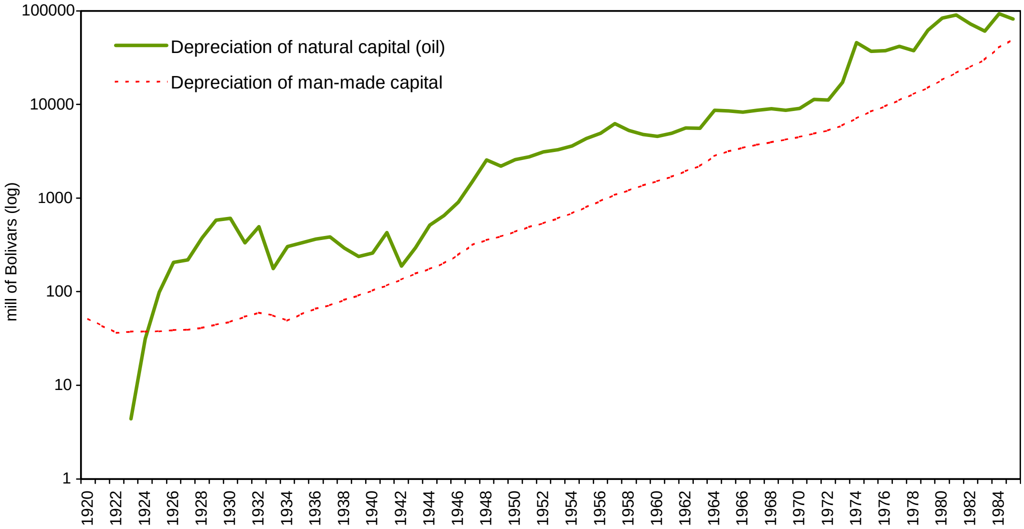

Fig. 1. Man-made capital vs. natural capital depreciation for Venezuela 1920s–1980s (mill. Bolivars at current prices). See Data Appendix D for sources on fixed capital consumption ($\delta_M K_M$). Natural capital depreciation $\delta_N K_N$, using the net price method (Data Appendix, Table A.1).

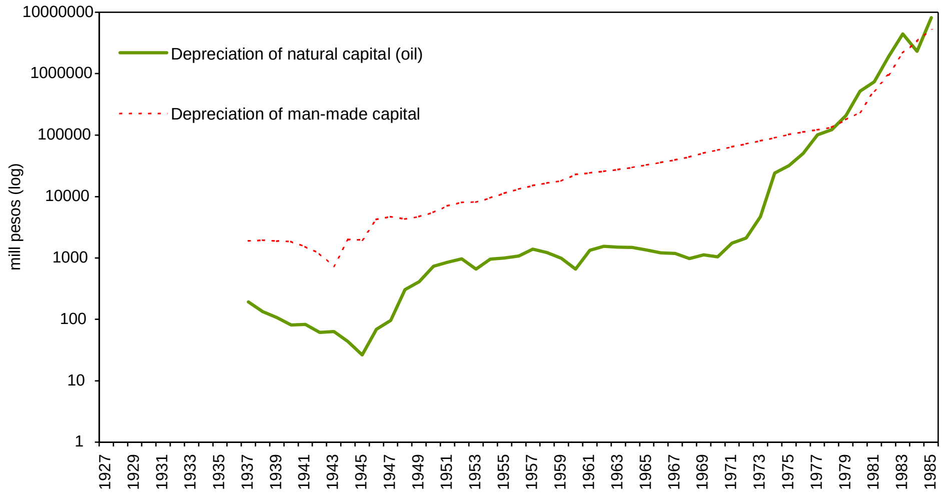

Fig. 2. Man-made capital vs. natural capital depreciation for Mexico 1930s–1980s (mill. Pesos current prices). See Data Appendix D for sources of fixed capital consumption ($\delta_M K_M$). Natural capital depreciation $\delta_N K_N$, using the net price method (Data Appendix, Table A.2).

estimated by Rubio Varas [24] for the depletion of oil resources in Mexico and Venezuela. Natural resource depreciation—approximated by the depreciation of oil resources—is larger than physical capital depreciation throughout the period studied in the case of Venezuela. For Mexico the scale of the natural depreciation cannot be dismissed from the 1970s onwards. Prior to that date the level of natural capital depreciation for Mexico was of the order of 1.5% of traditional GDP.

