Economic activity and the terms of trade. Argentina, a case study

Sergio Martín Buzzi, María Victoria Catalano, José Luis Arrufat, Alberto M.Díaz Cafferata

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Catalano, María
Arrufat, José L.
Díaz Cafferata, Alberto

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Economic activity and the terms of trade
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Sergio Martín Buzzi
María Victoria Catalano
José Luis Arrufat
Alberto M. Díaz Cafferata[2 3]

Summary
We address the influence of terms of trade (TOT) on GDP in Argentina using an 1810-2014 annual database. Eighteen multivariate VAR econometric models are estimated under diverse hypotheses for the relationship among economic activity, TOT, and a few control variables. We find for this particular case weak empirical evidence of a positive relationship between TOT and GDP levels; some evidence of a negative TOT volatility-GDP level relationship; and some evidence on the existence of a positive link between TOT growth volatility and GDP growth volatility. In general the relationships have the expected signs but are not statistically significant.

Keywords: Land abundance. Terms of trade. Volatility. Economic growth. Argentina. Case study.Policy strategy.

JEL classification: F10, F13, F14

Resumen
Contrastamos la hipótesis de que los términos de intercambio (TI) afectan la economía argentina estimando dieciocho modelos VAR con diversas hipótesis sobre la relación entre el PIB, los TI y variables de control con datos anuales para 1810-2014. Hay evidencia débil de relación positiva entre los TI y el PIB en niveles; de relación negativa entre volatilidad de TI y PIB; y cierta evidencia de una relación positiva entre las volatilidades del crecimiento de TI y del PIB. En general, las relaciones poseen los signos esperados pero baja significación estadística.

Palabras claves: Abundancia de tierra. Términos de Intercambio. Volatilidad. Crecimiento económico. Argentina. Estudio de caso. Estrategia de política.

Clasificación JEL: F10, F13, F14

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[2] Díaz Cafferata, Alberto Martín: diazcaf@eco.uncor.edu; Arrufat, José Luis, joseluisarrufat@eco.uncor.edu; Buzzi, Sergio Martín: sergio.buzzi@eco.unc.edu.ar; Catalano, María Victoria: mvictoriacatalano@gmail.com. All authors are from the Instituto de Economía y Finanzas, Facultad de Ciencias Económicas, Universidad Nacional de Córdoba.
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1. Introduction

International trade is central in economic life and a main area of academic research, but the influence of external factors on the dynamics of growth and welfare is still open to debate. A main issue in empirical international economics is to isolate the effect of trade prices and of price volatility, the two most important prices in the open economy being the real exchange rate and the terms of trade (TOT). But it is difficult to estimate the separate influences partly because there are interdependencies between these two prices, as warned in a well-known study for Argentina (Díaz Alejandro, 1981); and the interpretation of observed outcomes is further obscured by the effects of complex policy intervention in exchange markets and of taxation to trade flows. In addition, observed correlations may just be "historical accidents" in periods of strong intervention with protectionist tariffs and multiple exchange rate system, coincident with years of high TOT.

Very succinctly, academic research has addressed the effects of TOT along three lines, the short-term macro Harberger-Laursen-Metzler channel and the Current Account; sectoral impacts, tax collection and other fiscal issues, poverty and income distribution (Barraud, 2008, 2009; Barraud and Calfat, 2008); and the effect of TOT in the evolution of GDP. The latter is discussed here, with reference to Argentina.

We focus mainly on the different TOT-GDP relationships that may exist. In particular, we will test alternative hypotheses, which include these variables in level, rates of growth and volatility.

A concern when the effect of volatility is considered is how it shall be measured. To deal with the identification of the existence, the sign and the magnitude of the TOT volatility-GDP relationship in Argentina, we focus on uncertainty which, in the time series framework, is represented by volatility. High external TOT volatility may have detrimental effects on aggregate activity as it happens in resource abundant, commodity exporting developing countries whose TOT volatility is high compared with other types of economies[4].

Aizenman, Edwards and Riera-Crichton (2012) find that TOT volatility and GDP volatility in emerging countries triple that in industrial countries. Razin, Sadka and Coury (2002) mention (using data between 1960 and 1990) that volatility measured by the percentage standard deviation (SD) in developing countries is several times that of developed countries (Argentina 26.84, Brazil 27.33, Chile 18.86), and the oil exporters (Mexico 30.84, Venezuela 28.04). In contrast, the percentage SD is 7.11 in the United States, 4.56 in the United Kingdom, and 3.64 in Canada. Mendoza (1995) reports for the period 1955-1990 a percentage SD with a mean 4.73 in seven industrial countries, and 12.11 for six LA countries. If we compare land-abundant countries, the measure is 8.34 for Argentina and 2.87 in Canada.

In addition, TOT volatility in these countries is "a typical external source of (macro) fluctuations associated with the export basket" (Arrufat *et al*, 2014)[5].

The TOT are postulated to influence activity, but empirical estimations are generally made without reference to a full-fledged theoretical model[6]; rather, econometric estimations follow a general relationship of the type:

$$GDP=F(TOT, \text{control variables})$$

[4] Furthermore Argentina is relatively more volatile than others of the same type like Canada or Australia (Díaz Cafferata and Mattheus 2010).

[5] Usually associated with the possible inefficiency of choice under uncertainty. To be reviewed in Section 2.

[6] Dehn (2000a) states that "Uncertainty measures are conditional upon a model of the price process which must encapsulate what agents might reasonably regard as predictable components in the price process. Unfortunately, the 'true' model is unobservable, and is in any case likely to be highly subjective."

This general relationship provides stylized facts, empirical bases, to help formulate hypotheses.

In general, the dependent variable, level of activity (measured by "GDP"), may either be the absolute level, its growth, or its volatility.

In turn, the exogenous variable, "TOT", may also be in levels, its rate of change, or its volatility. When incorporating the latter, it is relevant to choose a proper empirical definition of volatility that will be used in the estimations of the TOT-growth relationship. Our definition of TOT volatility is the moving SD of residuals, or the prediction error. The procedures provide empirical limits of fluctuation to the degree of TOT historically observed volatility, as shown in Figure 3.1.

A key question is if the relationships between TOT volatility and GDP are robust to the use of the alternative admissible definitions of TOT volatility[7], understanding that "admissible volatility values" are those indices that recognize the decomposition into predictable and unpredictable components of TOT fluctuations.

We seek to test three hypotheses. Whether TOT are associated with GDP. If the TOT volatility is related to GDP. Whether there is a link between TOT volatility and GDP volatility. In order to do so, we use VAR models, and perform Granger, as well as instant, causality tests.

Measuring volatility: the role of uncertainty

The interest on the volatility of prices stems from the perspective that volatility is a measure of uncertainty, which is an *ex ante* notion assessing the unpredictability of future price movements. We adopt the convention that if economic agents are able to detect regular features in the price process, uncertainty is associated with the unpredictable element (Dehn, 2000a, 2000b). Observed TOT variability is not uncertainty; rather, uncertainty is non-observable, such that for empirical estimation a methodological issue emerges. We assume that a particular definition of a constructed variable, the TOT "volatility", is a *proxy* for the unexpected changes.

Frequency, structural breaks and other issues

The time series approach to empirical estimations of a relationship between TOT and GDP places in the forefront the time dimension; in particular, it makes explicit at which frequency the relationships might happen, i.e. short-term macroeconomic adjustment (shocks[8] of given characteristics, such as the magnitude, the sign, the duration), the medium-run cycles, and the long-run processes. A relationship between TOT and GDP may exist at a certain frequency (quarterly, annual, five years or other cyclical periods) and not at others.

Most empirical works deal with quarterly and annual data. However, Deaton and Miller (1995) point out that economic growth and commodity prices may be linked over quinquennia or decades, rather than over shorter periods[9]. They perform regressions of the average annual rate of growth of real GDP on the average annual rate of growth of the commodity-

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[7] Two related issues that we are not addressing here in detail but are relevant for choosing the control variables are, firstly, the relative influence of domestic and external factors, and secondly, the relative importance of volatility in the real exchange rate or in the terms of trade.

[8] Dehn (2000b) defines shocks in the following way: "Shocks are 'large' price changes, and they can, by virtue of the stochastic process, which determines their incidence, occur at any point in time."

[9] Page 56.

price index, with the averages over a five-year period. Chinn and Prasad (2000) use a panel data set that contains non-overlapping 5-years averages of the data for each country[10].

Other methodological issue is whether there is a contemporaneous or lagged influence. Finally, the relationships may change over time. It is expected that, in many decades of observation, structural breaks may appear.

Given that we have no available data for other countries for a long period, our empirical research exercise will only be for Argentina. Some considerable effort has been devoted to the building of a comparable data base for Australia, Canada, Uruguay, and New Zealand, but this is still work in progress.

We intend to contribute to the knowledge of the phenomenon in Argentina by providing an analysis of the particular relationship of the TOT with the evolution of economic activity in Argentina, by running VAR estimations under a number of admissible constructed *proxies* for uncertainty (*i.e.* volatility). This is a fresh perspective of uncertainty in the Argentine economy, by the use of several alternative admissible time series of TOT volatility.

In the rest of this paper Section 2 provides a selective literature review and provides background information about the Argentine economy.

Section 3 explains the econometric methodology and reports the empirical results. By means of multivariate and bivariate VARs, we implement causality tests, estimate IRFs and variance decompositions following the usual practices. To check for robustness we rely on different measures of volatility of TOT. This builds on previous research (Arrufat *et al.*, 2013; Arrufat *et al.*, 2014).

Section 4 provides a summary of the main results of the paper.

2. Literature review, theoretical and empirical

What kind of evidence emerges from empirical research? There are several different versions of the TOT-economic activity relationship. The explained variable is either the level of output, or the fluctuations of output, or the rate of growth. On the independent side there is the TOT volatility and a set of control variables. Some authors also deal with TOT levels and TOT shocks.

Mendoza (1995) estimates a three sector intertemporal model concluding that TOT shocks account for about one half of the observed variability of GDP. In another contribution the same author (1997) concludes that "the terms of trade are typically a significant and robust determinant of economic growth", and a "positive relationship between terms of trade and growth has been clearly identified".

