Co-movements in terms of trade volatility of land-abundant countries
Alberto M. Díaz Cafferata, Maria Virginia Mattheus

Abstract

Terms of trade volatility of Argentina, Australia and New Zealand in 1870-2009 exhibit similarities which are consistent with the conjecture that their extreme land-abundance is a structural restriction.

We analyze terms of trade volatility and found parallelisms in statistical measures of dispersion and structural breaks in variability; cross correlations between terms of trade cycles are significant. From time series modeling we found similarities among the conditional standard deviations, high between the world wars and falling in the last decades. In some cases, TOT series are heteroskedastic and cross correlations change in time.

Extreme land abundance generates strong incentives for exporting commodities. Hence, in spite of the high costs of volatility, those countries show a historically low diversification that keep terms of trade volatility at high levels and at the mercy of world trends.

If observed similitudes in volatility for more than a century are indirect evidence of rigidities in resources allocation, choices would be restricted due to a “first nature” extreme land abundant endowment. In this case, the policy implication is that forced sectorial diversification may not be optimal. Rather, a balance between reducing terms of trade volatility by export diversification at rising costs, and a combination of efficiency improvements and internal flexibility to manage volatility effects must be achieved.


JEL Classification: F10, F13, F14.

1. Terms of trade volatility in first nature land abundant countries

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In this paper we tackle the question of the persistence of export specialization of commodity-exporting countries and the scope for efficient diversification. We assess stylized facts of the high volatility of terms of trade of a group of land-abundant commodity-exporting countries; we discuss about the causes of the long-term persistence of the phenomenon and suggest policy implications about how these countries shall deal with volatility.

Not only are the barter terms of trade a key relative price for an open economy, but also its relatively high instability, with local trends cycles, large unexpected shocks, and high volatility, are causes of external vulnerability and hinder economic development. The amplitude and irregularity of terms of trade volatility, with deleterious effects on development, is a latent menace for natural-resource based exports countries.1

To learn the influence of structural features on trade, we focus on historical terms-of-trade of a selective group of so-called “New Settlement” countries, which are frequently studied together in reason of a common past and resource abundance. Argentina, Australia and New Zealand belong to a peculiar group of small open economies, which experienced an export and growth boom after the mid 19th Century based on extreme endowments differences from their European trading partners, as shown in Table 1 and Table 2 (See also Table 9 in the annex at the end).

We proceed on a perspective to our knowledge hitherto unexplored: namely, the hypothesis that the pattern of terms of trade (TOT) volatility throughout time is common about these countries. In many empirical studies it has been noted the contrast between developing and advanced economies, characterized by a relatively high and low TOT volatility, respectively. Hence, coincident paths of TOT volatility in a particular cluster of countries defined by land abundance would be indeed a remarkable fact to explain. Why should this happen?

If these countries had similar sectorial specialization determined by extreme land-abundance (assuming similar preferences), the trade direction with land-scarce economies (exporting land-intensive commodities and importing manufactures) and TOT volatility would exhibit a similar pattern. Our empirical task is to find out if data are consistent with this conjecture.

We are interested in finding out if, and to what degree, the early XIXth century relative abundance remains, and may explain why until nowadays manufactures are only a reduced fraction of their exports. Furthermore, this continued natural resource based specialization is likely to determine the high volatility of terms of trade in these economies: we look for co_movements in terms of trade volatility and determine volatility patterns throughout time.

In the following section we emphasize that land-abundant countries, which experienced extraordinary growth rates during the transition between the XIXth and XXth centuries, remain indeed highly specialized in exports based on agricultural commodities. They benefit only partially from the impressive growth of worldwide trade, which is largely explained by the expansion of trade in manufactures and services through the process of vertical specialization, and are nowadays vulnerable to terms of trade shocks and volatility.2

A research tradition has devoted attention to the comparison between the economic development of six land abundant countries, Argentina (AR), Australia (AU), Canada (CA), New Zealand (NZ), Uruguay (UY) and the United States of America (USA): the “club” of the so-called “New Western Countries” plus Argentina and Uruguay.

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1 A different perspective regarding development problems of economies specializing in the production of commodities and natural resource-based exports is related to the association of economic growth with knowledge and technical change dynamics which is arguably faster in manufactures. The argument has been used in many developing countries to promote import-substitution activities.

2 Also, their share in world exports has fallen since the early 1950s.

3 Maddison (1997).
Dyster (1979) mentions as the group of the so called “regions of recent settlement”, encompassing “large open grasslands”, AUS, NZ, South Africa, USA, CAN, UY and AR; and Meier (1969) describes AR, AUS, CAN and NZ as countries which proceeded at a rapid rate the transition between underdevelopment and the status of “advanced” economies. 

Several authors have been interested in comparisons between Argentina and Australia, namely Smithies (1965), Diéguez (1969), Dyster (1979), Di Tella (1986), Ferrer and Wheelwright (1966). Diéguez notes that Australian GDPpc was already higher at the beginning of the XXth Century. Its GDPpc growth was helped by the early industrialization, the improvement in agricultural productivity (reached thanks to a research effort), import substitution (more selective than in Argentina), and closer ties with the British Empire and European countries. 

Mundlak, Cavallo and Domenech (1989) compare the growth performance of Argentina with other countries of the new world with similar resource bases. An econometric simulation assuming policies that had preserved terms of trade free of distortions is found to generate a higher growth between 1929 and 1984, similar to Australia and slightly below that of Canada. 

Has the early gift of abundant land experienced a mutation into ballast for development? Schedvin (1990) selects AR, AUS, CAN and NZ as those which “have most characteristics in common and which are closest to the ideal-typical region of recent settlement”. “Their economic success was achieved swiftly because of the favorable ratio of resources to population, and the four countries enjoyed some of the highest per capita incomes in the world”. However, he warns that the structural characteristics of these countries may be inadequate for the modern conditions of the world economy: “Australia (with New Zealand and, to some extent Argentina) has been caught in a staple trap”; these economies have suffered adverse movements due to their “inability to move into high value-added production”.

Since those TOT fluctuations are costly, the policy problem is which recommendations for external strategy are appropriate for this specific class of economies. 

The presence of structural restrictions from endowments justifies Gottfried Haberler (1964) warning about the danger of concentrating efforts to control the highly cyclical fluctuations of prices of primary products at a high cost in terms of loss of trade, bureaucratic intervention and high administrative costs. He argued forcibly that a better approach is to learn to live with a certain degree of instability, building flexibilities in the economy and contriving methods to correct some of the consequences of fluctuations in international demand.

In synthesis, we ask about the existence and reasons for the similarities in TOT volatility of land abundant economies, and about policy lessons that can be learnt from this perspective. 

The content of the rest of the paper is the following. Section 2 assesses the theoretical link between land abundance and volatility. Furthermore, it provides a brief literature review focusing on how TOT trends, shocks and volatility are determined by natural resource endowments and conceptual issues on the effects of volatility and the assumptions and mechanisms that determine whether TOT volatility is beneficial or costly. Section 3 addresses methodological issues concerning the question of what is volatility in contrast with measures of statistical variability. Time series analysis provides a framework for the empirical identification. We discus technical issues on the definition and measurement of barter TOT volatility and present empirical estimations of the long-term behavior of TOT in Argentina, Australia and New Zealand, focusing on the comparison of the component of “volatility” between them across time. Section 4 concludes with a synthesis and a discussion of what can be learned for policy. 

