Blue Plan Papers 5

EVALUATION OF THE ECONOMIC IMPACTS OF EXTREME EVENTS IN MEDITERRANEAN COUNTRIES

Céline Gimet




PLAN BLEU
UNEP/MAP Regional Activity Centre

December 2009

Blue Plan Papers 5

EVALUATION OF THE ECONOMIC IMPACTS OF EXTREME EVENTS IN MEDITERRANEAN COUNTRIES

Céline Gimet

PLAN BLEU
UNEP/MAP Regional Activity Centre

December 2009

Cover design: Plan Bleu

Layout: Plan Bleu

Legal Notice

The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of Plan Bleu concerning the legal status of any State, Territory, city or area, or of its authorities, or concerning the delimitations of their frontiers or boundaries.

Copyright

For bibliographic purposes this volume may be cited as:

Plan Bleu : Evaluation of the Economic Impacts of Extreme Event in Mediterranean Countires, Valbonne, 2010 (Blue Plan Papers 5).

ISBN : 978-2-912081-20-9

Plan Bleu
UNEP/MAP Regional Activity Centre
15, rue Beethoven, Sophia Antipolis
06560 Valbonne
France
www.planbleu.org

CONTENTS

Acknowledgements

Report realised under the direction of Henri-Luc Thibault, director of Plan Bleu.

Author

Céline Gimet

Senior Lecturer Lyon 2 University, GATE (Analysis and economic theory group) UMR 5824 CNRS, ENS Lyon Bureau R132, 15 Parvis René Descartes BP 7000, 69342 Lyon cedex 07, France
Tel: 04.37.37.62.82; Fax: 04.37.37.60.24; Email: gimet@gate.cnrs.fr

Production team

Bibliography and documentation: Hélène Rousseaux

Editing and page layout: Isabelle Jöhr

Proofreading: Sandra Dulbecco

Abstract

The Mediterranean counts among the regions that are most exposed to climate change. The undertaking of prevention and adaptation measures thus emerges as a priority for the region with a view to mitigating the costs connected with the climate. The objective of this study is to highlight the economic losses already incurred by the Mediterranean countries due to extreme weather events. A Structural VAR Model helps assess the vulnerability of the real monetary and financial sectors of four countries of the region—characterised by different economic profiles—, following periods of extreme climate variation. The analysis reveals that all the countries of the sample already incur quite significant economic losses which are set to further worsen with the exacerbation of these climate phenomena, if no action is undertaken.

JEL classification: Q54, C32, E00.

Keywords: Extreme weather events, economic cost, Mediterranean region, Structural VAR Model, temperature/ precipitation variation.

Introduction

The Mediterranean is one of the regions likely to be most rapidly confronted with major physical difficulties connected with climate variability (Stern, 2006; Plan Bleu, 2008). These problems will be further exacerbated by an increase in demand on agricultural products, infrastructures, housing and energy due to the economic development and the demographic growth of the countries. Such a situation is likely to give rise to a widening of the disparities not only between the North and the South, but also within the same region. More particularly, the adverse impacts of extreme events would significantly affect growth in the region and create major difficulties in the countries. Paradoxically enough, the economic impact of climate change in Mediterranean countries has received scarce attention in the empirical literature on the topic. It is, therefore, urgent to focus on the costs likely to be incurred by the countries in the coming decades, if no preventive measure is undertaken in order to pre-empt or mitigate these phenomena. The intention is to call attention of decision-makers as to the need to address this problem in a comprehensive way, as well as to the urgency of undertaking prevention and adaptation measures. Besides, an upstream consideration of climate change impacts and challenges in the very act of setting out development strategies is crucial for ensuring, in the years to come, the region's political stability.

The objective of this paper is to highlight the costs due to extreme weather events in the Mediterranean, taking into consideration the different profiles of the countries. All countries of the region already bear the brunt of this type of shock whose scope and frequency are set to be further exacerbated. Accordingly, this will consist, first of all, in evaluating the current losses which the countries incur in the advent of extreme climate variations. These costs vary according to the country's specialization in the production and exportation of goods issuing from the primary, secondary or tertiary sectors. Besides, certain countries have already opted for the implementation of measures aimed at mitigating the impacts of extreme climate variations, which should help them better control and more rapidly mitigate the adverse impacts of such shocks. Moreover, according to their geographical position, climate risks are, and will be, different, and the economic and social impacts will depend, to a large extent, on the specificities of the countries in terms of demographic growth and development. For this reason, it would be interesting to compare countries of the Mediterranean region which have quite diverse profiles: one from the North, one from the East, and two from the South, one of which is an oil importer and the other an oil exporter. This is conducted under the form of an innovative study on the topic. The innovative thrust rests on the use of a Structural VAR Model—one that has, as yet, scarcely been used—to estimate the costs due to climate variation. The Model allows for the introduction of restrictions with regard to the short and medium term relations between the variables according to underlying economic assumptions (hypotheses), which helps identify the model and facilitates the interpretation of the results (Sims, 1986)[1]. As

[1] The choices made are warranted by the economic literature (Blanchard *et al*., 1989, Gali, 1992, Mackowiak, 2007), as well as by the works of experts (Plan Bleu, 2005, 2008).

extreme weather events, one would consider, in particular, the case of heat waves and floods likely to occur over a period ranging from one day to several weeks and whose impacts are both catastrophic and large scale (Hallegate *et al*., 2007).