Barro (1997) states that "changes in the terms of trade have often been stressed as important influences on developing countries, which typically specialize their exports in a few primary products" (p. 28).

Raddatz (2007) writes that it has been extensively documented that unstable countries have grown slower and in a more unstable way.

Turnovsky and Chattopadhyay (2003) conclude that TOT volatility (as measured by the SD of the residuals of the autoregressive process) have a strong negative impact on growth. Furth (2010) finds that differences in TOT volatility account for 25% of the cross country variation. Per adult growth of GDP, capital stock and TFP are negatively linked to TOT volatility.

[10] Page 12.

Grimes (2006) reports also that, consistent with the international evidence, "higher TOT levels and lower TOT volatility contribute to enhanced growth outcomes" especially for commodity export and developing countries. He finds that half the variance in annual GDP growth is explained by the level and volatility of the TOT.

A document of the IADB (1995) concludes that volatility has had a negative effect on development. Joaquín Vial (2002) also found that, among a set of factors, TOT volatility has the largest negative impact (-0.48%) on growth. Similar conclusions can be seen in Kose (2002).

As Lutz (1994) argues, "the price of primary commodities is more volatile than that of manufactured goods" because demand for and supply of primary products is quite inelastic and, as a result, variations will lead to large price fluctuations. Related to this, TOT have proven to account for about half of output volatility in developing countries (Fatima, 2010; Mendoza, 1995).

For a selective survey of the literature, we focus on what the theoretical mechanisms and/or international empirical experience tell about the presence of a Granger-causal relationship running from TOT evolutions to GDP. In particular, we are interested in finding out if TOT volatility could eventually reduce growth.

We understand the use of the concept of TOT "volatility" as a *proxy* for uncertainty, an *ex-ante* measure, and we want to determine whether this volatility is associated to the pattern of growth.

Research on the problem of uncertainty in the TOT started with comparative statics models.

Pomery's (1984) chapter in the Jones and Kenen Handbook provides a perspective of uncertainty in trade models and policy implications. In the supply side uncertainty can be introduced through randomness in technology, in endowments, or in prices, and there may also be randomness on preferences. The question is how it alters results of the traditional models, and if the modeling with uncertainty gives raise to new results. Since uncertainty, and its policy implications varies across different models "we must forgo the comfort of strong conclusions, either positive or normative", and "where powerful results would be most welcome, e.g. on the desirability of free trade, there appear no justification for an unambiguous conclusion"[11].

Helpman and Razin (1978) "develop a theory of international trade in goods and securities in the presence of uncertainty"[12]. They argue that "for many years the main body of the theory of international trade was confined to nonstochastic environments". Uncertainty was taken into account since, "on many occasions arguments about the existence of uncertainty were used to justify assumptions upon which a deterministic analysis was built." And they quote Kemp (1976) telling that "The **recognition of uncertainty seems to have a devastating effect in many of our most cherished propositions**" (p260).

More modern attention is placed on the dynamic effects of volatility on TOT.

Importance of volatility

For a general perspective of the literature, a comprehensive discussion is found in Aizenman and Pinto (2005). The book contains 11 papers reviewing what volatility is and why it matters. They discuss the "consistent empirical finding that volatility exerts a negative impact on growth", and that among the volatility of external origin TOT is a typical source of fluctuations. Chapters 1 (Wolf 2005) and 2 (Hnatkovska and Loayza, 2005) are the most relevant for our study.

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[11] Pomery (1984) p. 461.

[12] Helpman and Razin (1978), pp. 1 – 2.

Hnatkovska and Loayza (2005) pose four questions: (pp. 66-67) whether the link between volatility and growth depends on country and policy characteristics, if there is a causal link, the stability of this relationship, and if it reveals the negative impact of crisis rather than the overall effect of cyclical fluctuations. They conclude that macroeconomic volatility and long-run economic growth are negatively related, an association that does not appear to depend on the degree of openness, and is "exacerbated in countries that are poor, institutionally underdeveloped, undergoing intermediate stages of financial development, or unable to conduct countercyclical fiscal policies". They note that there appears to be a negative relationship between the average and the SD of *per capita* GDP growth, and the connection "seems to depend on structural country characteristics" (p. 66).

Transmission channels: TOT volatility to GDP[13]

TOT volatility, as a *proxy* for uncertainty, may affect growth "via factor accumulation, technical progress, and efficiency. Technical progress and factor accumulation shift out the production possibility frontier, while efficiency brings the economy from a point within the frontier to a point closer to the perimeter" (Dehn, 2000b). However, factor accumulation, or investment, seems to be the main channel through which TOT volatility appears to be transmitted[14]. As Dehn, Gilbert and Varangis (2005) argue, "uncertainty is likely to be particularly important in investment decisions where resources are committed in advance of prices being revealed" (*ex-ante*)[15].

If economic agents face uncertainty, then producers' decisions to invest may be affected. When there are irreversibilities, price uncertainty "renders the future value of an investment project uncertain" and "there is an additional cost to investing in a project" (Lutz, 1994, quoting Pindyck, 1991). The final consequence would be lower output if we deal with a risk-averse firm, imperfect competition and decreasing returns to scale, compared to the certainty case.

Firms would not only underinvest, but also invest in the "wrong" projects (Hnatkovska and Loayza, 2005), resulting in lower economic growth. For example, in countries that depend on the export of agricultural commodities, uncertainty may lead to diversification, both across crops, and of inputs across agricultural and non-agricultural activities, reducing growth (Dehn, Gilbert and Varangis, 2005). A report from the International Institute for Sustainable Development (IISD (2008) for short) presents a similar argument: More volatile commodity prices have a negative effect on producers (IISD, 2008), because uncertainty affects their level of investment (as previously discussed), resulting in lower welfare.

Servén (1998) argues that TOT "are related to the profitability of investment in different sectors", in this case, between the sectors of exportables versus that of importables. However, he also "finds that terms of trade uncertainty *per se* is not a significant determinant of investment. This suggests that to the extent that terms of trade uncertainty affects growth

[13] Many other authors deal with related issues: they either explain how uncertainty in other variables (volatility) affects the economy, or they explain the impact of TOT shocks. As regards the former, in the overview of their book, Aizenman and Pinto (2005) list some empirical studies of volatility: Aizenman and Marion (1993), Ramey and Ramey (1995), Easterly, Islam and Stiglitz (2000); as for the latter, we could mention Rodrik (1999), who suggests a link between trade shocks and growth, and Dehn (2000b), who deals with commodity price shocks and its effects on growth.

[14] The role of uncertainty on investment decisions has been treated by many researchers; among them, we could point out McDonald and Siegel (1986), Caballero (1991), Pindyck and Solimano (1993), Dixit and Pindyck (1994) (see Aizenman and Pinto, 2005).

[15] However, "economists have found only weak empirical evidence for a direct link [between volatility and investment in commodity-dependent countries]" (Dehn, Gilbert and Varangis, 2005).

it must do so via routes other than investment, for example via efficiency and/or the rate of adoption of new technologies" (Dehn, 2000b).

Lower investment is not limited to physical capital; uncertainty could also depress human capital (Perry, 2009; Hausmann and Gavin, 1996).

Hausmann and Gavin also assert that TOT volatility is an important factor underlying volatility of fiscal policy, the latter having sizeable effects that spill over the entire economy.

Finally, volatility in the TOT could also lead to volatility in exports and imports, and hence, give rise to higher output volatility (Larraín and Parro, 2008). This is relevant to the extent that some researchers have found that the relationship between macro fluctuations and growth is negative. Thus, higher TOT volatility renders the economy more unstable, which ultimately reduces growth (Larraín and Parro, 2008).

Macroeconomic volatility is also related to inequality[16]. Firstly, as it has a negative impact on growth, it raises poverty. But it also affects income distribution; one transmission channel works through the relative prices between goods and services, labor demand and employment, returns on physical assets and capital gains or losses, public or private transfers, and community environment effects (Laursen and Mahajan, 2005).

It is important to point out that the negative link between (macro) uncertainty and growth is "exacerbated in countries that are poor, institutionally underdeveloped, undergoing intermediate stages of financial development and unable to conduct countercyclical fiscal policies" (Hnatkovska and Loayza, 2005).

Using covariates

Mendoza (1997) presents an open economy growth model. One class of empirical test considers only TOT to explain growth, noting that other authors (Fischer, 1993 and Easterly *et al.*, 1993) find that TOT "are robust determinant of economic growth, even in the presence of variables that measure country characteristics and economic policies" and that "there is strong evidence … that the contribution of the terms of trade to explain growth can be examined within a simple bivariate framework".

This is however not common practice in empirical research, rather the usual framework is like the one adopted in Aizenman and Marion (1999) who tackle the link between volatility and investment. They report a statistically significant negative correlation linkage between volatility and private investment. So is the case of other studies that employ control variables, as documented in Levine and Renelt (1992):

$$GDPg_i = \beta_0 + \beta_1\sigma_i + \beta_2 X_i + \varepsilon_i$$

where $GDPg_i$, σ_i and X_i stand for GDP growth rate, GDP volatility, and a control variable, respectively.

This is also the case of the growth regression in Hnatkovska and Loayza (2005).

Since the variety of forces that explain growth cannot be captured by TOT only, the practice in empirical research is to use a set of control variables Xi. Eduardo Cavallo (2007) includes 21 variables, among them several usually employed, like government consumption or an oil-exporter dummy, institutional, policy intervention, and a few unusual ones like latitude (distance to the Equator line) or the occurrence of natural disasters.

[16] Shocks can also affect income distribution; in particular, volatile shocks raise inequality, which creates more credit constraints for poorer people (magnified by bad institutions). This has adverse effects on human capital, which reduces growth (Aizenman and Pinto, 2005).

Aromí and dal Bianco (2013) use quarterly data 1959:1-2006:2 to estimate disequilibria of the real exchange rate for Argentina, caused by price rigidities (Edwards, 1988; Razin and Collins, 1999; Aguirre and Calderón 2005). The variables they use are the real exchange rate, the as determined by fundamentals; the TOT (the income effect and the substitution effects of a TOT shock affect the price of nontradeables in a SOE); the degree of openness (trade flows over GDP); the size of the government; and the international rate of interest.