2. Extreme endowments and implications for TOT volatility
The importance of relative abundance on the direction and the composition of international trade is illustrated by exports flows of Argentina in 1911, at the beginning of the XXth Century. Agricultural products amounted to almost 60% of the total exported; the rest was mostly meat and, only marginally, other primary commodities. More than half of total exports went to four (land scarce) European countries: Belgium, France, Germany and the UK. Further, there was no trade with New Zealand and only a negligible amount of imports from (and no exports to) Australia (Tornquist 1920). This pattern is in line with traditional resource based explanations of trade specialization.

Table 1 and Table 2 show that the geography of “first nature” extreme land abundance on which the growth of the New Settlement countries was based, remains almost unchanged to our days. We argue that this is a long-term structural restrictions on trade specialization. Furthermore, it may cause a limited response to trade policies, as seems to had happened in trade liberalization episodes.

### Table 1. Historical and current extreme differences in land endowments

<table>
<thead>
<tr>
<th>Year</th>
<th>Land abundant countries</th>
<th>Scarce-land industrial countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AR AU NZ UY CAN USA FRA BEL ESP SWI UK DEU JPN</td>
<td></td>
</tr>
<tr>
<td>1870</td>
<td>0.7 0.2 1.1 n.a. 0.4 4.4 70.2 168.3 32.4 66.6 121.2 66.1 94.5</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>15 3 16 19 4 33 114 354 91 191 254 235 350</td>
<td></td>
</tr>
</tbody>
</table>

Sources: Population 1870 from Maddison. 1997 adjusted to 1990 surface. Land surface from WDI. Population 2008 from WDI.

### Table 2. Continuing sectorial export specialization: participation of manufactures on exports and imports in 2008.

<table>
<thead>
<tr>
<th></th>
<th>Land abundant countries</th>
<th>Scarce-land industrial countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AR AU NZ UY CAN USA FRA BEL ESP SWI UK DEU JPN</td>
<td></td>
</tr>
<tr>
<td>Xm</td>
<td>31 15 25 26 47 75 78 77 73 89 71 86 89</td>
<td></td>
</tr>
<tr>
<td>Mm</td>
<td>83 71 68 59 76 65 70 70 65 80 68 71 45</td>
<td></td>
</tr>
</tbody>
</table>

Sources of data: WTO Statistic Database, Trade Profiles.

Table 1 shows the extreme difference in population per square kilometer between the land abundant and selected European countries and Japan. This relative abundance has remained for almost one and a half century between 1870 and 2008.

On turn, Table 2 highlights that for land abundant countries the direction of trade remains largely to our days of the “classical” type. In particular, exports of manufactures in Argentina, Australia and New Zealand are on the range of 15% to 30%, while imports of manufactures are between 70% and 80%. This contrasts with the high participation of manufactures both on exports and imports of industrial countries, revealing the importance of intra industry flows on North-North trade.

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4 We use the following abbreviations: Argentina AR, Australia AUS, Belgium BEL, Canada CAN, France FRA, Germany DEU, Japan JPN, Spain ESP, United States USA, Switzerland SWI, New Zealand NZ.
A factor proportions approach interpretation

The level of barter TOT, their long-run trends, shocks (of different size and duration), and the degree of volatility are expected to have differentiated influence on economic activity. We shall now review briefly how volatility enters in the framework of trade models and is related with the peculiar resource endowment of land abundant countries, as well as the reasons why volatility is beneficial or costly.

Models of open economies are real or with financial assets. A tradition of real general equilibrium models without assets to explain trade flows originates, as early as the Ricardian model, and later with the Heckscher-Ohlin-Samuelson, theoretical presumptions about the (atemporal) static structure of resource allocation, which are valid for whatever size and direction of changes in TOT; this is a world without frictions, with perfect information and costless resource reallocation.

The resource abundance approach to comparative advantages predicts that trade occur between countries with different endowments. In the Heckscher-Ohlin-Vanek model trade is a linear function of the endowments.

The direction of AR, AU and NZ trade with Europe was as expected by the Heckscher-Ohlin presumption. Further, they started a rapid path of economic growth in mid-XIX Century, the epoch of the first wave of globalization, blessed with an initial extensive supply of fertile land, which absorbed for decades a continuous flow of European migration. These international factor movements are consistent with a combination of high productivity of labor and capital and rising terms of trade. Not only did physical capital in agricultural activities and transportation grow at rapid pace, but also the agricultural frontier expanded, with technical change working in the same direction. In synthesis, \( \frac{L}{K} > 1 \).

The whole process was fueled by a growing global demand for agricultural commodities, and the effects of TOT on resource allocation and growth were dominated by the dynamics of trade. Rising exports prices and improving TOT trends helped to keep the expected positive differential factor payments rates with Europe, such that the volatility of terms of trade was not a factor of concern. The economic process was accompanied by domestic polices and institutions which encouraged immigration and capital flows, keeping the stimuli for the flow of capital and labor alive for half a century.

A basic result of international trade theory is that differences in domestic prices open opportunities to trade, which on turn, tends to equalize prices and factor rewards.

Theory predicts however that factor equalization may not be reached in a small open economy highly endowed with natural resources. Rather, the large natural endowment differences with the rest of the world shall drive the economy towards complete sectorial specialization before factor price equalization is reached.

Gandolfo (1994) notes that there is an admissible range of variation of relative factor prices; beyond these limits a country will be completely specialized in the production of one good. The equalization of factor prices in a two country model is possible if the ranges in both of them coincide. The presence or absence of equalization with countries producing all goods is related to the spreads between the relative factor endowments. The farther the relative factor endowments of the two countries are apart, the less probable is the presence of a segment of equalization, and if this segment doesn’t exist there will be complete specialization in at least one country.

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5 Consistent with this description, an estimation of the rental to wages ratio in Uruguay and New Zealand was raising steadily between 1875 and the end of the WWI; then declined until 1940. Scanniello et al. (2008), Figure 1.
Resource allocation does not react to terms of trade movements if there are structural rigidities, such as little elasticity of the TC, or if the economy is specialized out of the cone of imperfect specialization.

**Terms of trade trends, shocks and volatility**

Unexpected once-for-all TOT shocks determine shifts in sectorial specialization and factors returns, with the economy adapting instantly and without costs in continuous trade balance equilibrium. The point is that TOT shifts affect allocations and welfare, but “volatility” has not implication whatsoever\(^6\).

Unexpected once-for-all TOT shocks determine shifts in sectorial specialization and factors returns but for an economy which is able to reallocate resources instantly and without costs in continuous trade balance equilibrium. “volatility” has not efficiency costs\(^7\). This is still true when the economy is not in the “cone of diversification”.

Why volatility? Since the early fifties, following the seminal studies by Prebisch (1950) and Singer (1950), the issue of the characteristics, causes and effects of TOT trends and shocks has been a field of intense debate. More recent references are among others Grilli and Young (1988), León and Soto (1995). Furthermore, the effect of TOT shocks has been found to depend on their duration, profile, size, and sign.

Less attention was granted traditionally to volatility of TOT. However, the modern experience is calling attention towards its influence on incentives, related to uncertainty and the added difficulty to form accurate forward expectations. In the last years academic research is increasing its efforts devoted to understand the separate, specific, theoretical implications and empirical characteristics, of the volatility of TOT.