Some caveats are required in relation to this comparison. First, it is worth bearing in mind that the natural capital depreciation estimates calculated here are only considering a single natural resource, i.e. oil. It is the resource that generated the greatest rents and therefore the greatest depreciation during the century, but the depreciation of other natural resources should ideally be also accounted for (consider, for instance, natural gas). Therefore, the figures shown here underestimate natural depreciation. In the second place, the comparison should be regarded with caution since the historical estimates of consumption of fixed capital are feeble, especially in the case of Mexico. Finally, new discoveries are only implicitly taken into account. Levels of production at any point were possible because new discoveries were made along the way. Yet, new discoveries were not accounted as additions to the capital stock of the country when they were found. Most empirical adjustment are made without treating new discoveries as income (see for example Van Tongeren [29], the US Department of Commerce [28]) because including mineral additions as capital formation may make the aggregate GDP series more volatile and less useful for traditional economic analysis than the environmentally adjusted GDP. Yet, as a reviewer pointed out, the conventional GDP may be the one containing the distortions.

All in all, however the message from Figs. 1 and 2 is clear: natural depreciation is by no means negligible. These estimates of natural depreciation are used for the computation of the Z indicator described in Eq. (1). Fig. 3 offers the graphical representation of the gross, net and genuine savings as percentage of GDP for Venezuela, while Fig. 4 provides the estimates for Mexico.

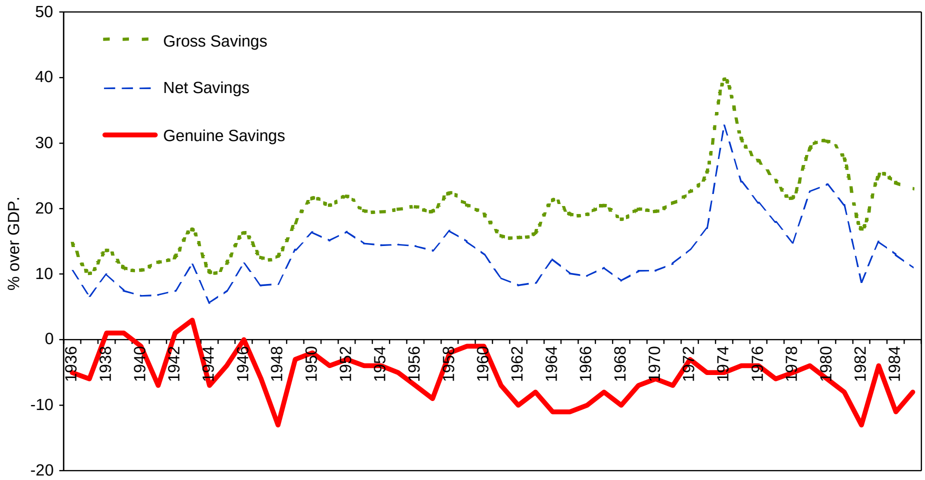

Fig. 3. Gross, net and genuine savings of Venezuela for the period 1936–1985, expressed as percentage over GDP. See Data Appendix Table A.5 for data and sources.

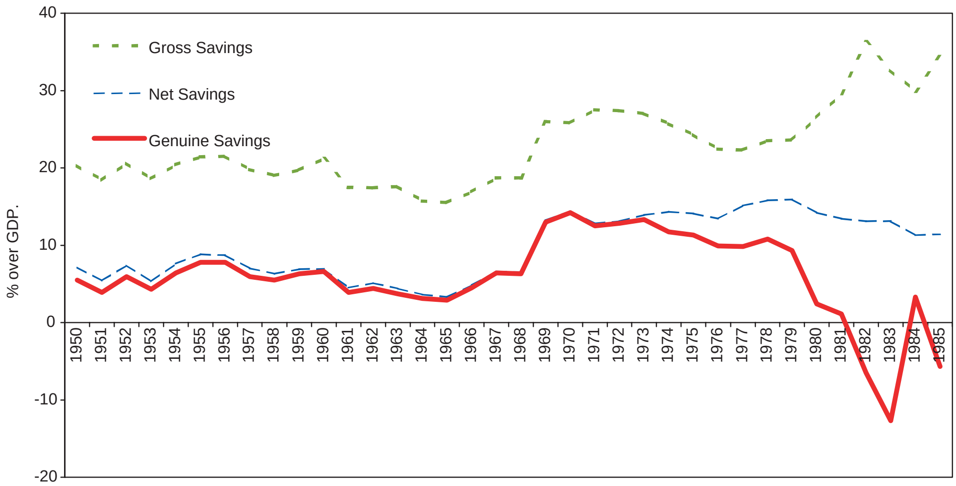

Fig. 4. Gross, net and genuine savings of Mexico for the period 1950–1985, expressed as percentage over GDP. See Data Appendix Table A.6 for data and sources.