On turn, Larraín and Parro (2008) estimate both a regression and a VAR, including as control variables a measure of openness, the dispersion of TOT growth (a proxy of external shocks), the volatility of investment growth, and the volatility of money growth.

Summing up, variables which are frequently included may be grouped in three types:

i) Variables associated with the influence of the external sector: the degree of openness; TOT, international trade openness (i.e. degree of protection); the average share of trade in GDP.

ii) Variables related to fiscal and monetary policy that may explain economic growth: the degree of fiscal policy procyclicality; investment, fiscal balance, the initial GDP per capita level, the private credit over GDP ratio, growth rate of government consumption as a share of GDP.

iii) Structural variables capturing country characteristics: the growth rate of population; normal as different from crisis volatility (p75); the fraction of population in secondary school; the initial log level of real GDP per capita; the degree of financial deepening; and institutional development.

Basu and McLeod (1992) model the effect of TOT fluctuations on capital accumulation showing that because of the stochastic properties of LDCs output growth, even occasional shocks could lead to persistent changes in output levels and average growth rates. The key structural feature is that imported inputs are purchased only with uncertain export revenue. The two main results are: first, transient TOT shocks have persistent effects on output levels, and second, a mean-preserving spread in export prices may lower output growth.

They examine TOT and growth dynamics by estimating unrestricted VARs[17]. Three variables are included: log levels of TOT and output, and a time varying price variance measure (squared deviations from trend); small country assumption dictates the ordering of TOT level first, followed by the variance measure and output (p107, 109). They conclude that transient shocks have persistent effects on output and that output is positively associated with the level and negatively correlated with variance of export prices.

Case studies

An issue in the estimation strategy is the number of countries considered, with most frequent empirical studies working with panel data. To illustrate this characteristic some of the usual references are Mendoza (1997) who uses data from 40 countries (9 industrial and 31 developing); Bleaney and Greenaway (2001) work with 14 sub-Saharan countries; Hadass and Williamson (2003) look for asymmetries in economic growth between the core and the periphery; Blattman, Hwang and Williamson (2003) examine 35 countries (19 core and 16 periphery); Turnovsky and Chattopadhyay (2003) use a sample of 61 developing countries.

However, even when the usual approach to the study of the TOT-GDP relationship relies on cross-country data, there is also some useful research which is based on individual country experiences.

This latter approach may be particularly useful when there are idiosyncratic features which characterize a group of economies. One such possibly interesting case for our analysis is

[17] The sample includes 19 developing countries, including Argentina (with annual data for 1928- 1988), and also the United States.

that made up by land-abundant countries. This is not necessarily homogeneous, and consequently it may be difficult or even impossible derive or obtain well-grounded economic implications and policy rules given the high degree of disparity. In a nutshell, in this context multi-country studies may be highly inefficient. For these reasons we center our analysis on Argentina to try and bridge the gap from general rules to specific policy applications.

An example of case studies on the volatility-growth relationship is Shilinde (2013) who examines the impact of TOT shock on macroeconomic volatility in Tanzania, and on exchange rate and inflation volatility. Using a VAR framework he estimates there is some influence on the real exchange rate, real interest rate, the real GDP and inflation, though with minimal magnitude and this fluctuation highly persisted through the remaining period. "Overall, these findings lead to the conclusion that the Tanzanian is to some extent susceptible to the terms of trade shock".

Hernández (2013) finds empirical evidence for Colombia: as much as one third of GDP quarterly growth is explained by TOT variations.

Wong (2010), in a study of Korea and Japan, argues that "it is interesting to examine the impact of TOT and TOT volatility on a particular economy[18] (p140) because the impact of TOT on growth is different across economies. Wong estimates an augmented production function, using terms of trade, the TOT volatility measured by a moving SD of order four, and TOT volatility based on a GARCH model, and other five variables: GDP per capita, oil price, labor, capital, and financial development. He concludes that "favorable and less volatile terms of trade are important for economic growth" (p. 157).

Sahay and Goyal (2006) study TOT shocks in LA, where high and low growth episodes occur, argue that "averages mask wide differences in individual country experiences".

Another case, Sub-Saharan Africa by Deaton and Miller (1995), shows that the general case is that volatility is detrimental to growth. Through VARX panel econometric estimations they find that fluctuations in prices of commodities affect output growth, warning that the diversity of economic structures and the heterogeneity of country experiences (p9) may lead to wrong policy advice while, on the contrary, contain wealth of detailed local information that cannot be brought into the econometric methods, and help find similarities and differences. They add that the appropriate general methodology is to use case studies for generation of hypotheses.

Argentina

Argentina is a standard small open economy, commodity exporter, and we want to understand the implications for growth. It is a paradigmatic case of a land abundant country, to a degree we have elsewhere named "extreme land abundant", to mean that it is permanently facing exogenous fluctuating prices.

This structural property, on turn, is a historical restriction for trade with a large component of commodities with volatile prices. A growing interest is given to this feature due to the perceived impact on growth and welfare. However, up to now no significant empirical evidence of the existence of this particular link has been found.

Many policy mismanagements arise from an incorrect perception of the relevant issues at stake. They may also be a consequence of the mishandling of the relevant information available or from judgments errors when forecasting relevant variables.

Some recent research efforts regarding the TOT-GDP relationship have been carried out for the case of Argentina. Gay (2013), for example, introduces TOT in a production function, assuming that exogenously determined TOT affect the quality of the land employed in

[18] We stress this point and we might add the comment is valid for a particular type of economy such as resource abundant, commodity exporters.)

agricultural activities and may also impinge on the agricultural production function. Artana *et al.* (2011), in turn, estimated different versions of an aggregate production function, using TOT as an independent variable, concluding that they had a great influence on Argentina's growth during the historical period they have analyzed.

Another instance is given by an SVAR model by Lanteri (2009), who imposes long-term restrictions and uses the following variables: external TOT; manufacturing output; real multilateral exchange rate; and the consumer price index, to estimate the importance of domestic and external shocks as determinants of macro-fluctuations. External prices shocks have a positive effect on manufacturing output. Manufacturing output fluctuations are mainly due to aggregate supply shocks, and only a mere 5% is accounted for of external prices shocks. In Lanteri (2011), a SVEC model is estimated involving the following variables: external TOT; real GDP; multilateral RER; and the consumer price index. Imposing the restriction of exogenous external TOT in the long-run, he concludes that TOT shocks have a positive and permanent impact on GDP, while their contribution to real GDP fluctuations is only a 17%.

An important topic in applied empirical work is how to deal with structural breaks. This may not seem relevant in many countries but Argentina is particularly prone to sudden and abrupt regime changes. Further, along the two centuries of the sample, the economic relationships have likely changed, a fact that is necessary to determine formally to work with a correct econometric model.

Díaz Cafferata and Fornero (2003) estimate using the state-space method the presence of structural changes in the openness degree variable. They find two structural changes in the trend level for 1938 and 1948 and a structural change for the trend slope in 1974.

Arrufat *et al.* (2013) also deal with structural breaks, finding TOT structural breakpoints in 1839, 1917 and 1951 and GDP structural breakpoints in 1882, 1913, 1945 and 1975. This defines 4 subperiods for the TOT series, and 5 subperiods for the GDP. Subperiods I and II of TOT and GDP coincide with the golden age of export-led growth; afterwards, structural breaks are coincidental with the interwar period. Finally, subperiod IV in the TOT (1951-) and IV and V of the GDP (1945-) is related to the globalization period.

Figures 2.1 and 2.2 show TOT and their standard deviation, respectively. As can be seen, TOT have been increasing during the last two centuries. However, both their levels and their variability have not been stable; rather, some subperiods can be identified.

Figure 2.1

Terms of trade index evolution

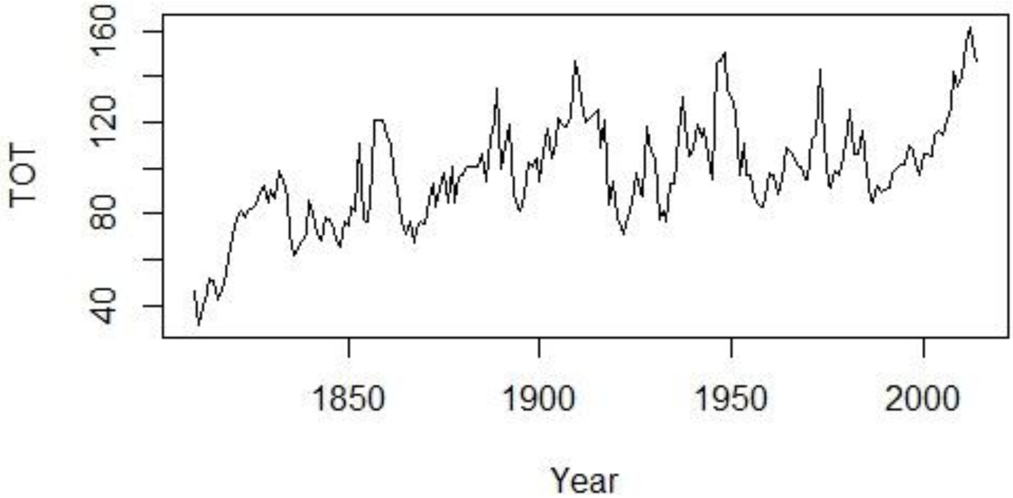
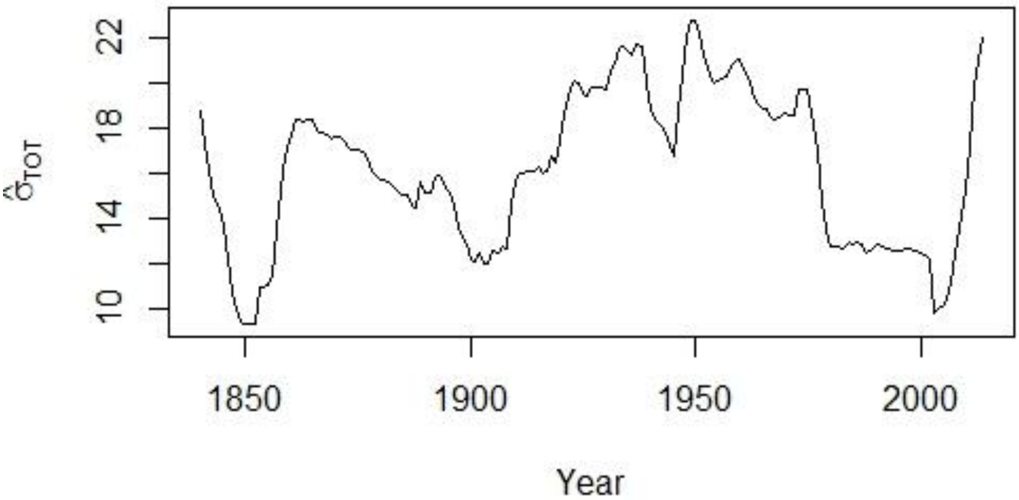


Figure 2.2

Rolling window standard deviation of the terms of trade index



3. The choice of the econometric model and other issues on the testing for causality

Despite the intuition that fluctuating terms of trade would be reflected in economic activity, the international literature has found controversial evidence of this link. We try to find out what is the empirical evidence for Argentina.