Economies whose exports production and exports flows are concentrated in commodities with volatile prices have suffer from volatile terms of trade.

We conjecture that, due to complete specialization, a group of small economies with common extreme endowment would have traditional North-South sectorial specialization and trade patterns. In the extreme case of identical specialization they would face identical (exogenous) terms of trade fluctuations, a proposition that can undergo empirical testing.

**The costs of TOT volatility**

Two recent crises in Argentina are illustrative of the mechanisms through which TOT volatility has costs for the economy. In the nineties, the rising TOT (together with a favorable world trade environment) kept the exports to debt ratio at apparently safe levels; however over optimism regarding the future path of TOT led to over-borrowing and contributed to precipitate the external crisis and default in 2001 (Díaz Cafferata and Fornero, 2006). Another recent case is the soybean crises of 2008: a rapid jump in price triggered a battle between the state and the producers; when the episode finished the government had lost the majority in Parliament and the soybean price had returned to its previous level.

How costly are the impacts of terms of trade fluctuations on the economy? Joaquín Vial (2002) Table 2 mentions an IADB study reporting that for the whole of Latin American countries in 1970-1992, the effect of TOT and real exchange rate volatilities, along with economic policy volatility on growth, is negative and equal to \(-1.22\%\). Among those factors, TOT volatility has the largest impact (\(-0.48\%\)). In the case of the Andean countries the values found are even larger; a TOT effect of \(-1.24\%\) out of a total and \(-2.22\%\).

\(^6\) In the popular 2x2x2 model terms of trade is the ratio of prices of homogeneous aggregates assumed to fulfill the “composite good” condition. Weights and concentration are not an issue in the analysis.

\(^7\) In the popular 2x2x2 model terms of trade is the ratio of prices of homogeneous aggregates assumed to fulfill the “composite good” condition. Weights and concentration are not an issue in the analysis.
Mendoza (1995) with data for 30 countries in the period 1965-1999 reports standard deviation of terms of trade 5.37 for the countries of the Group of Seven (3.32 for Canada and 4.89 for the USA) and 12.44 for developing countries (8.91 for Argentina and 12.45 for Brazil). He concludes from simulations that terms of trade disturbances account for about one half of the observed variability of GDP.

A long-run perspective provided by the Prebisch (1950) and Singer (1950) hypothesis concerning the effects of declining TOT trend may be included in this type of real models. Incorporating financial assets, intertemporal phenomena are allowed such that TOT may have an effect on the current account. A large literature developed until our days in the framework of the Harberger- Laursen-Metzler effect. A discussion about the relevance of the duration and other characteristics of the temporal profile of the shock has been intensively discussed. Another type of these models is concerned with the dynamics of the TOT and the long-run effects on economic development, postulating that TOT volatility has an influence on risk and on savings and investment decisions.

Volatility becomes relevant when rigidities, imperfect information and time are introduced in the analysis. With limited information and imperfect mobility restrictions, the characteristics of TOT movements may affect different types of decisions. Volatility determines the degree of uncertainty and is linked to savings-investment decisions and economic growth.

Properties of volatility related to the information set which must be identified in empirical studies are amplitude, frequency and irregularity (including the time span of cycles, outliers and asymmetries in the size of ups and downs).

Does volatility have a separate effect on welfare? Of what sign? In spite of the broad agreement that commodity exporters LDCs are vulnerable to commodity price volatility, theory recognizes the possibility that under particular assumptions volatility be good. Rodriguez (1980) compare welfare gains from trade of a small open economy with fixed or variable exogenous terms of trade that have the same mean. If taking risky decisions has a welfare cost the gains may disappear. He assumes a firm which decides first the level of use of capital services based on expectations about the price, and determines the level of production after the price is known by changing the use of variable factors. A risk neutral firm maximizes expected benefits given a probability function of the prices. The possibility of gains from volatility is the consequence that the gains from a high price are larger than losses when the price is low. Also, Pomery (1984) points out that in theory the welfare effect of random terms of trade are ambiguous. They may be negative or beneficial depending on whether trading decisions can be postponed until after the realization of the terms of trade.

However, it is generally agreed that the welfare consequences of volatility are negative, usually associated with the possible inefficiency of choice under uncertainty. In the model proposed by Mendoza (1997), uncertainty of returns with risk aversion may or may not reduce investment impairing growth, but in any case the effect on welfare is negative.

**Recommending diversification**

If TOT volatility is costly, and if volatility rises with concentration of exports in a reduced number of commodities, it seems natural to prescribe diversification as the remedy.

The effects of diversification in the exports pattern have apparently worked in the correct direction, reducing TOT fluctuations in diverse countries as in Australia, Mexico, and New Zealand. To mention a couple of studies, Blazquez and Santiso (2004) explain how Mexico gained stability in export income moving from a high specialization in oil (70% of exports in 1985) to a diversified manufactured production and pattern of exports. Jansen (2004) using the UNCTAD’s exports concentration index, finds that concentration has a highly and significant effect on TOT volatility, which is defined as the standard deviation of the log differences in terms of trade.
In view of this kind of evidence we shall discuss if the advice of diversification can be generalized, and which policy options exist. For example, Mansfield and Reinhardt (2008) suggest that participation in trade agreements is stimulated not only by improved access to the partners market, but also because it decreases the volatility of trade flows. In a nutshell, since the volatility of relative prices raises the costs of contracting arrangements of firms, trade agreements increase the volume of trade by reducing uncertainty. Supporting empirical evidence is reported.

Regarding to the links with financial markets, Hilscher and Nosbusch (2010) find that the volatility of terms of trade has a statistically and economically significant effect on emerging market sovereign credit spreads. It has been noted that financial markets do not in practice allow developing countries to smooth fluctuations\(^8\).

When modeling the effects of volatility, theory does not provide unique indication for the identification of volatility in the data. In consequence, diverse practical measures of volatility have been used in empirical research. We shall discuss alternatives which range from the mere application of the variance or the standard deviation, to detrending or modeling time series.

### 3. Variability and volatility. Empirical indicators

In this section, firstly, we analyze variability properties of historical TOT time series for Argentina (AR), Australia (AU) and New Zealand (NZ). Secondly, we discuss the differences between variability and volatility. The latter is associated not only with the amplitude and frequency of the movements of terms of trade, but also with uncertainty. In this framework, we estimate three alternative measures to approximate “TOT uncertainty” and compare the obtained results\(^9\).

#### 3.1. TOT variability

Some empirical commonly used measures of variability are variance, standard deviation, coefficient of variation (CV), either of raw data or else of the log differences, and the mean of the absolute value of the log differences. Descriptive statistics of raw data: mean, median, maximum and minimum, rank and standard deviation, depend on the year chosen as the base of the index. The CV, which is exempt from this problem, indicates that Australia is the most variable of the analyzed series (CV=0.20), followed by Argentina (CV=0.16) and New Zealand (CV=0.14). Note that these TOT coefficients of variation are higher than those usually reported for developed economies.

Terms of trade indexes for 140 years between 1870 and 2009 are depicted on the left column of Figure 1; the right column shows the absolute value of the log difference of annual TOT series for the three countries.

![Figure 1. Argentina, Australia and New Zealand.](image)

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\(^8\) Caballero 2000.