As a first step, it would be useful to provide an overview of the main findings of the economic literature on the costs of climate change in the Mediterranean. Afterwards, there will be conducted an empirical analysis whose purpose is to reckon the cost of extreme weather events in the countries selected for the study. Then, prior to highlighting the costs incurred by inaction over the years to come (2010-2030), it would be relevant to estimate the current costs based on concrete data. The method elected and the restrictions selected to characterise the Model will be specified. The results will highlight the various types of response by the countries, the scope of the costs incurred by each type of extreme weather event, and the response capacity of each of the countries as elicited by the scope and duration of the shock. The conclusions may lead to recommendations on the likely measures to be adopted with a view to preventing and mitigating the impacts of such extreme shocks, notably in the more vulnerable countries.

The Mediterranean at grips with climate change

Most of the studies purporting to evaluate the economic losses due to the climate tend to focus mainly on the future costs of climate change, ignoring the damage already inflicted. Therefore, the evaluation of such costs rests on a set of hypotheses in terms of anticipation of climate forecasts based on scientific studies. However, the uncertainty inherent to the countries' socio-economic, climatic and environmental evolution necessarily involves the consideration of various climatic and economic scenarios, especially when it comes to studies whose time frame extends beyond 2050.

Meteorological references

It is difficult to estimate with any exactness the future climate variations. For this reason, it is often resorted—in order to take into consideration the various possible cases—to several forecast scenarios whose actual materialisation depends on a certain probability. Thus, pessimistic and optimistic scenarios are compared to a baseline scenario, called "business as usual", which is identified as maintaining the status quo (Stern, 2006). Choices vary according to economists, which makes it difficult to conduct an objective comparison of their results. The main climate hypotheses selected in the economic literature are those put forward by the third IPCC Assessment Report (mainly the A2, A1B and B2) (Mendelson *et al*. 2000 ; Nordhaus, 2006, Stern, 2006). Nevertheless, the more precise studies, focusing on a region in particular, tend to resort to detailed climate scenarios derived from specific models[2].

Regarding the Mediterranean region, warming had started at the turn of the century and has intensified over the past few decades. A rise in temperature by around +2°C over the last forty years has been observed in South-West Europe (IPCC 2007; Plan Bleu, 2008). This situation is identical in North Africa, though not so easily quantifiable due to an incomplete observation network. Climate studies with a focus on the region forecast a rise in atmospheric temperature in the range of +2.2 C° to +5.1 C° for Southern European and Mediterranean countries over the period 2080-2099 as compared with the period 1980-1999 (IPCC 2007, scenario A1B). This phenomenon is set to be accompanied by a marked decrease in rainfall, ranging between -4 and -27 % for Southern European and Mediterranean countries (while Northern European countries are due to report an increase ranging between 0 and 16 %) (IPCC 2007, scenario A1B) (Plan Bleu, 2008). Extreme weather events are due to become more frequent in the decades to come, together with a change in trajectories, which will extend the scope of the areas concerned. Their frequency had almost doubled between the 1960s and 1990s, thus incurring increasingly heavier costs (Munich-Re, 2009)[3]. In the Mediterranean, this will result, more particularly, in a greater recurrence of drought periods due to a greater frequency of days with a temperature above 30°C (Giannakopoulos *et al.* 2005). Similarly, and besides these heat waves, floods are likely to be more violent (greater frequency of flash floods). In addition, they will exponentially increase as from a certain temperature level, thus causing irreparable damage (Stern, 2006). And yet, although it has been clearly demonstrated that the frequency of such extreme disturbances is set to increase in the future, it remains difficult to establish precise evaluations as to their recurrence.

Nevertheless, despite the lack of precision of these climate studies inherent to the uncertainty with regard to the future evolution of the climate, they serve as a basis for the economic studies of climate change costs.

Economic studies

The studies concerning the economic evaluation of climate change impacts have multiplied over the past few years following an increasing awareness about the significant economic and social costs related to inaction. In

[2] For Mendelson (2007), for instance, climate forecasts are reckoned according to three different processes: the "Panel Climate Model" (Washington *et al*., 2000), the "Center for Climate Research Studies Model" ((Emori *et al*., 1999) and the "Canadian General Circulation Model", (Boer *et al*., 2000).

[3] According to the statistics issued by the major insurance companies for an average number of 650 natural disasters worldwide per year, over the past ten years, 15% are of an exclusively geological nature (volcanic eruptions, earthquakes…), while the remaining 85% are for the major part related to the climate (storms, cyclones, floods…). Their cost for 2004 amounts to 145 billion dollars, of which 100 billion can be ascribed to extreme climate variations, that is more than twice the cost incurred in the year before (Munich-Re, 2005).

order to urge a rapid response by decision-makers, as well as to elicit, as of now, the adoption of preventive or adaptive action policies aimed at an optimal response to climate change, it is necessary to highlight the current economic losses incurred , and the future risks run, by the countries. Besides, the consideration of a whole set of economic, demographic, social and environmental factors, together with their interactions, within the same study, often results in an under-estimation of climate change costs.