TOT could be expressed as levels, shocks, growth, or volatility. The same consideration applies to economic activity.

We do not have a formal theoretical model with desirable properties (*i.e.,* a model that is suitable to capture the structural characteristics of the Argentine economy) to estimate possible TOT-GDP relationships. Given this shortcoming, we instead carry out several empirical exploratory exercises. To this end we consider several "cases" suggested in the literature (see Table 3.1).

Subsection 3.1 presents the working hypotheses and the data. In subsection 3.2 we explore the TOT-GDP relationship, both in levels and growth rates. In subsection 3.3 we study the TOT volatility-GDP relationship (levels and growth), and the subsection 3.4 deals with the TOT volatility-GDP volatility relationship (levels and growth, as well).

Table 3.1

Econometric estimations[19] of TOT and economic activity relationships in the literature.

TOT \ GDP	Level	Growth	Volatility of GDP	Volatility of GDP growth
Level	**Section 3.2.a** Basu and McLeod (1992)	Bleaney and Greenaway (2001); Turnovsky and Chattopadhyay (2003); Grimes (2006); Wong (2010)		
Shocks	SR macroeconomic effects HLM	Dehn (2000b)		
Growth		**Section 3.2.b** Mendoza (1997); Turnovsky and Chattopadhyay (2003);		
Effects of volatility				
Volatility of the TOT	**Section 3.3.a *** Basu and McLeod (1992); Wong (2010)	Inter American Development Bank (1995); Mendoza (1997); Vial (2002); Blattman *et al.* (2003); Turnovsky and Chattopadhyay (2003); Grimes (2006); Furth (2010); Wong (2010)	**Section 3.4.a *** Eduardo Cavallo (2007)	
Volatility of the TOT growth		**Section 3.3.b ***		**Section 3.4.b *** Larraín and Parro (2008)

* Each of the estimations involving “volatility of the TOT” is carried out with 4 alternative definitions of volatility which, on turn implies different TOT volatility – GDP (volatility) relationships.
\+ TOT shocks may be shocks in the TOT levels or in shocks in the volatility.

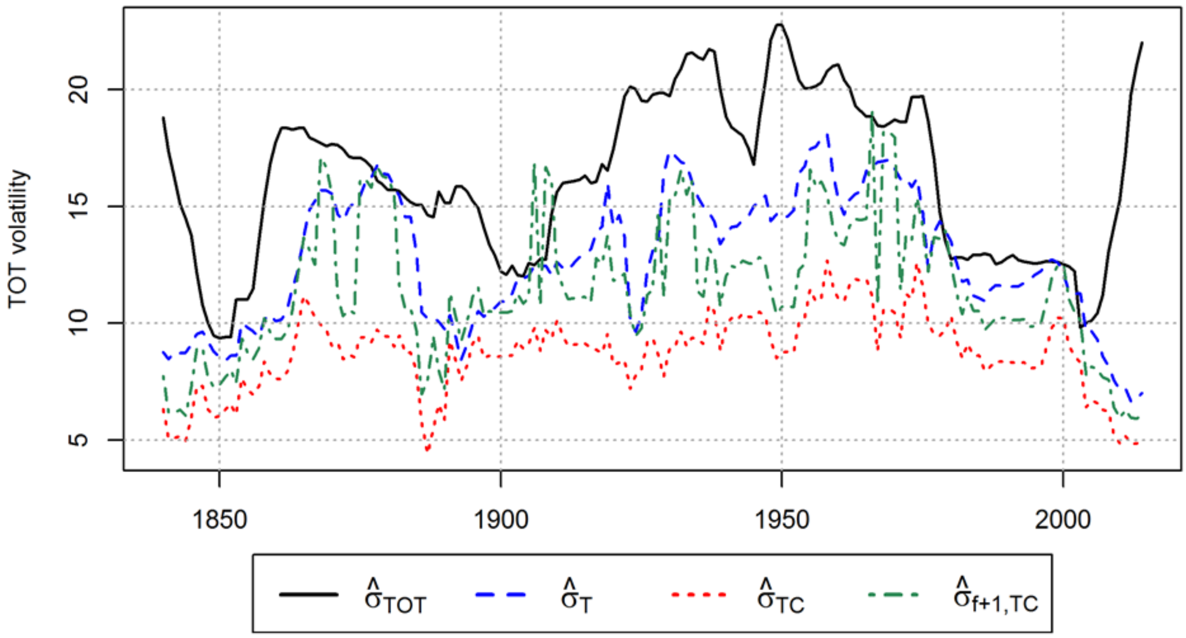
[19] We estimate eighteen models, one in section 3.2.a, one in section 3.2.b, and four models in each of the sections 3.3.a, 3.3.b, 3.4.a, 3.4.b.

Subsections 3.3 and 3.4 take into account the warning in Arrufat *et al.* (2014) that, rather than relying on a unique "correct" TOT volatility series, several admissible constructions deserve consideration. These volatility measures are derived by means of various procedures. The pairwise correlation between the different measures is variable. In particular there is not a perfect positive correlation, with the implication that the econometric estimations are influenced by each particular choice of the TOT volatility series.

Therefore, four alternative TOT volatility indicators will be used as follows: a 30-year fixed width rolling-window; the SD of the raw TOT ($\hat{\sigma}_{TOT}$); the SD of the detrended TOT ($\hat{\sigma}_{T}$); the SD of the detrended an decycled TOT ($\hat{\sigma}_{TC}$); and the one-step ahead SEP of the detrended and decycled TOT ($\hat{\sigma}_{f+h,TC}$). Analogous indicators are built in order to proxy TOT growth volatility such as $\hat{\sigma}_{TOTg}$; $\hat{\sigma}_{T,TOTg}$; $\hat{\sigma}_{TC,TOTg}$; and $\hat{\sigma}_{f+h,TC,TOTg}$, where g is a subscript that denotes that the measures rely on the use of TOT growth rate as input.

Figure 3.1

Argentina, TOT volatility measures; rolling window m=30, 1840-2014.



Our TOT volatility benchmark is the Standard Deviation of the TOT, a widely used indicator of volatility in the literature. To make it comparable with other methods it is estimated with a 30-year fixed width rolling window (**m**=30). It may be argued that this series tends to overestimate "volatility" because it does not remove the predictable components which are not a surprise to economic agents.

When additional modeling is incorporated, the unexplained residual is reduced, such that the estimated *ex ante* volatility falls, giving rise to substantially different representations of TOT uncertainty with regards to the temporal patterns and magnitudes, as shown in Figure 3.1.

The SD of the residuals from the detrended model is necessarily smaller than our benchmark.

If the cycles are also removed, the SD of the residuals from detrending plus decycling ($\hat{\sigma}_{T}$ > $\hat{\sigma}_{TC}$) is smaller than the SD of the residuals from the detrending only model since the former has removed additionally the variability due to cycles.

From this perspective, the SD from the logged TOT would seem to overestimate TOT volatility. However this is not necessarily true if we consider the additional uncertainty faced by agents when they look forward into the future. That is, the main costs for producers and consumers arise from errors in forward looking plans. In order to represent this kind of volatility, we calculated the one-step ahead standard error of prediction from the detrending plus decycling model. Figure 3.1 shows that the widely used SD from the raw series does not always overestimate TOT volatility if it is compared with $\hat{\sigma}_{f+h,TC}$.

Also, the one-step ahead standard error of prediction from the detrending plus decycling approach is more unstable than the SD of the residuals from the same model, and $\hat{\sigma}_{TC}$ < $\hat{\sigma}_{f+1,TC}$, provided $\hat{\sigma}_{f+1,TC}$ incorporate the forecasting uncertainty.

Without a formal model it would be questionable claim that any of these could be purported to be superior to the remaining ones on better capturing the underlying unobservable phenomenon.

A particular structural hypothesis of the Argentine economy is posed. We work with a 200 year annual database, without structural breaks, a particular definition of the TOT (net barter TOT) and multiple definitions of volatility.

3.1. The data and working hypotheses on the relationship TOT-GDP

In order to analyze the TOT effects on GDP, we explore three main hypotheses that may be followed in Table 3.1:

1) TOT improvements (levels or growth rate) raise both GDP and GDP growth rates.
2) TOT volatility impairs GDP.
3) TOT volatility is positively related with GDP volatility.

In the context of time series analysis, these relationships are studied by means of either bivariate reduced form VAR models (as an exploratory approach) or multivariate VARs which include additional variables.

We use annual data for Argentina from 1810 to 2014. The original variables are: GDP, TOT, real investment, real government spending and real M_3 monetary aggregate. Using these series, several growth rates and volatility measures are computed.

The data were obtained from Ferreres (2010) and the *Instituto Nacional de Estadísticas y Censos* (INDEC) for all the variables except for the monetary aggregate M_3. This latter series was built using data from Ferreres (2010), the *Banco Central de la República Argentina*, and the *Dirección Provincial de Estadísticas y Censos de San Luis*.