\(^9\) See data sources in Annex 1.
The mean of $|d \log(tot)|$ is another common variability measure, with the particular advantage of allowing to analyze the variability throughout time. Note in the right column of Figure 1, that the mean of the absolute value of the differenced logarithm $|d \log(tot)|$ appears to change among sub-periods in the three economies. To formalize this perception, following...
Gillitzer and Kearns (2005) and Borkin (2006)\textsuperscript{10}, we test the presence of structural breaks in the mean using the Bai and Perron (1998, 2003) test and compare the mean among sub-periods.

The Bai and Perron (1998, 2003) test, evaluates the null hypothesis of "l" breaks against the alternative of "l+1" breaks, with arbitrary but fixed l. It is recognized for its virtues\textsuperscript{11}. First, the breakpoints used to compute the value of the F are not required to be global minimizers. Second, the test is still useful when the trimming period on the two compared models differs. Third, it allows modeling from particular to general to determine the adequate number of breaks. The procedure has two instances, dating the breaks and determining the optimal number of breaks. In general, adding breaks minimizes the sum of squares, but optimal number of breaks is chosen in order to minimize Bayes information criteria (BIC).

Table 3. Optimal number of structural breaks in the mean \(|d \log(tot)|\)

<table>
<thead>
<tr>
<th>Number of breaks</th>
<th>Dates and mean of sub-periods (mean of absolute log differences)</th>
<th>Argentina</th>
<th>1870-1985</th>
<th>0.095</th>
<th>1986-2009</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Argentina</td>
<td>1870-1985</td>
<td>0.095</td>
<td>1986-2009</td>
<td>0.05</td>
</tr>
<tr>
<td>Australia</td>
<td>2</td>
<td>Argentina</td>
<td>1870-1985</td>
<td>0.095</td>
<td>1986-2009</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Australia</td>
<td>1870-1985</td>
<td>0.095</td>
<td>1986-2009</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New Zealand</td>
<td>1870-1979</td>
<td>0.08</td>
<td>1980-2009</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 3 shows remarkable differences in variability of TOT among sub-periods. According to the breakpoints obtained, two sub-periods are defined for Argentina and New Zealand, and three for Australia. We find for Argentina that the mean of \(|d \log(tot)|\) fell from 0.095 in 1870-1985 to 0.05 in 1986-2009. In New Zealand, \(|d \log(tot)|\) went down from 0.08 in 1870-1979 to 0.03 in 1980-2009.

Australia shows a somewhat different pattern, with three sub-periods: 1870-1921 with a low variability of 0.05; a second high variability period 1922-1951 with a value of 0.15 and, like the other two countries, shows a reduction in 1952-2009 to 0.07. In all cases, variability of TOT has been reduced in the last period.

Gillitzer and Kearns and Borkin explain the reduction of the terms of trade “volatility” as a consequence of the diversification of exports. However, this argument does not imply an advance towards the exports of goods which are not intensive in land but widen the range of goods within the traditional specialization.

Even when the CV of Australia is the highest, with the identification of sub-periods in the mean of absolute log differences, it is noticeable that Australia has only three decades of extremely high variability.

3.2. Volatility throughout time

Since we are interested in estimating a proxy for uncertainty, it is necessary to distinguish in the variability measures a predictable and an unpredictable component, the latter is which we call “volatility”. From this perspective the forward looking path of a more volatile variable is less predictable.

\textsuperscript{10} Gillitzer and Kearns (2005) and Borkin (2006) calculate the mean of \(|d \log(tot)|\) for Australia and New Zealand, respectively; and test the presence of structural breaks in the mean. We reproduced the test with their data and did the same for Argentina. Our results for Australia and New Zealand are the same as reported by these authors and can be compared with our estimations for Argentina.

\textsuperscript{11} Garegnani (2001).
Furthermore, measures of mere variability, in spite of being commonly used, may lead to misleading interpretation. Given other properties, a variable is intuitively more volatile when its movements are irregular. For example we would not interpret as “volatile” a variable, such as stational prices, that evolves on regular temporal cycles.

A procedure to calculate uncertainty is to compute deviations from an equilibrium value. In this case a model to determine equilibrium prices of exports and imports in the international markets is required. Since this is a research effort in itself, a substitute for this procedure is to work with deviations from long run trends. Here we follow this second approach.

Economic agents may recognize TOT trend but would have more difficulties to predict each actual observation, because the former is more stable than the latter. Also, they might be aware of the fact that large shocks, such as the oil shock or the incorporation of China in the world economy, may be expected to affect trends. On the contrary, short term movements such as the unexpected up movement in soy prices in 2008, are difficult to predict.

Dehn (2000) distinguished variability from volatility suggesting leaving aside the regular part to estimate volatility. Moreover, he observes that uncertainty may change across time. Uncertainty is a concept ex ante different from “variability”, which reflects components that are predictable by producers. Following Ramey and Ramey (1995), these components may be modeled as a function of explanatory variables, taking the variance of the residuals as the component of “uncertainty”.

As a proxy for the unexpected component of the TOT variability we will estimate two alternative measures: deviation from trend using a Hodrick-Prescott filter and the conditional standard deviation from an ARCH type model, applying two detrending procedures. In the last part of the section, we compare the results decomposing the variance of each of them in the explained and unexplained components.

Mansfield and Reinhardt (2008) point out that some studies measure volatility on trade as the variance within a time series for a given country over a long period. They argue that a weakness of this technique is that unexpected shocks are not distinguished from predictable changes in terms of trade, and it does not allow for the possibility of varying volatility between sub-periods. One of the suggested measures of volatility is a dichotomic variable constructed thorough selecting changes equal or greater than 50% -or other appropriate cutoff12. We adapt this indicator, in order to identify size and frequency of TOT jumps.

Consider that a series might be variable because of its high frequency, even if it moves in a narrow band. On the contrary, large irregular shocks are more difficult to predict. Negative shocks are likely to be especially disturbing, and drops may be expected to be more costly than positive jumps. Since the TOT of the three economies are trend stationary, shocks are temporary. Along the stationary time series, large ups and downs alternate: in the three countries the occurrence of large jumps, are followed by a sharp change in the opposite direction rather than compensated smoothly.

3.2.1. Volatility measured by dispersion of the cycle generated from the Hodrick-Prescott filter (HP)

The upper panel of Figure 2 shows the local trend and the lower panel the cycle generated by decomposing a series into a trend and a cycle with the Hodrick and Prescott (1997) filter with lambda 100.

12 They estimate four measures, one is similar to our log difference, which we consider it is not “volatility” but variability; the other two measures that we are not going to use here are the absolute value of the change in the supplier’s export share in the importer’s market; the other is a GARCH estimate to assess the influence of trade agreements on exports volatility.
Let’s consider the trends of TOT in the upper panel of Figure 2.

The first period of growing TOT trends with a common local maximum around the beginning of the WW1, is particularly characterized by fast GDP growth. There is a “U” that ends with another local maximum about 1950, and again, after a valley in our times, in 2009 a third local maximum seems to appear.

**Figure 2. Argentina, Australia and New Zealand. 1870-2009.**

Terms of trade index 1951=100.

Trend and cycle generated by HP filter $\lambda = 100$ (log scale)

Regarding to the cycles drawn in the lower panel of Figure 2, the generated HP cycle has a zero mean by construction. Australia presents the largest difference between the maximum and the minimum, as well as the largest standard deviation (0.11), while New Zealand and Argentina have the same difference and standard deviation (0.10).