This first exercise shows Venezuela's Z indicator taking negative values by the 1930s and from 1944 it permanently failed to satisfy the rule in Eq. (1). This is a striking result for an economy historically portrayed as an exceptionally high saver. In 1961 the IBRD reported 'Venezuela has devoted 30% of its GNP to gross investment, a proportion equalled or exceeded in only a few European countries notably West Germany and Norway' [15]. The Mexican indicator turned negative only for a couple of years in the early 1980s. These results are on the line of those reported by Pearce and Atkinson [22, p. 173] for Mexico for the year 1985 (0 genuine savings). The results presented here also coincide with the World Bank [36] for the period 1970–1993, which reports that 'strong savers like Brazil and Chile are offset by the genuine dissaving of Venezuela and Ecuador and the near-zero genuine savings of Mexico' (p. 12). In theory, these results indicate that Venezuela has been living beyond its means to a greater extent and for a longer period than Mexico.

According to the World Bank [36] 'persistently negative rates of genuine savings must lead, eventually, to declining well-being' (p. 8). The puzzling question regarding this prediction is: for how long can a country endure negative genuine savings before the eventual decline of well-being becomes apparent? If Mexican results were the measure, it could be argued that a couple of years with negative genuine savings are sufficient to observe a decline in well-being by the mid 1980s. In contrast, in Venezuela negative rates of genuine savings occurred continuously for over 40 years and yet, declining well-being was only perceived from the 1980s, and according to some authors, only from the 1990s onwards (see Coronil [4] and Goodman [7]). Not in vain Venezuela has the best overall performance in Latin America throughout the twentieth century in terms of traditional GDP growth according to Hofman [14, p. 87]. The negative rents of Venezuela seem to be persistent enough, yet the expected decline in well-being was greatly delayed. Hence, the predicted unsustainability of negative genuine savings comes into question.

As mentioned above, several authors have theorised about the role of capital gains arising from (a) improved terms of trade and (b) technological change in modifying the $Z > 0$ rule. The next section tests empirically the first of these theoretical objections to the genuine savings indicator.

3. The effects of the terms of trade

The national income literature has long noted the problem that traditional indicators 'may not be a good indicator of national welfare in an open economy experiencing substantial change in its terms of trade' (Hamada et al. [9, p. 752]). This occurs because traditional measures of output and income fail to account for the impact of changing terms of trade on the consumption possibilities of the economy. Gutman [8] summarised the many attempts to adjust for the terms of trade impact on the measurement of national income, although he does not include the later attempt by Hamada et al. [9]. The general result from those attempts is that 'when the terms of trade deteriorated, measures of economic growth tended to overstate gains in real income; when they improved, those measures understated such gains' (Irwin [16, p. 100]).

This observation has not escaped the analysis of environmental accountants. Sefton and Weale [25] argued that the net price method is inappropriate for adjusting the net income for the depletion of oil reserves in open economies precisely because it ignores the effects on welfare income of the expected improvement of the terms of trade of an oil exporter (the model explicitly mentioned by Sefton and Weale is not the net price of Repetto, but Dasgupta et al. [5] and Hartwick [11], which are the foundations of Repetto's model). Accordingly, the sustainability rule Z presented in the section above would differ for open and closed economies. Sefton and Weale derived the necessary adjustment for an open economy that exports natural resources. Their suggestion is that the adjusted income would be incomplete without an imputed income for the stock of the resource targeted for export. This imputed income should be included in the measures of adjusted income in order to take into account the effects from the expected gains in the terms of trade. In fact their model suggest two adjustments: an imputed income for the stock of resource targeted for export and a rate of interest effect. Yet, the second adjustment is considered 'harder to estimate and it seems reasonable to assume is negligible as real interest rates can be expected to remain almost constant in the long run' (Sefton and Weale [25, p. 46]). Appendix A offers a brief discussion of Sefton and Weale method. The environmentally adjusted income from the Sefton and Weale methodology corresponds to the following formulation:

$$NNP_{\text{adj}} = NNP - N_t + \frac{i}{1+i} Vt, \tag{3}$$

where NNP is the traditionally computed net income, N_t is still the resource rent (the net price in other words). The last term corresponds to the imputed income from the expected gains from the improved terms of trade, where V_t is the value of the resource targeted for exports. This value is calculated multiplying the per unit net price (u) times the stock of the resource targeted for exports (Q_E) taking the suggestion of Sefton and Weale of 'assuming the ratio of the domestic utilisation of the resource to foreign utilisation remains constant', so that $V_t = uQ_E$. In this second exercise, the Z indicator is re-estimated using Eq. (2), but rather than adjusting the traditional income by the net price method, the net income is adjusted by the imputed income method just defined in Eq. (3). Fig. 5 illustrates the effects of the expected gains from trade in modifying the Z indicator. When net income is adjusted using the imputed income method, it appears that Venezuela and Mexico consumed within their means throughout the period analysed. According to the results the levels of consumption were not necessarily unsustainable given the expected continuous improvement on the terms of trade of a resource exporter. However, some important caveats should be taken into account.

The expected gains from trade in Sefton and Weale method arise from their application of Hotelling's rule. That is the expectation that the resource rent is going to grow at the rate of interest in the economy until the resource is exhausted. But the analysis of the behaviour of the rents calculated for Mexico and Venezuela in the section above revealed that there is no historical

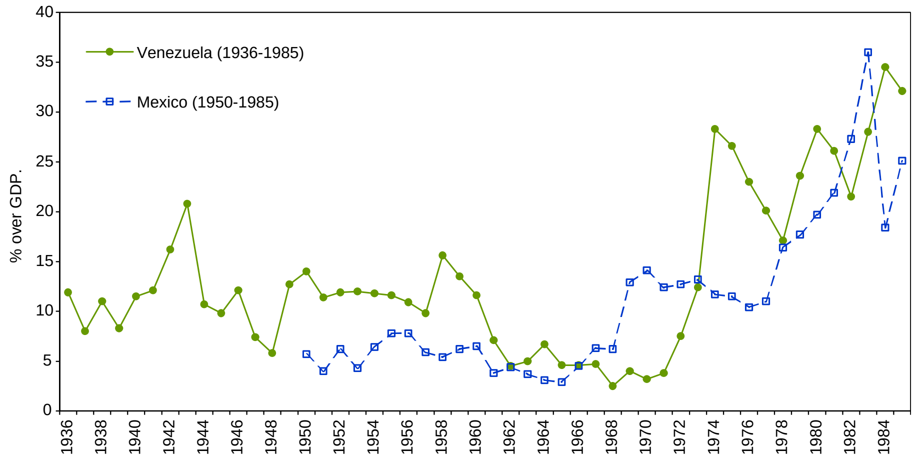

Fig. 5. Genuine savings calculated taking into account the expected gains from trade. The Z indicator is calculated here using the NNP_{adj} resulting from Eq. (3). For Venezuela' data see Table A.5 and for Mexico's Table A.6 in the Data Appendix.

evidence supporting Hotelling's principle: rents have not grown at the rate of interest. This is not surprising considering that Hotelling's rule only holds under very strict assumptions which result unrealistic when applied to an actual case such as: (a) optimal management while state enterprise and/or monopoly/oligopoly are present; (b) endogenous prices while most countries are price takers on international markets; (c) endogenous costs while technological advance has driven extraction costs steadily downward; (d) absence of production constraints when in general producers do face production constraints. Consequently, the possibility of escaping from negative savings in open economies through the expected improvement of the terms of trade based upon such assumptions is considerably reduced and needs further investigation.

The obvious way to establish the role of the terms of trade is to observe their historical evolution. Fig. 6 reveals the terms of trade for Venezuela and Mexico for the relevant periods. Contrary to what would be expected from the application of Hotelling's rule, the terms of trade do not improve continuously in either of the two countries. Venezuelan terms of trade improved markedly from 1942 to 1957 and during the 1970s, but from the end of the 1958 until 1972 remained constant and from the early 1980s declined notably. In the case of Mexico, before it re-started its oil exports, the terms of trade exhibit a modest upward trend; when oil regained a significant position in Mexican exports from 1974, the terms of trade improved briefly but started to decline from the 1980s and finally arrived at a constant level. The historical terms of trade do not satisfy the theoretical predications of the imputed income method.