Before estimating the models, we conducted tests for the order of integration which revealed that the series are stationary.

Table 3.2 contains a summary of the estimated models specifications.

Table 3.2

Estimated multivariate VAR models

		Model	Variables
TOT vs. GDP	TOT vs. GDP	1	TOT, GOV, INV, GDP
	TOTg vs. GDPg	2	TOTg, GOVg, logINV, GDPg
TOT volatility vs. GDP	TOT volatility vs GDP	3	$\hat{\sigma}_{TOT}$, TOT, GOV, INV, GDP
		4	$\hat{\sigma}_{T}$, TOT, GOV, INV, GDP
		5	$\hat{\sigma}_{TC}$, TOT, GOV, INV, GDP
		6	$\hat{\sigma}_{f+h,TC}$, TOT, GOV, INV, GDP
	TOTg volatility vs. GDPg	7	$\hat{\sigma}_{TOTg}$, TOTg, GOVg, logINV, GDPg
		8	$\hat{\sigma}_{T,TOTg}$, TOTg, GOVg, logINV, GDPg
		9	$\hat{\sigma}_{TC,TOTg}$, TOTg, GOVg, logINV, GDPg
		10	$\hat{\sigma}_{f+h,TC,TOTg}$, TOTg, GOVg, logINV, GDPg
TOT volatility vs. GDP volatility	TOT volatility vs. GDP volatility	11	$\hat{\sigma}_{TOT}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
		12	$\hat{\sigma}_{T}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
		13	$\hat{\sigma}_{TC}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
		14	$\hat{\sigma}_{f+h,TC}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
	TOTg volatility vs. GDPg volatility	15	$\hat{\sigma}_{TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$
		16	$\hat{\sigma}_{T,TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$
		17	$\hat{\sigma}_{TC,TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$
		18	$\hat{\sigma}_{f+h,TC,TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$

3.2 Terms of trade effects on GDP: levels and growth

3.2.a TOT levels vs. GDP levels (indices 1993=100) (Model 1)

Several researchers such as Lutz (1994), Artana *et al.* (2011), Samimi (2011) and Gay (2013) have included either the TOT or the TOT volatility in an aggregate production function. In this line, Basu and Mc Leod (1992) build a dynamic model which incorporates imported inputs in the production function. Also if in the long term the economy must satisfy its balance of payments constraint, imports must be financed with exports whose relative value depend on the TOT.

In order to explore whether or not there is some evidence of a TOT-GDP relationship for Argentina, we estimate both a bivariate reduced form VAR for the TOT index and the GDP index, and a multivariate reduced form VAR. Under the latter approach, additional variables are included. As was shown in Section 2, the literature suggests a broad set of admissible variables. However, many of the usual control variables are not available for a long time span. The variables included are the TOT; real government spending (*GOV*); real investment (*INV*); and the real GDP indices, for the period 1864-2014. The lag selection is made by the Bayesian Information Criterion.

The multivariate VAR estimation has the following impulse response functions and forecast error variance decomposition for the GDP:

Figure 3.2

Impulse response function and cumulative impulse response functions

(Impulse: TOT; response: GDP)

(a) (b)

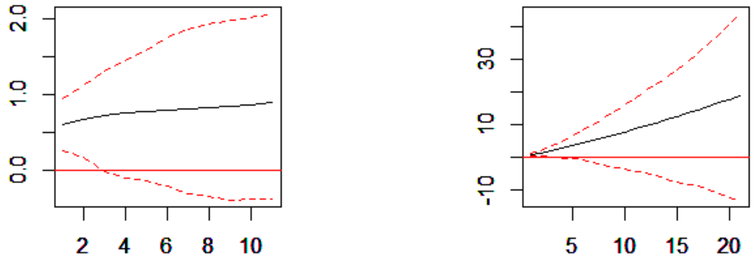


Table 3.3

Forecast error variance decomposition of GDP

lag	TOT	GOV	INV	GDP
1	0.0379	0.2065	0.5846	0.1710
2	0.0432	0.1628	0.5648	0.2292
3	0.0473	0.1289	0.5393	0.2846
4	0.0502	0.1031	0.5118	0.3348
5	0.0522	0.0839	0.4848	0.3791

In Figure 3.2, panel (a) we report the responses of GDP to a shock of TOT, whereas panel (b) shows the cumulative responses. A TOT shock generates a permanent positive but not significant response of GDP. Also the magnitude of these responses is nearly zero. The contribution of TOT growth shocks accounts for 5% of the GDP growth rate fluctuations. This number has the same sign but is significantly lower than that obtained in Lanteri (2011) who estimates an SVEC using quarterly data for the period 1980:1-2009:1.

In addition to the multivariate VAR, we also estimate a bivariate reduced form VAR in order to explore if the TOT Granger cause the GDP index or whether there is instant causality. In the following table, the p-values of both tests are reported.

Table 3.4

Bivariate Granger and instant causality tests p-values
Null-hypothesis: TOT does not (Granger or Instant) cause GDP

Granger	Instant
0.8756	0.0352

The Granger non-causality test shows that the TOT growth rate does not Granger-cause the GDP growth rate. On the other hand, the instantaneous non-causality test suggests the existence of instant causality between both variables.

3.2.b TOT index growth vs. GDP index growth (Model 2)

In order to explore whether the TOT growth-GDP growth link is valid for Argentina we run a multivariate reduced form VAR. The variables included are the TOT index; real GDP; and real government spending growth rates (TOTg, GDPg, and GOVg, respectively), and the logged investment (logINV) for the period 1865-2014.

Figure 3.3

Impulse response function and cumulative impulse response functions

(Impulse: TOT growth; response: GDP growth)

(a) (b)

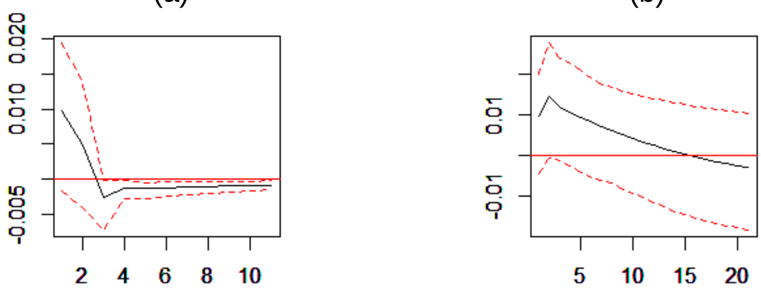


Figure 3.3 shows that a TOT growth rate shock generates initially a positive but not statistically significant response of the GDP growth rate but after three periods the partial effect turns negative, and the cumulative response is nearly zero.

Table 3.5

Forecast error variance decomposition of the GDP growth rate

lag	TOTg	GOVg	logINV	GDPg
1	0.0231	0.0458	0.3895	0.5415
2	0.0287	0.0454	0.3890	0.5368
3	0.0301	0.0452	0.3909	0.5339
4	0.0303	0.0450	0.3927	0.5319
5	0.0306	0.0449	0.3943	0.5302

The contribution of TOT growth shocks accounts for about 3% of the GDP growth rate fluctuations.

Table 3.6

Bivariate Granger causality and instant causality tests p-values.
Null-hypothesis: TOT growth does not (Granger or Instant) cause GDP growth

Granger	Instant
0.2859	0.0585

The Granger non-causality test shows that the TOT growth rate does not Granger-cause the GDP growth rate. On the other hand, the instantaneous non-causality test suggests the existence of instant causality between both variables, provided that its p-value is close to the standard 5% significance level.

The analysis of both the TOT-GDP and the TOT growth-GDP growth relationships suggests that positive TOT shocks permanently increase GDP, and positive TOT growth shocks generate a transient increase on GDP growth rate.

3.3 Terms of trade volatility effects on GDP: levels and growth

In this subsection we explore the TOT volatility-GDP link. This analysis is made estimating multivariate and bivariate VARs, both in levels and growth rates.

3.3.a Terms of trade volatility vs. GDP (Models 3, 4, 5, 6)

We first run four models including the variables TOT volatility ($\hat{\sigma}_{TOT}, \hat{\sigma}_{T}, \hat{\sigma}_{T}, \hat{\sigma}_{f+h,TC}$); TOT; real government spending (GOV); real investment (*INV*); and real GDP. Following Arrufat *et al.* (2014), the four alternative TOT volatility measures cited in Section 3.2 are used.

Table 3.7

Estimated models

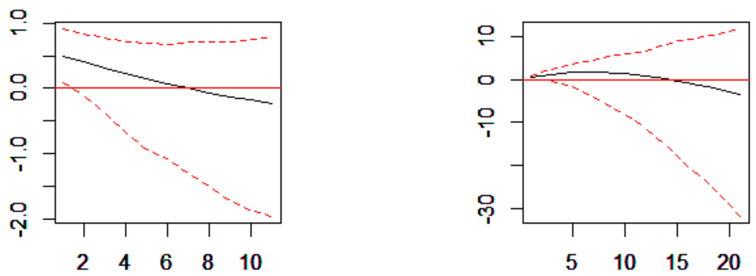
Model	Variables
3	$\hat{\sigma}_{TOT}$, TOT, GOV, INV, GDP
4	$\hat{\sigma}_{T}$, TOT, GOV, INV, GDP
5	$\hat{\sigma}_{TC}$, TOT, GOV, INV, GDP
6	$\hat{\sigma}_{f+h,TC}$, TOT, GOV, INV, GDP

Figure 3.4

Impulse response and cumulative impulse response functions

(Impulse: TOT volatility; response: GDP)

Model 3 (Impulse: $\hat{\sigma}_{TOT}$; response: GDP)



Model 4 (Impulse: $\hat{\sigma}_{T}$; response: GDP)