We shall stress that this measure of volatility is not constant in time. For the three economies, the early period 1870-1913 of fast commodity-export-oriented growth is characterized by relatively low volatility, with standard deviations: AR 0.08; AU 0.05; NZ 0.09. The period 1914-1955 is the most volatile with standard deviations: AR 0.13; AU 0.19; NZ 0.13. After the mid fifties there follow years of medium TOT volatility (in 1956-1975 standard deviations are: AR 0.10; AU 0.08; NZ 0.11). The last sub-period 1976-2009 exhibits the historically lowest volatilities: 0.07; 0.05; 0.04 for AR, AU and NZ, respectively. Note that, in
contrast to the complete sample, when it is split into the mentioned sub-samples normality holds for all of them.

Ahumada and Garegnani (2000) recommend estimating the value of lambda simultaneously by maximum likelihood and propose a “less mechanical use” of the filter, by testing the behavior of the generated components: the stationarity of the generated cycle and the existence of genuine cross correlation between the cycles. Although we use lambda=100, suggested by the Backus and Kehoe (1992) quadratic approximation for annual data, we follow their second advice and test stationarity of the cycle and cross correlations.

To test the presence of unit roots in the generated TOT cycle, we performed the Augmented Dickey-Fuller test for the generated cycles using a model without constant or trend. The generated cycles are found to be stationary for the three countries.

Next, we proceed to evaluate the presence of genuine autocorrelation between the cycles generated by the Hodrick-Prescott filter (for the indexes 1951=100 in log scale). Following Ahumada and Garegnani, we construct the confidence interval considering the following asymptotic distribution:

$$r_{xy}(h) \sim AN\left(0, T^{-1}(1+2\sum_{j=1}^{\infty} \rho_x(j)\rho_y(j))\right)$$

where $r_{xy}$ is the sample cross correlation at lag $h$ between two series, T is the number of observations of the sample, and $\rho_x(j)$, $\rho_y(j)$ are the autocorrelation of stationary processes $x_i$ and $y_i$ at lag $j$.

In none of the cases the confidence interval for $\rho_{xy} = 0$ (spurious correlation) includes the sample cross correlations observed. We conclude that, in the whole period 1870-2009, sample cross correlations are statistically different from zero.

**Table 4. Cross correlation of TOT cycles** (log scale series).

<table>
<thead>
<tr>
<th>Period</th>
<th>Volatility</th>
<th>AR-AU</th>
<th>AR-NZ</th>
<th>AU-NZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1870-2009</td>
<td></td>
<td>0.49***</td>
<td>0.5***</td>
<td>0.62***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.37)</td>
<td>(0.35)</td>
<td>(0.42)</td>
</tr>
<tr>
<td>1914-1955</td>
<td>High</td>
<td>0.66**</td>
<td>0.68***</td>
<td>0.85**</td>
</tr>
<tr>
<td>1956-1975</td>
<td>Medium</td>
<td>0.20</td>
<td>0.81***</td>
<td>0.32</td>
</tr>
<tr>
<td>1870-1913</td>
<td>Low</td>
<td>0.27*</td>
<td>0.03</td>
<td>0.1</td>
</tr>
<tr>
<td>1976-2009</td>
<td></td>
<td>0.24</td>
<td>0.09</td>
<td>0.12</td>
</tr>
</tbody>
</table>

*, ** and *** denotes that the observed cross correlation is statistically different from zero at the 10, 5 and 1 percent level of significance, respectively.
Those correlations are not constant in time, and seem to be positively associated with volatility. Cross correlation between TOT of the different economies, higher in more volatile periods, suggest predominance of “external forces” in TOT formation during those periods. When world prices are overall more stable, the influence of specific to each economy prices are likely to prevail.

Compare the correlations for sub-periods with the values for the whole sample shown in Table 4: in the sub-period characterized by the highest observed volatility, between 1914 and 1955, the cross correlations of TOT deviations from the HP local trends are high: 0.66 for AR-AU, 0.68 for AR-NZ and 0.85 for AU-NZ. For the period 1956-1975 cross correlations are low for AR-AU and AU-NZ (0.20 and 0.32 respectively) and extremely high (0.81) for AR-NZ. Finally, the TOT cycles do not seem to be coordinated in the periods of lower volatility 1870-1913 and 1976-2009, in which cross correlations are between 0.03 and 0.27.

3.2.3. A third volatility measure: residuals from ARMA/ARCH models

The second measure of volatility is the conditional standard deviation. Enders (1995) provides support for this approach. He argues that "rational expectation hypothesis asserts that agents do not waste information. In forecasting any time series, rational agents use the conditional distribution rather than the unconditional distribution".

The next paragraphs are devoted to the estimation of the ARCH type models. With this aim we start by characterizing the series, testing for stationarity and trends. Next, we detrend the series and estimate the ARCH.

Stationary terms of trade are characterized by shocks with transitory effect. It implies that it is possible for economic policy to smooth its effects, for example through insurance or the use of stabilization funds on exports reward. A priori there is no reason why terms of trade should be stationary, trend stationary (TS) or difference stationary (DS).

A range of tests have been developed to test the presence of unit roots. The tests can be classified into three categories. A first brand includes the Dickey-Fuller (1979) and Augmented Dickey-Fuller (1981), the Phillips (1987) and the Phillips-Perron (1988) (“first generation”) tests. Using the same principle reforms to improve the power of the test under particular situations have been introduced, among those the Augmented Dickey-Fuller generalized least Squares proposed by Elliott, Rothemberg and Stock (1996). A second brand introduces unit roots tests for panel data such as Maddala and Wu (1999), Im et al. (1997), Levin and Lin (1993). The third group includes authors such as Perron (1990) and Zivot and Andrews (1992), among others, who focus on the debate of the lack of power of the first generation test when there are structural changes in time series.

The first generation tests have a low power to distinguish between a unit root process and a near unit root, biased towards the presence of a unit root. In addition, they have little power to distinguish between trend stationary and drifting processes, especially with finite samples and shocks that dissipate slowly. Elliott, Rothemberg and Stock (1996) propose a modified version of ADF to improve the power when an unknown mean or trend is present, the Dickey-Fuller Generalized Least Squares (DFGLS). Since this is the case of our TOT series, we perform this test in order to assess whether the series are stationary. On account that the results vary depending on the criterion used to select the lags number, we use the Bayes information criterion (Min SC), and the modified AIC (MAIC) proposed by Ng and Perron (2001). With the Bayes information criterion, the unit root null hypothesis is rejected at 5% of significance in the Argentinian terms of trade and at 1% in the Australian and New Zealand’s

---

13 Gillitzem and Kearns (2005) mention Lutz (1999) argument that it is not appropriate to model the quotient of export and import prices, two nonstationary indexes, because it is implicitly assumed that the two prices are cointegrated with a long run elasticity of one. Gillitzer et al. point out that due to the fact that terms of trade are found to be stationary, it is a correct treatment.
series. Nevertheless, since the more lags we add the more difficult is to reject the null, if MAIC criterion is followed the null is rejected at 10% for Argentinian terms of trade and it is not rejected for New Zealand’s and Australian series.