It is possible to argue that even if the rents had increased at the rates assumed by Hotelling's rule, the gains from the terms from trade may have not continuously increased. Some of the gains apparently associated with the improved terms from trade may be lost since oil is a basic input for producing the goods that the oil-exporter-country needs to import. This is actually a common

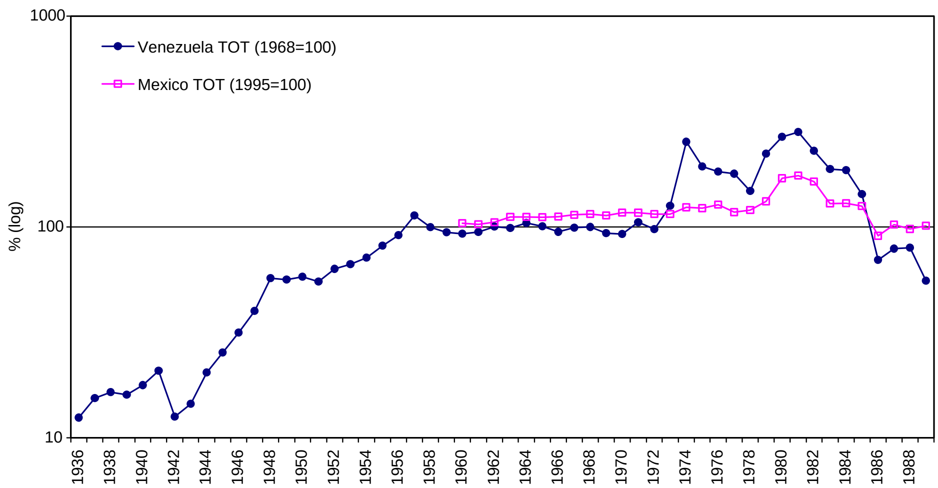

Fig. 6. Terms of Trade of Venezuela (1936–1989) and Mexico (1960–1989). For Venezuela the terms of trade were calculated as the ratio between exports and imports price indexes. The export price index was elaborated using the exports and prices series of oil from Data Appendices A and B. It is worth recalling that oil exports represent the vast majority (over 90%) of Venezuelan exports for the dates shown. Imports price index from Baptista [3]. Mexican terms of trade from Easterly et al. [6].

assumption in models that take natural resources into account (for instance Sefton and Weale [25]). Higher oil prices will influence the price of imports and the gains from the terms of trade will be reduced. The theoretical models do not consider this feedback effect. The deterioration in the terms of trade observed reflect, in addition to the changes in the real economy, monetary effects (such as currency devaluations) that escaped the theoretical formulations.

These results do not overrule the fact that the terms of trade have an effect in modifying the Z indicator. Although Mexico and Venezuela did not experience the continuous improvement in the terms of trade implicitly assumed by the imputed income method, both countries were at different points in time open economies experiencing substantial changes in their terms of trade. As a consequence, their welfare incomes (their consumption possibilities) will differ from the standard income measures and this will have an effect on whether they were living beyond their means.

A re-estimation of the Z indicator is needed taking into account the effect on income of the actual changes in the terms of trade instead of the expected gains from the terms of trade. Hamada et al. [9, p. 761] affirm that 'since the mid-1950 many authors have discussed the measurement of the effect of changes in the terms of trade on real income.' In 1960, Nicholson [20] proposed a procedure for assessing the effect of changes in the terms of trade on national income. His adjustment has the advantage of being specifically designed for the adjustment of net income (rather than production) and it does not include quantity changes which facilitate the comparison with the expected gains. These reasons justify the choice of this method among the available in the literature. For a discussion of the alternatives see Hamada et al. [9]. His adjustment formula for income gains/loss, taken here from Hamada et al. [9], ignores net property income from abroad and can be expressed as

$$E^t\left(\frac{P_E^t}{P_M^t} - \frac{P_E^{t-1}}{P_M^{t-1}}\right), \tag{4}$$

where E^t are exports in the current year t and, P_E and P_M denote exports and imports deflator respectively, thus the ratio P_E/P_M corresponds to the terms of trade.

Employing Eq. (4), Tables 1 and 2 present evidence on how much the terms of trade fluctuations actually affect estimates of national income and contrast these results with the expected gains from the terms of trade assumed by the imputed income method. The results are shown as the percentage adjustment in income (NNP). Within each table, *Panel a* examines the relevant periods by decade averages, while *Panel b* divides the years into periods based on broad trends (such as peak-to-trough movements) in the terms of trade. This second Panel magnifies the possible effects of the terms of trade on measured income in the case of the actual effect figures. The first line of each table describes the importance of trade in the economy. It is evident from this line that the share of exports in Venezuela's income is much important than that of Mexico. This is relevant because as Spraos [27] revealed the effects of the changes in the terms of trade on income are more important the higher the proportion of income that is derived from exports.