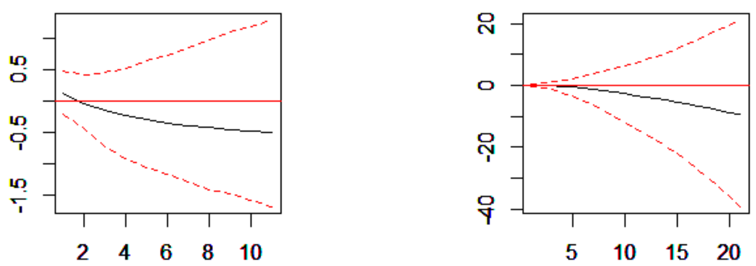
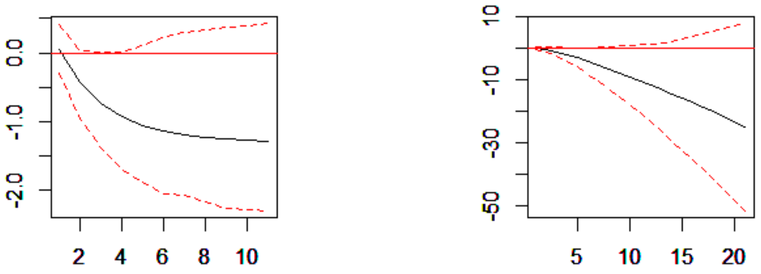
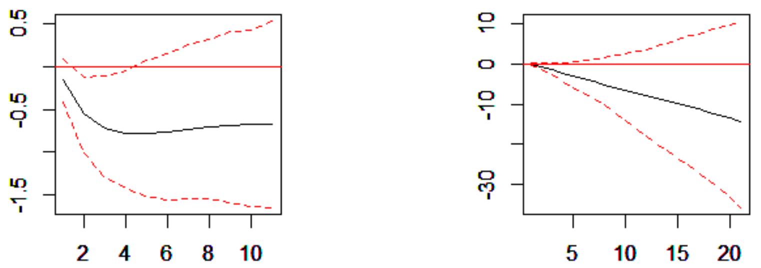


Figure 3.4 (continued)

Model 5 (Impulse: $\hat{\sigma}_{TC}$; response: GDP)



Model 6 (Impulse: $\hat{\sigma}_{f+h,TC}$; response: GDP)



The impulse response functions suggest that the effects of TOT volatility shocks on GDP are significant for $\hat{\sigma}_{f+h,TC}$, and almost significant for $\hat{\sigma}_{TC}$.

Table 3.8

Forecast error variance decomposition of the GDP index

Model 3

lag	$\hat{\sigma}_{TOT}$	TOT	GOV	INV	GDP
1	0.0257	0.0202	0.1926	0.5885	0.1729
2	0.0218	0.0241	0.1448	0.5718	0.2375
3	0.0181	0.0263	0.1090	0.5466	0.3000
4	0.0147	0.0272	0.0834	0.5175	0.3572
5	0.0120	0.0271	0.0656	0.4875	0.4079

Model 4

lag	$\hat{\sigma}_{T}$	TOT	GOV	INV	GDP
1	0.0013	0.0312	0.2007	0.5906	0.1762
2	0.0008	0.0310	0.1473	0.5675	0.2534
3	0.0013	0.0306	0.1089	0.5343	0.3250
4	0.0024	0.0301	0.0824	0.4981	0.3870
5	0.0038	0.0299	0.0646	0.4632	0.4386

Table 3.8 (continued)

Model 5

lag	$\hat{\sigma}_{TC}$	TOT	GOV	INV	GDP
1	0.0002	0.0289	0.1771	0.6076	0.1862
2	0.0101	0.0271	0.1186	0.5669	0.2773
3	0.0264	0.0261	0.0811	0.5127	0.3538
4	0.0423	0.0258	0.0588	0.4598	0.4132
5	0.0558	0.0263	0.0457	0.4139	0.4584

Model 6

lag	$\hat{\sigma}_{f+h,TC}$	TOT	GOV	INV	GDP
1	0.0022	0.0307	0.1919	0.5985	0.1767
2	0.0169	0.0290	0.1387	0.5690	0.2464
3	0.0291	0.0296	0.1022	0.5315	0.3075
4	0.0369	0.0314	0.0778	0.4947	0.3592
5	0.0410	0.0339	0.0613	0.4614	0.4024

The forecast error variance decompositions displayed in Table 3.7 show that the TOT volatility shocks do not have, in general, a great impact on GDP except for the case of $\hat{\sigma}_{TC}$, and $\hat{\sigma}_{f+h,TC}$.

Table 3.9

Bivariate Granger causality and instant causality tests p-values

Null-hypothesis: TOT volatility does not (Granger or Instant) cause GDP

	Granger	Instant
$\hat{\sigma}_{TOT}$ **does not cause GDP**	0.6688	0.5504
$\hat{\sigma}_{T}$ **does not cause GDP**	0.4322	0.5286
$\hat{\sigma}_{TC}$ **does not cause GDP**	0.0645	0.6695
$\hat{\sigma}_{f+h,TC}$ **does not cause GDP**	0.3922	0.9594

There is no evidence of Granger or instant causality from TOT volatility to GDP, except for $\hat{\sigma}_{TC}$ whose Granger causality test's p-value is 0.0645.

The impulse response functions, forecast error variance decompositions shows that TOT volatility (if measured by $\hat{\sigma}_{TC}$, and $\hat{\sigma}_{f+h,TC}$) negatively impacts on the level of economic activity. On the other hand, the Granger and instant causality tests, show that the unique TOT volatility measure that seems to impact on GDP is $\hat{\sigma}_{TC}$. To sum up, we can conclude that there are some evidence of a negative relationship between TOT volatility and GDP levels.

3.3.b TOT growth volatility vs GDP growth (Models 7, 8, 9, 10)

Further, we run four models including the variables TOT growth volatility ($\hat{\sigma}_{TOTg}$, $\hat{\sigma}_{T,TOTg}$, $\hat{\sigma}_{TC,TOTg}$, $\hat{\sigma}_{f+h,TC,TOTg}$); TOT growth (*TOTg*); real goverment spending growth (GOV*g*); logged real investment (*logINV*); and real GDP growth (*GDPg*).

Table 3.10

Estimated models

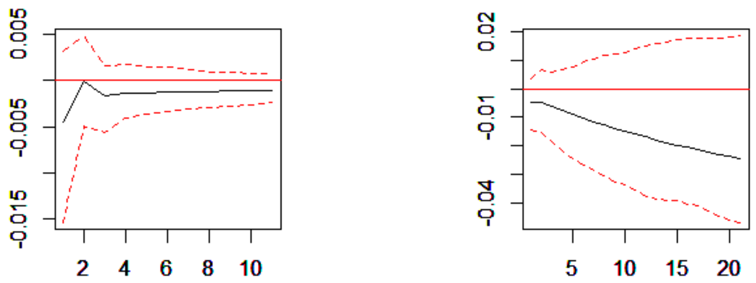
Model	Variables
7	$\hat{\sigma}_{TOTg}$, TOTg, GOVg, logINV, GDPg
8	$\hat{\sigma}_{T,TOTg}$, TOTg, GOVg, logINV, GDPg
9	$\hat{\sigma}_{TC,TOTg}$, TOTg, GOVg, logINV, GDPg
10	$\hat{\sigma}_{f+h,TC,TOTg}$, TOTg, GOVg, logINV, GDPg

Figure 3.5

Impulse response and cumulative impulse response functions

(Impulse: TOT growth volatility; response: GDP growth)

Model 7 (Impulse: $\hat{\sigma}_{TOTg}$; response: GDP growth)



Model 8 (Impulse: $\hat{\sigma}_{T,TOTg}$; response: GDP growth)

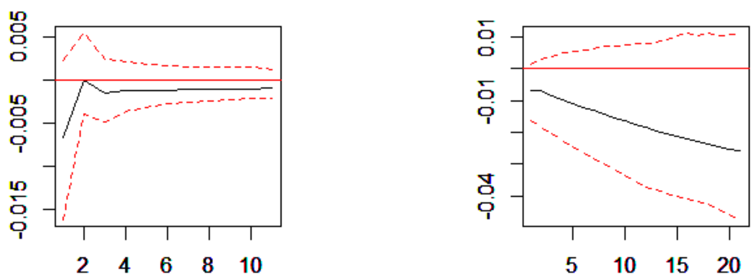
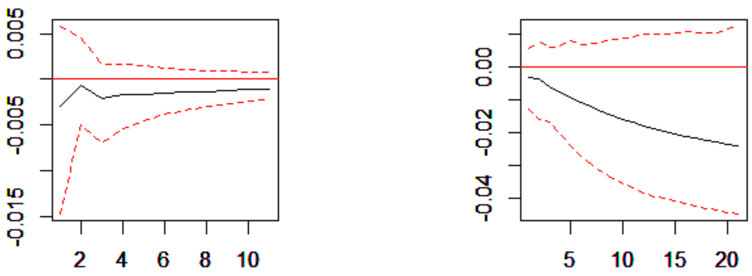
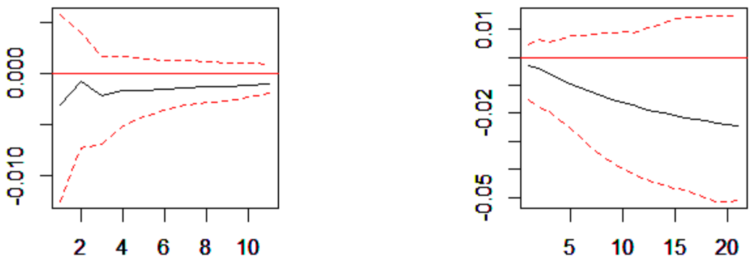


Figure 3.5 (continued)

Model 9 (Impulse: $\hat{\sigma}_{TC,TOTg}$; response: GDP growth)



Model 10 (Impulse: $\hat{\sigma}_{f+h,TC,TOTg}$; response: GDP growth)



The impulse response functions show that TOT growth volatility shocks generate a negative but not significant effect on GDP growth.