The decision of treating the series as having a deterministic trend is not trivial. Following Enders (1995) first differencing a trend stationary model implies introducing a non invertible unit root process into the moving average component of the model, while subtracting a deterministic trend from a difference stationary process results in a misspecification error and can generate a non stationary series. Comparing the two models, the author argues that the short run forecast have nearly identical forecasting, while the long run forecast will be quite different. In borderline cases, Monte Carlo simulations show that in many cases differencing the series brings about better one-step ahead forecast than detrending. For that reason, and because of the lack of data to perform a stationarity test, Dehn (2000) prefers to take first differences. However, Gillitzern and Kearns (2005) and Borkin (2006) treat the series as TS based on their finding that the shocks dissipate in a relatively short period. Because of this and due to the fact that more data was available to test for units roots, and hence the risk is lower than with a shorter sample, we will consider the series are formally trend stationary TS.

We test a deterministic trend\(^\text{14}\) in a linear model: \(\text{tot}_t = \alpha + \beta t\), including a constant term and a trend (Table 5.ii). Notwithstanding that both the constant term and the trends are found statistically significant for the three countries, with a positive trend in the cases of Argentina and New Zealand and negative for Australia, the trend coefficients are close to zero in all the series. Even when we do not find evidence that formally rejects the Prebisch and Singer hypothesis, there is not a “strong” long-run trend but rather several changing local trends.

In addition, we tested the presence of structural changes in the linear model using the Bai and Perron test. Hence, we performed the detrending procedure through two alternatives, first the series are linearly detrended without considering the structural breaks (A); then, they are taking into account (B).

A) Linearly detrended series

Table 5. Stationarity test of the TOT series and detrending through linear model

<table>
<thead>
<tr>
<th>(i) Unit root test: TOT</th>
<th>(ii) Linear trend</th>
<th>(iii) Unit root test: detrended series</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFGLS</td>
<td>(\text{tot}_t = \alpha + \beta t)</td>
<td>ADF</td>
</tr>
<tr>
<td>(Intercept and trend)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min SC</td>
<td>Min MAIC</td>
<td>Constant, Trend</td>
</tr>
<tr>
<td>Argentina</td>
<td>** (1 lag)</td>
<td>4.38 (0.000), 0.0006494 (0.059)</td>
</tr>
<tr>
<td>Australia</td>
<td>*** (1 lag)</td>
<td>4.13 (0.000), -0.0022658 (0.000)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>*** (1 lag)</td>
<td>4.22 (0.000), 0.0006013 (0.037)</td>
</tr>
</tbody>
</table>

*, ** and *** denotes the rejection of the null hypothesis of unit root at the 10, 5 and 1 percent level of significance respectively. \(p\)-values in parenthesis.

Table 5 (ii) and Figure 3 show the detrended TOT log series obtained as residuals of the linear model. The three TOT linearly detrended series are stationary: the ADF test (without constant or trend) the null hypothesis of unit root rejects at 1% of significance (second column of Table 5 iii).

\(^{14}\) Other trends, such as polynomial trend, were tested but we did not find an improvement in the obtained results.
Reinforcing the visual image of co-movements, sample cross correlations are high, 0.40 for Argentina-Australia; 0.43 for Argentina-New Zealand; and 0.65 for Australia-New Zealand (not shown in the table)\textsuperscript{15}.

Other features to note are, firstly, that the distributions are not normal except from Australia; secondly, the most variable detrended TOT series, according to the standard deviation and the difference between maximum and minimum is Australia, followed by Argentina and New Zealand.

**Figure 3.** Linearly detrended terms of trade series. Index 1951=100, log scale

We estimate the ARMA/ARCH models in two steps\textsuperscript{16}. First, we look for the best fitting ARMA following the Box Jenkins procedure. Second, in case of finding time-varying conditional standard deviation, we include a model for the conditional variance and estimate the equations jointly. Several specifications were compared looking forward to minimizing the Akaike (Ak) and Schwarz (Sch) information criteria. Table 6 summarizes the results showing the best fitting model for each series.

As the detrended series are stationary in mean, we can proceed to estimate ARMA models. Then, we shall examine if the variance is constant. In case we found time varying variance, a Garch type model would be the appropriate one. Hence, we would have to distinguish two types of volatility, a short term one (the time varying conditional standard deviation) and the long term volatility (the long run standard deviation, which is assumed constant). If the conditional standard deviation is not time-varying, an ARMA model will be the best representation for data. In the last case, conditional standard deviation do not add valuable information for the agent.

Tests for the behavior of the residuals and squared residuals are shown in Table 6. Residual autocorrelation is tested using Portmanteau Q test (Q); the null hypothesis is that the residuals are uncorrelated; hence, rejecting the null implies that there is residual autocorrelation remaining.

\textsuperscript{15} Although it is noticeable that cross correlations differ widely from period to another, the inclusion of this feature in the time series analysis would lead us to a much more complex multivariate framework, which would be left for subsequent studies.

\textsuperscript{16} Our procedure differs from the one applied by Dehn (2000) who, when looking for volatility measures applies a homogeneous GARCH (1,1) model for all the countries.
Normality of the residuals of the AR is tested with the Jarque Bera (JB) test, the null of normality is rejected in all the models.

Table 6. Modeling TOT time series

<table>
<thead>
<tr>
<th>Country</th>
<th>ARMA(p, q)</th>
<th>Variance Equation</th>
<th>Information Criteria</th>
<th>Q</th>
<th>ARCH Q</th>
<th>ARCH LM</th>
<th>JB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ak</td>
<td>Sch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARG</td>
<td>AR(1)</td>
<td></td>
<td></td>
<td>-220.3</td>
<td>-214.4</td>
<td></td>
<td>39.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.491)</td>
<td>(0.44)</td>
<td></td>
<td>(0.98)</td>
</tr>
<tr>
<td></td>
<td>GARCH(1)</td>
<td></td>
<td></td>
<td>40.62</td>
<td>0.51</td>
<td>5.15</td>
<td>11.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.076)</td>
<td>(0.44)</td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>AUS</td>
<td>AR(1)</td>
<td></td>
<td></td>
<td>-269.7</td>
<td>-257.9</td>
<td></td>
<td>46.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.219)</td>
<td>(0.000)</td>
<td></td>
<td>(0.81)</td>
</tr>
<tr>
<td></td>
<td>GARCH(1)</td>
<td></td>
<td></td>
<td>47.77</td>
<td>11.01</td>
<td>11.01</td>
<td>11.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>NZ</td>
<td>AR(1)</td>
<td></td>
<td></td>
<td>-272.6</td>
<td>-257.9</td>
<td></td>
<td>39.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.502)</td>
<td>(0.000)</td>
<td></td>
<td>(0.81)</td>
</tr>
<tr>
<td></td>
<td>AR(2)</td>
<td></td>
<td></td>
<td>59.8</td>
<td>6.58</td>
<td>6.58</td>
<td>6.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.037)</td>
<td>(0.037)</td>
<td></td>
<td>(0.037)</td>
</tr>
<tr>
<td></td>
<td>GARCH(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We performed two tests for ARCH effects: the Pormanteau test (ARCH Q) for the square residuals and the Engle (1982) Lagrange Multipliers (ARCH LM) test. In the latter, the square of the fitted error is regressed on a constant and q lagged values of the squared residual; the statistic converges to a Chi square with q degrees of freedom. In both tests rejecting the null suggest the possibility of conditional heteroskedasticity.