By decades, the adjustment is most significant in the 1970s and the 1980s but with opposite signs. The figures for the terms of trade adjustment may be interpreted as follows: if the increase in the terms of trade from 1970 to 1979 is taken into account, then the recorded national income in 1979 understates the level of Venezuela's income by about 7.2%. Similarly, the decline in the terms of trade of the 1980s means that the national income in 1989 overstates the level of Mexico's income by about 1%.

Table 1
Terms of trade effects on Venezuela's national income (% over *NNP*)

	Panel a					
	1936–1939	1940–1949	1950–1959	1960–1969	1970–1979	1980–1985
Share of exports	32.4%	28.0%	32.2%	29.7%	31.2%	27.4%
Expected effect	13.5%	17.2%	18.3%	15.4%	23.3%	41.4%
Actual effect	0.3%	1.1%	1.3%	0.0%	7.2%	−2.5%
	Panel b					
	1936–1942	1943–1957	1958–1972	1973–1981	1982–1985	1936–1985
Share of exports	32.8%	29.4%	29.2%	32.6%	26.1%	30.1%
Expected effect	15.2%	17.9%	14.9%	30.3%	43.7%	20.9%
Actual effect	0.1%	2.0%	−0.3%	9.9%	−8.3%	1.7%

Notes: The expected effect on income from expected improvements in the terms of trade corresponds to the second term $(Vt(i/(1+i))$ of Sefton and Weale's equation. The actual effect on income from changes in terms of trade calculated using Nicholson's method defined in Eq. (4) with data on exports as in Data Appendix B and actual terms of trade as in Fig. 6. Sources for the *NNP* are listed in Data Appendix D.

Table 2
Terms of trade effects on Mexico's national income (% over *NNP*)

	Panel a			
	1960–1969	1970–1979	1980–1989	1960–1989
Share of exports	6%	5%	14%	8%
Expected effect	0.1%	1.8%	26.9%	9.6%
Actual effect	0.1%	0.1%	−1.0%	−0.3%
	Panel b			
	1960–1973	1974–1981	1982–1986	1987–1989
Share of exports	5%	6%	16%	15%
Expected effect	0.0%	7.8%	34.6%	17.3%
Actual effect	0.0%	0.6%	−2.6%	0.6%

Notes: as in Table 1.

In looking at broad trends in the terms of trade (Panel b), the adjustment is also important (about 2%) for the period 1943–1957 for Venezuela, and the effects of the changes in the terms of trade of the oil boom and oil crisis are considerably magnified for both countries. These findings may lead economic historians to revise, at the margin, their interpretation of parts of the century. As a consequence of the terms of trade improvements, it appears that income increased much more than suggested by conventional estimates of national income during the 1970s. Likewise, the 1980s saw stronger losses in income than national accounts data suggested because of the sharp deterioration of the terms of trade during the what it has been called in Latin-American historiography the 'lost decade'.

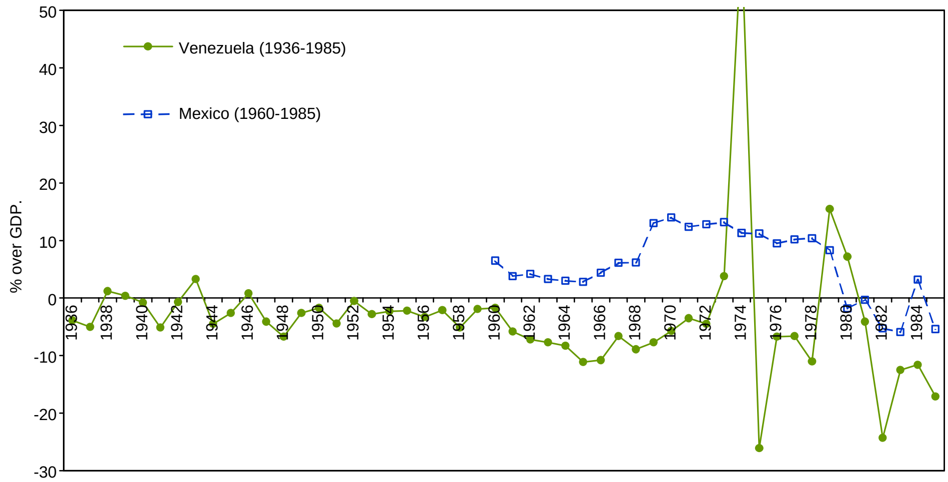

Fig. 7. Genuine savings taking into account the actual gains from trade for Venezuela (1936–1985) and Mexico (1950–1985) as percentage over traditional GDP. Calculated using the results of Tables 1 and 2.