Table 3.11

Forecast error variance decomposition of GDP growth

Model 7

lag	$\hat{\sigma}_{TOTg}$	TOTg	GOVg	logINV	GDPg
1	0.0050	0.0253	0.0966	0.3314	0.5417
2	0.0049	0.0299	0.1017	0.3280	0.5355
3	0.0056	0.0316	0.1018	0.3279	0.5332
4	0.0060	0.0317	0.1018	0.3285	0.5320
5	0.0064	0.0320	0.1018	0.3290	0.5308

Model 8

lag	$\hat{\sigma}_{T,TOTg}$	TOTg	GOVg	logINV	GDPg
1	0.0111	0.0263	0.0934	0.3271	0.5422
2	0.0109	0.0307	0.0987	0.3238	0.5358
3	0.0115	0.0325	0.0988	0.3237	0.5335
4	0.0118	0.0327	0.0989	0.3243	0.5324
5	0.0122	0.0330	0.0989	0.3248	0.5311

Table 3.11 (continued)

Model 9

lag	$\hat{\sigma}_{TC,TOTg}$	TOTg	GOVg	logINV	GDPg
1	0.0022	0.0238	0.0984	0.3318	0.5438
2	0.0023	0.0284	0.1037	0.3282	0.5374
3	0.0033	0.0300	0.1038	0.3280	0.5349
4	0.0040	0.0301	0.1039	0.3284	0.5336
5	0.0047	0.0303	0.1039	0.3289	0.5322

Model 10

lag	$\hat{\sigma}_{f+h,TC,TOTg}$	TOTg	GOVg	logINV	GDPg
1	0.0023	0.0239	0.0984	0.3316	0.5438
2	0.0024	0.0285	0.1037	0.3280	0.5374
3	0.0035	0.0301	0.1038	0.3278	0.5348
4	0.0042	0.0302	0.1038	0.3283	0.5335
5	0.0049	0.0304	0.1038	0.3287	0.5322

The forecast error variance decompositions show that TOT growth volatility shocks have a nearly zero impact on GDP growth.

Table 3.12
Bivariate Granger causality and instant causality tests p-values.

Null-hypothesis: TOT growth volatility does not (Granger or Instant) cause GDP growth

	Granger	Instant
$\hat{\sigma}_{TOTg}$ **does not cause GDP growth**	0.8761	0.6264
$\hat{\sigma}_{T,TOTg}$ **does not cause GDP growth**	0.8403	0.3630
$\hat{\sigma}_{TC,TOTg}$ **does not cause GDP growth**	0.7523	0.7196
$\hat{\sigma}_{f+h,TC,TOTg}$ **does not cause GDP growth**	0.7519	0.7084

There is no evidence of Granger or instant causality from TOT growth volatility to GDP growth. As a conclusion of impulse response functions, forecast error variance decomposition and granger and instant causality tests, there is no evidence of a TOT volatility growth - GDP growth link.

3.4 Terms of trade volatility and GDP volatility: levels and growth

In this subsection, we analyze the TOT volatility - GDP volatility relationship, in both levels and growth rates. The variables included in the models are inspired by Larraín and Parro (2008).

3.4.a TOT volatility vs. GDP volatility (levels) (Models 11, 12, 13, 14)

We first run four models including the variables TOT volatility ($\hat{\sigma}_{TOT}$, $\hat{\sigma}_{T}$, $\hat{\sigma}_{TC}$, $\hat{\sigma}_{f+h,TC}$); real M_3 volatility ($\hat{\sigma}_{M_3}$); real investment volatility ($\hat{\sigma}_{INV}$); and real GDP volatility ($\hat{\sigma}_{GDP}$), where each one of the models use a different TOT volatility measure.

Table 3.13
Models estimated

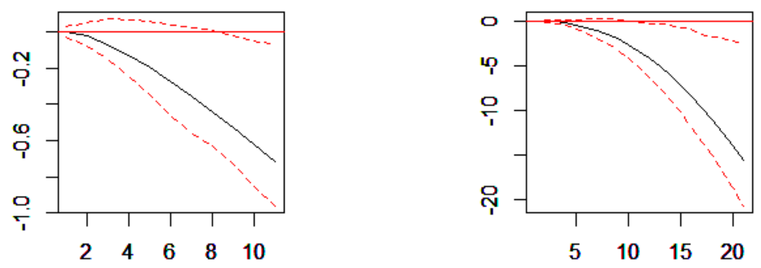
Model	Variables
11	$\hat{\sigma}_{TOT}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
12	$\hat{\sigma}_{T}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
13	$\hat{\sigma}_{TC}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$
14	$\hat{\sigma}_{f+h,TC}$, $\hat{\sigma}_{M_3}$, $\hat{\sigma}_{INV}$, $\hat{\sigma}_{GDP}$

Figure 3.6

Impulse response and cumulative impulse response functions

(Impulse: TOT volatility; response: GDP volatility ($\hat{\sigma}_{GDP}$))

Model 11 (Impulse: $\hat{\sigma}_{TOT}$; response: $\hat{\sigma}_{GDP}$)



Model 12 (Impulse: $\hat{\sigma}_{T}$; response: $\hat{\sigma}_{GDP}$)

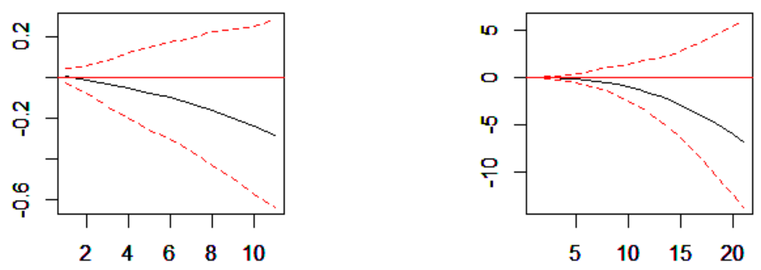
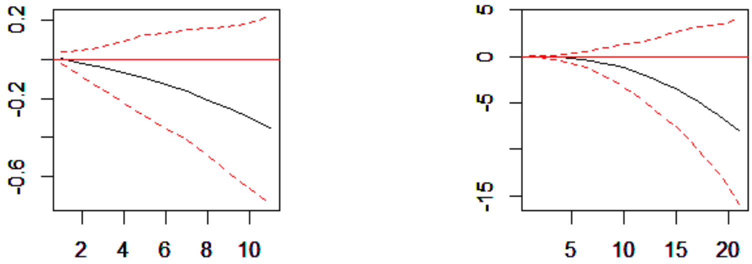
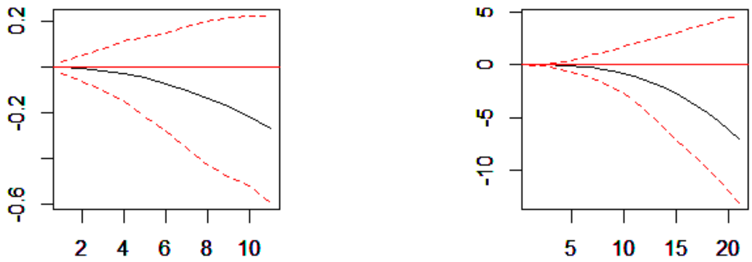


Figure 3.6 (continued)

Model 13 (Impulse: $\hat{\sigma}_{TC}$; response: $\hat{\sigma}_{GDP}$)



Model 14 (Impulse: $\hat{\sigma}_{f+h,TC}$; response: $\hat{\sigma}_{GDP}$)



The impulse response functions show that TOT volatility shocks may have a negative effect on GDP volatlity, but the results are not significant except in the case of shocks in the $\hat{\sigma}_{TOT}$. Even so, this impact is nearly zero.

Table 3.14

Forecast error variance decomposition of the GDP volatility ($\hat{\sigma}_{GDP}$)

Model 11

lag	$\hat{\sigma}_{TOT}$	$\hat{\sigma}_{M_3}$	$\hat{\sigma}_{INV}$	$\hat{\sigma}_{GDP}$
1	0.0001	0.2175	0.4080	0.3744
2	0.0027	0.2166	0.3248	0.4559
3	0.0106	0.2177	0.2766	0.4951
4	0.0227	0.2228	0.2478	0.5067
5	0.0380	0.2322	0.2294	0.5005

Model 12

lag	$\hat{\sigma}_{T}$	$\hat{\sigma}_{M_3}$	$\hat{\sigma}_{INV}$	$\hat{\sigma}_{GDP}$
1	0.0017	0.2727	0.3786	0.3470
2	0.0009	0.2922	0.3035	0.4034
3	0.0024	0.3156	0.2553	0.4267
4	0.0040	0.3435	0.2238	0.4286
5	0.0056	0.3755	0.2021	0.4168

Table 3.14

Table 3.14 (continued)

Model 13

lag	$\hat{\sigma}_{TC}$	$\hat{\sigma}_{M_3}$	$\hat{\sigma}_{INV}$	$\hat{\sigma}_{GDP}$
1	0.0010	0.2563	0.3865	0.3562
2	0.0017	0.2788	0.3012	0.4183
3	0.0039	0.3021	0.2460	0.4481
4	0.0063	0.3280	0.2096	0.4560
5	0.0090	0.3576	0.1846	0.4488

Model 14

lag	$\hat{\sigma}_{f+h,TC}$	$\hat{\sigma}_{M_3}$	$\hat{\sigma}_{INV}$	$\hat{\sigma}_{GDP}$
1	0.0000	0.2627	0.3940	0.3432
2	0.0001	0.2894	0.3163	0.3942
3	0.0005	0.3146	0.2697	0.4152
4	0.0011	0.3419	0.2404	0.4166
5	0.0020	0.3724	0.2207	0.4049

The forecast error variance decompositions suggest that TOT volatility shocks are not important to explain GDP volatility fluctuations

Table 3.15
Bivariate Granger causality and instant causality tests p-values.

Null-hypothesis: TOT volatility does not (Granger or Instant) cause

GDP volatility ($\hat{\sigma}_{GDP}$)

	Granger	Instant
$\hat{\sigma}_{TOT}$ **does not cause** $\hat{\sigma}_{GDP}$	0.1253	0.5432
$\hat{\sigma}_{T}$ **does not cause** $\hat{\sigma}_{GDP}$	0.1503	0.6853
$\hat{\sigma}_{TC}$ **does not cause** $\hat{\sigma}_{GDP}$	0.0779	0.8994
$\hat{\sigma}_{f+h,TC}$ **does not cause** $\hat{\sigma}_{GDP}$	0.2366	0.7499

Table 3.14 displays that there is not evidence on the existence of Granger nor instant causality from TOT volatility to GDP volatility.