Both tests indicate that Argentina does not present heteroskedasticity. Australia shows a strong heteroskedasticity that remains even after modeling conditional variance. The evidence is not conclusive in the case of New Zealand because the tests gave contradictory results.

In Figure 4, Argentinean TOT volatility is represented through the squared residuals of the ARMA and can be compared with the conditional variances of the GARCH models fitted for Australia and New Zealand. The squared residuals of Argentina show frequent short term peaks without a temporal pattern. In contrast, the conditional variances of Australia and New Zealand have noticeable time varying volatility, with periods of persistently high volatility followed by periods of tranquility.

The estimated standard deviations of the white noise disturbance of the estimated models are 0.11 for Argentina and Australia and 0.09 for New Zealand.

\[\text{\textsuperscript{17} Several model were tested without getting a favorable result.}\]
Figure 4. Argentina squared residuals from ARMA. Australia and New Zealand conditional variance;

Argentina

Australia

New Zealand
B) Detrended through linear trend with structural breaks series

Next, we perform the analysis detrending the series through a linear model with structural breaks. We found that the detrended series are stationary.

Firstly, we determine the breaks making use of the Bai and Perron test following the procedure mentioned in the beginning of the section. The optimal number and dates of the breaks are presented in Table 7 (i) (the coefficients of the linear model of each of the sub-periods are not presented) Secondly we apply Box-Jenkins procedure to estimate the ARMA/ARCH models. Results are presented in Table 7 (ii).

The variance equation was only necessary for Australia. Argentina and New Zealand showed constant conditional variance.

Table 7. Series detrended through a linear model with structural breaks and ARMA/ARCH model

<table>
<thead>
<tr>
<th></th>
<th>(i) Detrending the series</th>
<th>(ii) ARMA/ARCH estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Structural breaks in the linear trend</td>
<td>ARMA(p,q)</td>
</tr>
<tr>
<td>Nº</td>
<td>Date of breaks</td>
<td>AR(1)</td>
</tr>
<tr>
<td>AR</td>
<td>4</td>
<td>1892-1917-1951-1985</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AR(6)</td>
</tr>
<tr>
<td>AUS</td>
<td>4</td>
<td>1902-1923-1946-1986</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MA(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MA(4)</td>
</tr>
<tr>
<td>NZ</td>
<td>3</td>
<td>1917-1949-1974</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AR(3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AR(5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AR(7)</td>
</tr>
</tbody>
</table>

*, ** and *** denotes 10, 5 and 1 percent level of significance respectively.

The estimated standard deviations of the models are: 0.1 for Argentina and Australia and 0.08 for New Zealand; all of them lower than the ones obtained through the linear detrending without breaks.

This method allows us to find the particular characteristics in the TOT trend of each country. Even though we observe the high volatility period between the world wars, TOT trends in the defined sub-periods are remarkably different: growing for Argentina, deteriorating for Australia and almost constant for New Zealand. This suggests the convenience of deepening research about the specific export structure of each country.
Figure 5. TOT detrended through a linear model with structural breaks

Argentina

Australia

New Zealand
## 3.2.4. Comparing the results

We argued above that the uncertainty created by TOT variability is related to its unexpected component, which can be associated to the deviation from a perceived equilibrium value or, as a proxy for equilibrium levels, the long-term trends of the TOT. In Table 8, we decompose the TOT variability into the explained and unexplained components of each of the models in order to compare them.

According to the property of the variance of a sum:

\[ y = z + v \rightarrow \text{var}(y) = \text{var}(z) + \text{var}(v) + 2 \times \text{cov}(z, v) \]

In our case, the observed TOT value at each point in time is the sum of two terms: i) the component expected by agents (the part explained by a model: H-P trend, ARMA/GARCH model + linear- trend); ii) an error term or unpredicted component, which we call “volatility”.

In our estimation of volatility as the standard deviation from H-P filter, explained component of the variance is given by the variance of H-P trend, the unexplained variance is the variance of the cycle generated by the H-P filter.

In the ARMA/GARCH models, the explained variance is the variance of the sum of the trend component (with or without breaks) and the ARMA/GARCH model. The unexplained variance is the variance of the error term.

### Table 8. Variance decomposition

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Australia</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hodrick-Prescott filter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explained</td>
<td>0.01162 (46%)</td>
<td>0.02189 (54%)</td>
<td>0.00696 (36%)</td>
</tr>
<tr>
<td>Variance H-P cycle</td>
<td>0.00988 (39%)</td>
<td>0.01276 (31%)</td>
<td>0.00989 (52%)</td>
</tr>
<tr>
<td>2 x Cov(,)</td>
<td>0.00386 (15%)</td>
<td>0.00606 (15%)</td>
<td>0.00222 (12%)</td>
</tr>
<tr>
<td>Total Variance</td>
<td>0.02537 (100%)</td>
<td>0.04076 (100%)</td>
<td>0.01909 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Australia</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARMA/ARCH of TOT linearly detrended</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explained</td>
<td>0.01 (52%)</td>
<td>0.01 (53%)</td>
<td>0.03 (69%)</td>
</tr>
<tr>
<td>Unexplained</td>
<td>0.012 (47%)</td>
<td>0.012 (46%)</td>
<td>0.009 (28%)</td>
</tr>
<tr>
<td>2 x Cov(,)</td>
<td>0.00 (1%)</td>
<td>0.00 (1%)</td>
<td>0.00 (3%)</td>
</tr>
<tr>
<td>Total</td>
<td>0.03</td>
<td>0.02</td>
<td>0.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Australia</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARMA/ARCH of TOT linearly detrended with breaks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explained</td>
<td>0.01481 (60%)</td>
<td>0.03380 (82%)</td>
<td>0.01224 (70%)</td>
</tr>
<tr>
<td>Unexplained</td>
<td>0.01026 (41%)</td>
<td>0.01061 (26%)</td>
<td>0.00603 (34%)</td>
</tr>
<tr>
<td>2 x Cov(,)</td>
<td>-0.00020 (-1%)</td>
<td>-0.00318 (-8%)</td>
<td>-0.00078 (-4%)</td>
</tr>
<tr>
<td>Total</td>
<td>0.02487 (100%)</td>
<td>0.04105 (100%)</td>
<td>0.01748 (100%)</td>
</tr>
</tbody>
</table>

In the most of cases, the *unexplained* component is less than 50% of the total variability. From this comparison, it is noticeable that the order of the degree of volatility varies with the
chosen model. The cycle generated by the Hodrick-Prescott filter includes a cycle and a residual or irregular component. The variance of the cycle of Australia is the highest one, followed by Argentina and New Zealand. In the ARMA/GARCH models uncertainty is higher for Argentina, followed by Australia and New Zealand. Finally, if we consider the models obtained with the linearly detrended series with structural breaks, TOT Australia are the most predictable ones. In this model, our proxy for “uncertainty of TOT” amounts to 26% for Australia, 34% for New Zealand, and 41% for Argentina.

4. Synthesis and policy implications

Sharp fluctuations in commodity prices in recent years have renewed the academic interest in the pattern and effects of TOT volatility. The interpretation of the observed movements in the TOT, and the subsequent prediction capacity, is becoming crucial for policy making.

A key decision for development is the way of integrating the economy in the world; the design of policy strategies must be based on the knowledge of how the economic system works on each specific economy, rather than just following general receipts. In particular, when evaluating the advantages of insertion in the international economy, due concern must be kept about the possibility of adding instability on economic activity.