All in all, the actual effect on income from the terms of trade is much smaller than the imputed income for each and every period. This is also true for the whole period: an actual gain of 1.7% contrasts with the expected gain of 20.9% for the period 1936–1985 for Venezuela, and for Mexico an expected gain of 9.6% contrasts with an actual loss of −0.3% for the period 1960–1989. The terms of trade do not appear to have helped oil producers over the long run as much as some theoretical models predict. We can now re-calculate Z taking into account the effects on income from the actual changes in the terms of trade. Fig. 7 displays the results.

Contrary to the results obtained using the expected gains from trade, the additions to income due to the historical changes in the terms of trade do not suffice to compensate for the depletion of oil reserves, resulting in the return of the paradox of negative genuine savings for over 30 years in the case of Venezuela and yet no observable decline in well-being. The Mexican indicator also improves slightly as a consequence of the effects of the terms of trade, but it still remains negative for the early 1980s.

Following Irwin [16] at least two caveats should be noted to this section. First, the analysis presented here presumes that an increase in the relative price of exportable goods, an improvement in the terms of trade, is also an improvement from some welfare standpoint. Although Krueger and Sonnenschein [17] established this presumption, simple connections between the terms of trade and national income or economic welfare cannot necessarily be drawn. In words of Irwin, ‘a tariff that improves the terms of trade, for example, may no increase national income if it reduces the volume of trade excessively.’ Second, the figures for NNP and savings are estimates and their precision should not be overstated. Thus, the figures presented here should be considered merely illustrative of the impacts of the terms of trade and depreciation of natural capital on national income.

4. Conclusions

This paper has explored the first of two theoretical objections to the $Z>0$ rule: the role of capital gains arising from improved terms of trade. It has been shown that although theoretically it can be expected that the gains from improved terms of trade more than compensate for the cost of depleting oil resources, thus guaranteeing the future consumption of an oil exporter country, the historical changes in the terms of trade do not correspond to the theoretical expectations. The historical evolution of the terms of trade do not compensate the costs of depleting oil resources in Mexico and in Venezuela in particular. The terms of trade influenced income, but much less than expected, having even a negative impact in some instances. The results show that the role of technological change in sustaining the historical levels of consumption may be substantial since the terms of trade did not improve in the continuous way needed to rescue the two economies from declining levels of consumption. This is an important finding because while gains from trade have now been included in some environmental accounting models, technological change is left out.

As expected by environmental accountants, income differs when natural resources are included in national accounts. But traditional income estimates do not always exaggerate income as standard environmental accounting predicts once the effects of the terms of trade are considered. This should not discourage environmental accountants for it implies that the misfit between traditional and environmentally adjusted income is even greater than simple theoretical models predicted. Traditional measures of income can no longer be considered either a reliable indicator of sustainable income or the future consumption possibilities of the economy.

Several caveats apply to all the exercises in this paper. The analyst should bear in mind that savings are for the most part a residual value calculated from the macro economic data which (sources) are listed in Data Appendix D. Furthermore, in the calculation of the resource rent average and not marginal costs have been used and most of the traditional macro indicators used in the calculations are also estimates. Finally, no explicit account has been made for new discoveries in the year they are found. Some of these are strong compromises needed in order to apply theoretical formulations into the real world and may introduce biases to the results. Nevertheless, the overall message of the paper seems robust enough even when the figures provided are not as precise as desired.

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Appendix A

The adjustment proposed by Sefton and Weale [25] to conventional income for the use of non-renewable resources can be expressed as follows in the absence of expected changes in the return on net foreign assets:[1]

$$NNP_{\mathrm{w}} = NNP_{\mathrm{c}} - s(0)(R_1(0) + R_2(0)) + \int_0^{\infty} srR_2 \exp\left(-\int_0^t r \, \mathrm{d}\tau\right) \mathrm{d}t \tag{A.1}$$

NNP_{w} and NNP_{c} denote the welfare income and the conventional expenditure estimate of national income respectively. The rest of the nomenclature is as follows: s represents the per unit price of the resource net of costs; R_1 the amount of the resource used domestically, R_2 the amount of the resource exported and r is the rate of interest. As derived from the work of Weitzman [33], in the absence of natural resource, the conventional income equals the welfare income.