In summary, the impulse response functions, forecast error variance decompositions, and Granger and instant causality tests find no evidence of a TOT volatility – GDP volatility relationship.

3.4.b TOT growth volatility vs. GDP growth volatility (Models 15, 16, 17, 18)

Further, we run four models including the variables TOT growth volatility ($\hat{\sigma}_{TOTg}$, $\hat{\sigma}_{T,TOTg}$, $\hat{\sigma}_{TC,TOTg}$, $\hat{\sigma}_{f+h,TC,TOTg}$); real M_3 growth volatility ($\hat{\sigma}_{M_3g}$); real investment growth volatility ($\hat{\sigma}_{INVg}$); and real GDP growth volatility ($\hat{\sigma}_{GDPg}$).

Table 3.16

Models estimated

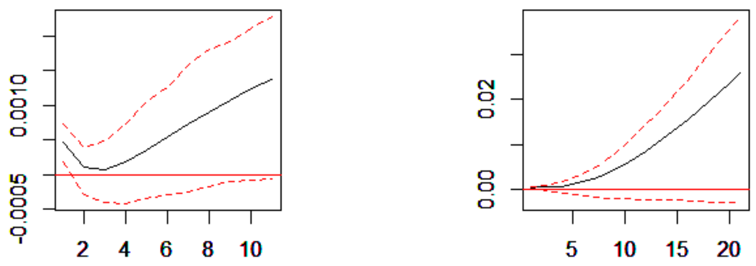
Model	Variables
15	$\hat{\sigma}_{TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$
16	$\hat{\sigma}_{T,TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$
17	$\hat{\sigma}_{TC,TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$
18	$\hat{\sigma}_{f+h,TC,TOTg}$, $\hat{\sigma}_{M_3g}$, $\hat{\sigma}_{INVg}$, $\hat{\sigma}_{GDPg}$

Figure 3.7

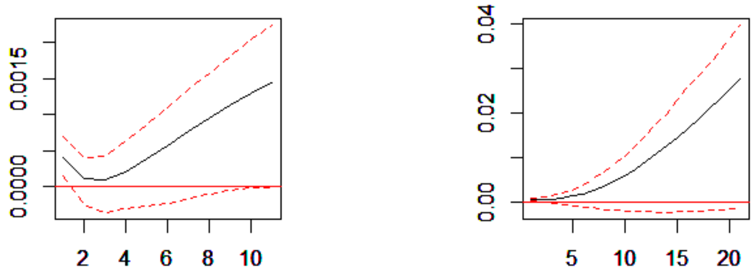
Impulse response functions

(Impulse: TOT growth volatility; response: GDP growth volatility ($\hat{\sigma}_{GDPg}$))

Model 15 (Impulse: $\hat{\sigma}_{TOTg}$; response: $\hat{\sigma}_{GDPg}$)



Model 16 (Impulse: $\hat{\sigma}_{T,TOTg}$; response: $\hat{\sigma}_{GDPg}$)



Model 17 ((Impulse: $\hat{\sigma}_{TC,TOTg}$; response: $\hat{\sigma}_{GDPg}$)

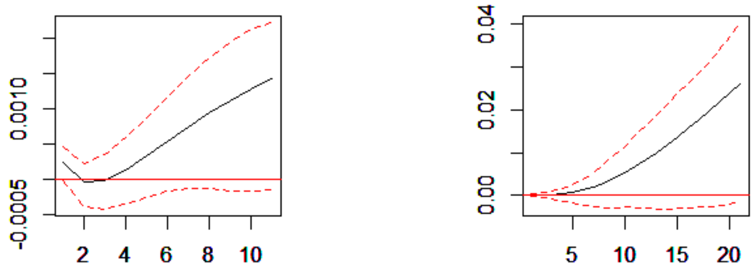
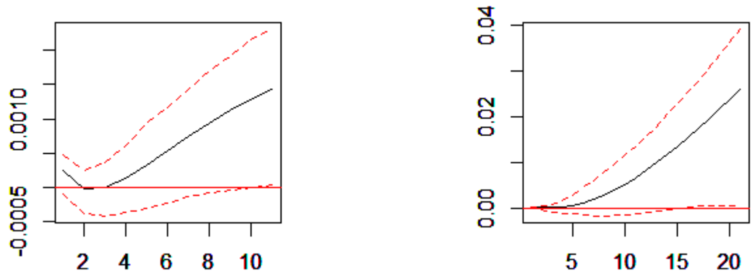


Figure 3.7 (continued)

Model 18 (Impulse: $\hat{\sigma}_{f+h,TC,TOTg}$; response: $\hat{\sigma}_{GDPg}$)



From the impulse response functions we find evidence of positive effects of TOT growth volatility on GDP growth volatility. Those effects are not statistically significative, but they seem to have a quite important size if we consider that the mean of the GDP volatility growth is 0.0545.

Table 3.17

Forecast error variance decomposition of the GDP growth volatility

Model 15

lag	$\hat{\sigma}_{TOTg}$	$\hat{\sigma}_{M_3g}$	$\hat{\sigma}_{INVg}$	$\hat{\sigma}_{GDPg}$
1	0.0560	0.0038	0.0878	0.8524
2	0.0317	0.0021	0.3465	0.6198
3	0.0205	0.0041	0.5381	0.4374
4	0.0163	0.0101	0.6508	0.3229
5	0.0178	0.0192	0.7126	0.2504

Model 16

lag	$\hat{\sigma}_{T,TOTg}$	$\hat{\sigma}_{M_3g}$	$\hat{\sigma}_{INVg}$	$\hat{\sigma}_{GDPg}$
1	0.0454	0.0056	0.0845	0.8645
2	0.0265	0.0030	0.3386	0.6319
3	0.0177	0.0044	0.5303	0.4476
4	0.0152	0.0098	0.6442	0.3308
5	0.0182	0.0182	0.7069	0.2568

Model 17

lag	$\hat{\sigma}_{TC,TOTg}$	$\hat{\sigma}_{M_3g}$	$\hat{\sigma}_{INVg}$	$\hat{\sigma}_{GDPg}$
1	0.0157	0.0052	0.0889	0.8902
2	0.0085	0.0028	0.3487	0.6400
3	0.0053	0.0048	0.5417	0.4481
4	0.0049	0.0101	0.6560	0.3290
5	0.0088	0.0176	0.7193	0.2543

Table 3.17 (continued)

Model 18

lag	$\hat{\sigma}_{f+h,TC,TOTg}$	$\hat{\sigma}_{M_3g}$	$\hat{\sigma}_{INVg}$	$\hat{\sigma}_{GDPg}$
1	0.0161	0.0053	0.0890	0.8897
2	0.0087	0.0029	0.3485	0.6400
3	0.0055	0.0048	0.5413	0.4484
4	0.0050	0.0101	0.6556	0.3293
5	0.0089	0.0176	0.7189	0.2545

The forecast error variance decompositions show that the alternative TOT volatility measures explain a reduced portion of GDP growth volatility fluctuations. Nevertheles, the impulse response fucntions sugest that this portion may be greater for lags higer than five.

Table 3.18

Bivariate Granger causality and instant causality tests p-values.

Null-hypothesis: TOT growth volatility does not (Granger or Instant) cause

GDP growth volatility ($\hat{\sigma}_{GDPg}$)

	Granger	Instant
$\hat{\sigma}_{TOTg}$ **does not cause** $\hat{\sigma}_{GDPg}$	0.0148	0.2234
$\hat{\sigma}_{T,TOTg}$ **does not cause** $\hat{\sigma}_{GDPg}$	0.0291	0.3654
$\hat{\sigma}_{TC,TOTg}$ **does not cause** $\hat{\sigma}_{GDPg}$	0.0687	0.9383
$\hat{\sigma}_{f+h,TC,TOTg}$ **does not cause** $\hat{\sigma}_{GDPg}$	0.0688	0.9163

There is evidence of Granger causality from the TOT growth volatility measures to GDP growth volatility. Further, the overall analysis shows that there are some evidence of a positive link between TOT growth volatility and GDP growth volatility.

To sum up, there is not an clear cut TOT volatility - GDP volatility link when the analysis is made in levels. If any significant relationship existed, it would be a negative one. On the contrary, there is some evidence of a positive link between TOT growth volatility and GDP growth volatility.

4. Synthesis

What do we mean by volatility? Are there different types of volatility? Do all types of volatility matter for growth? How does higher volatility translate into lower growth?

In this work we addressed the study of the TOT-GDP links, implementing multivariate VAR models and testing different hypotheses:

1) TOT improvements (levels or growth rate) raise both GDP and GDP growth rates.
2) TOT volatility impairs GDP.

3) TOT volatility is positively related with GDP volatility.

Our approach considered volatility as a proxy for uncertainty, and we used several constructed measures (from Arrufat *et al.*, 2014) for estimations of the impact of TOT volatility.

The main results are:

1) The analysis of both the TOT-GDP and the TOT growth-GDP growth relationships suggests that positive TOT shocks permanently increase GDP, and positive TOT growth shocks generate a transient increase on GDP growth rate.

2) TOT volatility (if measured by $\hat{\sigma}_{TC}$, and $\hat{\sigma}_{f+h,TC}$) seems to have a negative impact on the level of economic activity. This fact does not stand true for the TOT growth volatility-GDP growth relationship.

3) There is not an apparent TOT volatility-GDP volatility link. On the contrary, there is some evidence of a positive link between TOT growth volatility and GDP growth volatility.

To sum up, we find that in general the relationships have the expected signs, but in certain cases they are not statistically significant. This latter fact can be due to different reasons, such as the expected links can be inexistent or weak for Argentina; the relationships may exist at a different frequency than the captured for annual data; the presence of unmodeled structural breaks or outliers; the existence of thresholds or assymetries; and the omission of variables which are important to explain GDP growth or GDP volatility.

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