Based on the perception that specialization rises (and diversification reduces) the terms of trade volatility, together with the empirical findings in the literature indicating that volatility is harmful, a usual policy recommendation for countries with high terms of trade volatility is to reduce it via export diversification. However, given the “first nature” of these countries’ endowment, to move specialization away from their comparative advantages may be costly.

The sectorial specialization due to endowment abundance is associated to current controversial discussions: the role of natural resources in economic development, the distribution of benefits from trade, and the dynamic effects of exports diversification towards manufactures.

We argue that the fact that Argentina, Australia and New Zealand show a similar pattern of volatility along time may be caused by their shared “extreme specialization”. Our empirical estimations showed that there are substantial similitudes in the pattern of volatility of Argentina, Australia and New Zealand along 140 years. We test if the volatility of Argentina, Australia and New Zealand terms of trade shares similar historical long-run patterns since the early times in the XIXth century along the years 1870-2009.

Firstly, results from the analysis of statistical measures of dispersion, and the finding of coincident structural breaks in terms of trade variability (around the beginning of the WWI and in the early 1950s), are consistent with our presumption.

Secondly, under the hypothesis that rational agents form their expectations using available data on past observations, we use “variability” for statistical features, in contrast to “volatility” taken as a proxy for uncertainty in economic decisions or, in other words, the unexpected changes in terms of trade. We propose two empirical measures of volatility as the unexpected change in the TOT.

The first one is the cycle generated by a Hodrick-Prescott filter. The local trend has three peaks, two near the breaks and a third one in the current time for the three countries; and terms of trade cycles of these land-abundant countries are genuinely cross correlated.

The second volatility measure is obtained through time series modeling, following the intuition that rational agents form expectations based on the conditional distribution rather than the unconditional distribution. We find there are common sub periods on terms of trade volatility, with high conditional standard deviations in the years between the world wars for the three countries. “Volatility” has been lower during the last decades for the three of them.
Policy recommendations

The three countries we study are sectorially specialized on trade as determined by land-abundance; as a consequence their TOT are volatile, but correcting via sectorial diversification is costly. The policy question is conceptually how to deal with volatility in the presence of structural resource rigidities.

The evidence suggests, in our view, that land-abundance, which is a peculiarity of resource endowment of these countries, creates a long run restriction that remains in spite of diverging production structures, trade and institutions. Export diversification may have reduced TOT volatility of Australia and New Zealand within the group of land-abundant countries - compared with Argentina-, but this diversification did not proceed to a point to alter the differences between groups, namely, their relative endowments and larger TOT volatility relative to capital abundant, land scarce countries.

The discussion provides an interesting new ingredient to the idea that export diversification increases welfare by reducing the magnitude of aggregate TOT shocks (Kenen 1969). This single strategy may be associated in certain countries with rising costs of diversification in terms of the loss of benefits from trade when the economy moves away from comparative advantages. Policy schemes based on multiple instruments, rather than focusing in export diversification to reduce volatility that is likely to face increasing costs, look preferable. A combined strategy would work in various spheres. One is to reduce volatility by diversification up to the point of optimal benefit-costs. A second is to develop policies and institutions to manage efficiently what remains of volatility. The third is to implement instruments to smooth welfare effects of shocks, particularly of food prices with substantial weight in the consumption basket of workers.

Last, a critical issue is that increasing productivity in the export sector would allow a higher level of the production frontier. Even in the extreme case of no diversification and hence, no reduction of volatility, those fluctuations would be at a higher welfare level.

Sectorial diversification may not have been worthwhile. From a revealed preferences perspective, persistent specialization may be the practical consequence of both private and public agents finding out that sticking in sectorial specialization is the best choice, given the set of information they have previous the realization of prices. However, if dynamic externalities or intergenerational transfer problems create a gap between private and social optimal choices, the observed specialization cannot be interpreted as the best option for society.

Note that even with large exogenous terms of trade movements, if reducing terms of trade volatility by sectorial diversification is costly, it might be advisable to pursue a balance between alternative ways to manage the effects of fluctuations by export diversification and smoothing internal effects through a combination of efficiency gains, institutional development, and internal flexibility.

Policy can be examined in two dimensions: the traditional “inter-sectorial” dichotomy (such as import substitution) and, with a given sectorial specialization, the “intra sectorial” opportunities with still ample room for raising efficiency. Improvements in productivity in the natural-resource abundant sector rises GDP: even if terms of trade volatility remains unchanged, higher efficiency expands the possibilities frontier with resulting higher factor income and welfare.

A related suggestion is that the diversification strategy may be intra-sectorial rather than inter-sectorial.

It has also been noted that the lack of efficient financial systems in developing economies weakens the capacity to smooth the effects of terms of trade shocks and volatility. Policy debates about optimal specialization and import substitution alternatives for developing countries have not reached a consensus. Moreover, in countries like Argentina government
renewals still cause policy shifts, failing to provide stable signals for investment decisions related to trade.

The research agenda includes, among others, revise theorizing about optimal trade and domestic policies when there is extreme land abundance; improving the empirical methods; distinguish movements in prices of exports and prices of exports and examine their time series properties together with terms of trade behavior; broaden the sample by including other natural resource abundant, "new settlement" countries (Uruguay, Canada and the United States), and non resource abundant countries to identify properties of world trade prices volatility.

5. References


Dyster, B. (1979), "Argentina and Australian development compared", Past & Present,
Volumen LXXXIV (1), pp 91.


Annex 1. Data sources

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOT</td>
<td>Annual data</td>
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</table>

Annex 2. Growth and exports

Table 9 illustrates the growth and trade framework. The three economies depict an extraordinary GDP growth record in the first epoch between 1870 and the First World War, specially faster in Argentina; but after the wars their GDPpc performance diverged markedly. Even more remarkable differences are seen on their exports performance in the three last columns.

Table 9. Growth performance of Argentina, Australia and New Zealand

<table>
<thead>
<tr>
<th>Year</th>
<th>AUS</th>
<th>ARG</th>
<th>NZ</th>
<th>AUS</th>
<th>ARG</th>
<th>NZ</th>
<th>AU</th>
<th>AR</th>
<th>NZ</th>
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</thead>
<tbody>
<tr>
<td>1870</td>
<td>6157</td>
<td>2354</td>
<td>906</td>
<td>23 (3801)</td>
<td>8.1 (1311)</td>
<td>16 (3115)</td>
<td>98</td>
<td>29</td>
<td>12</td>
</tr>
<tr>
<td>1913</td>
<td>26540</td>
<td>29060</td>
<td>5810</td>
<td>100 (5505)</td>
<td>100 (3797)</td>
<td>100 (5178)</td>
<td>382</td>
<td>515</td>
<td>112</td>
</tr>
<tr>
<td>1994</td>
<td>308125</td>
<td>282408</td>
<td>52193</td>
<td>1161 (17107)</td>
<td>971 (8373)</td>
<td>898 (15085)</td>
<td>42542</td>
<td>12235</td>
<td>9824</td>
</tr>
</tbody>
</table>

Sources: Maddison (1997). (a) GDPpc, constant dollars of 1990. Table D.1a and D.1d. (b) Index of GDP 1913=100 Table B.10a and B.10d. Author’s own tabulations.