According to Sefton and Weale 'the term $-s(0)(R_1(0) + R_2(0))$ is Hartwick's adjustment for the extraction of exhaustible resources in a closed economy'. Indeed, translating into our own notation we can write this term as $u(q_1 + q_2) = N_t$, that is the per unit rent times the amount produced in the year. The remainder of the expression adds up to an imputed income on the stock of the resource targeted for export. Both terms together constitute the adjustment term proposed by Sefton and Weale.

They argue that a resource exporter 'can enjoy a level of positive consumption, because even though the country deplete its resource stock, the value of the remaining stock increases in value'. This, they say, can be illustrated clearly from the expression above. If the resource producing country exports all its oil, $R_1 = 0$, then they claim the adjustment term becomes

$$-sR_2 + \int_0^{\infty} rsR_2 \exp\left(-\int_0^t r \, \mathrm{d}\tau\right) \mathrm{d}t = 0. \tag{A.2}$$

So they conclude that 'in this case welfare income equals the conventional measure of NNP so there is effectively no adjustment required'. But how can the adjustment term be equal to zero? Take the alternative form of expressing the adjustment term also provided by Sefton and Weale. Define $S_E(t)$ as the amount of the present stock of the resource earmarked for export, so that

$$S_E(t) = \int_t^{\infty} R_2(\tau) \, \mathrm{d}t. \tag{A.3}$$

[1] This equation is a simplification of eqution (46) in Sefton and Weale p. 40, which originally reads:

$$\int_0^{\infty} rC_1 \exp\left(-\int_0^t r \, \mathrm{d}\tau\right) \mathrm{d}t = C_1(0) + q_1(0)I_1(0) + (s(0)R_2(0) - T(0)) + r(0)H_1(0) - s(0)(R_1(0) + R_2(0)) + \int_0^{\infty} srR_2 \exp\left(-\int_0^t r \, \mathrm{d}\tau\right) \mathrm{d}t + \int_0^{\infty} \dot{r}H_1 \exp\left(-\int_0^{\infty} r \, \mathrm{d}\tau\right) \mathrm{d}t.$$

The left-hand side is welfare income. The four first terms in the right-hand side are the principal elements of the standard NNP: consumption, investment, the balance of trade and net property income. The last term represents the change in welfare income accruing to the country from changes in the return on net foreign assets over time. Assuming either zero net foreign assets or constant interest rates this last term disappears.

Sefton and Weale expect the price of the resource net of extraction costs to increases over time at the rate of interest in accordance with Hotelling's rule, thus

$$s = s(0)\exp\left(\int_0^t r\,\mathrm{d}\tau\right) \tag{A.4}$$

then the adjustment term can be expressed as

$$-sR_2 + r(0)s(0)S_E. \tag{A.5}$$

This is simply the result of taking the solution of the integral side of the adjustment term from equation (48) in Sefton and Weale assuming real interest remains constant. Since $R_1 = 0$, all of the resource is exported and S_E equals the whole stock of the resource available $S(0)$. Observe that for the adjustment term to become zero (so that no adjustment is required), the only possibility is that the ratio of production to reserves must equal the exogenous rate of interest ($R_2/S(0) = r$), otherwise the adjustment to income could be positive or negative at any point along the optimal path.

A closer look at the adjustment proposed by Sefton and Weale reveals that, if the whole of the resource is exported, their adjustment is conceptually equivalent to the adjustment framed by the Fundamental Equation of Asset Equilibrium. Translated into our notation, s is the per unit price of the resource u_t; R_2 is the quantity extracted for exports q_2 (understanding that total production equals production for domestic use plus production for exports, $q_t = q_1 + q_2$); Q was the notation used for the reserves or total stock $S(0)$; using discrete instead of continuous time formulation, so that the interest rate is i. If all the production is exported the adjustment proposed by Sefton and Weale becomes:

$$-u_t q_t + \frac{i}{(1+i)} u_t Q_t. \tag{A.6}$$

The first term is simply N_t. Following Miller and Upton [18] assuming constant returns to scale in extraction, so that average and marginal costs are equal, $u_t Q$ is the value of the resource V_t according to the Hotelling Valuation Principle, substituting

$$-N_t + \frac{i}{(1+i)} V_t \tag{A.7}$$

The adjustment proposed by Sefton and Weale is precisely the change in value of the asset, if the country exports all of its production, the per unit rents increase following Hotelling's rule and the interest rate does not change over time. In a closed economy model, where the country exports none of its resources and the rate of interest is constant, Eq. (A.7) should be replaced simply by $-N_t$, (dropping the terms of trade adjustment term). For a lengthier description and the calculation of the values see Chapters 2 and 5 in Rubio Varas [24].

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