In view of the complexity and the newness of this approach, there are only few studies on this subject[4]. The studies initially focused on industrialised countries, moved particularly by the wish of decision-makers to quantify the impacts of several options and compare them in order to best meet the requirements of GHG emissions reduction within the framework of the Kyoto Protocol. Then, gradually, the works started to focus on emerging economies, and this, following the various climate scenarios that underscored the fact that these countries are likely to be very rapidly confronted with major difficulties, while they have very limited means to adapt, and that they had had, until then, a relatively small responsibility in terms of GHG emissions. Such is the case, notably, of the Southern Mediterranean Countries (SMCs). However, lying on the boundary between two continents, this region is insufficiently addressed in the regional studies which favour Africa- or Europe-focused studies (Mendelson *et al.*, 2000; Tol., 2002; Nordhaus *et al*., 2000; Nordhaus, 2006; Stern, 2006).

The main reason why the Mediterranean region is an interesting case is that it is composed of countries with quite diverse economic and environmental profiles. Climate change impacts on the region are, thus, much differentiated. In view of their geographical situation, the northern countries will not undergo immediately any major losses due to climate change; rather, they may even, over a certain period, derive certain benefits from it (energy saving, evolution of crops), in the case of a temperature change within 2°C with respect to the pre-industrial period (from 1960 to 1990) (Mendelson *et al*., 2000, 2006; Tol 2002). The southern countries, however, already experience climate related losses which will go on increasing in the years to come.

The more precise analyses are those which take into consideration climate change impacts both on the countries' market and non market sectors, but—above all—those that integrate the occurrence of extreme events, as well as the additional cost they entail (Stern, 2006). There is no precise definition of extreme climate phenomena; however, they are identified as being large-scale climate changes likely to reach and exceed the maximum thresholds, and are characterized by their scarcity and the scope of their adverse impacts. Accordingly, their low recurrence makes it important to have a quite extended data series in order to study their impacts on the countries (IPCC, 2007). It is, therefore, quite difficult to integrate these phenomena in an economic model. They are often associated with a low-frequency, but high-impact, chaotic reaction of temperatures and precipitations. According to the IPCC (2001), in the case of an extreme weather event, there takes place a shift upwards of the distribution of temperatures and precipitations, as a whole, and in a disproportionate way beyond the thresholds identified as damage-causing. For Stern (2006), these thresholds are set at two standard-deviations with respect to the average. However, caution is required when using such a reference, as the definition of thresholds may be influenced by a change in the average of the data or the deviation, or both.

The impacts they induce result not only in a considerable destruction of capital (infrastructures, notably, but also agricultural production), but also—and above all—in disastrous social and environmental impacts (deaths, injuries, epidemics …) over a period ranging from one day (in the case of cyclones, for instance) to a few weeks (in the case of floods) (Hallegatte *et al*., 2007). Thus, for the Insurance Companies (Swiss Re, 2007; Munich Re, 2007), the threshold selected is reckoned based on a level of economic loss that differs from one country to another. Since the costs assume heavy investments that could have been avoided, this underscores the need for a preventive political intervention.

Most authors do not include these phenomena in their analysis. This is due to several factors. To begin with, all depends on the models implemented. In the case of analyses based on crosscutting data, only the changes occurring in the analysis period and in the sample of countries concerned are taken into consideration. Besides, analyses based on long term growth models do not consider short term shocks. Finally, very few IA[5] models

[4] Among the most commonly referenced: Mendelson *et al.* 2000, 2007; Tol 2002, 2007; Nordhaus *et al.*, 2000, 2006; Smith *et al*., 2003; Stern, 2006.
[5] Integrated Assessment Modelling.

(Tol, 2006) incorporate such events[6]. Moreover, as the anticipation of the frequency and scope of these extreme events by climate studies is difficult, they are often not taken into consideration.

Broadly speaking, the estimated future global costs range from 7% (in 2100) to up to 14% (in 2200) of global GDP per capita, according to the more comprehensive studies (Nordhaus *et al*., 2000; Stern, 2006). The results of the analyses relevant to the Mediterranean region are fairly disparate due to a determining influence of the analysis framework and the hypotheses selected. However, the losses anticipated into 2100 would be around 1.88% of GDP on average for Africa and of 1.50% for Eastern Europe, according to the hypothesis of an increase in temperature by 2.5° in 2100. At introduction of extreme events, it is assumed that the temperatures could increase by 6° with respect to the pre-industrial period. The losses would then reach 7.12% and 6.94% of GDP, respectively (Nordhaus *et al*., 2000). It is, thus, obvious that it is the extreme events which will be responsible for the greatest portion of the economic losses.

However, in order to assess more precisely the future economic impact of climate change, it is necessary to take into consideration the countries' adaptation capacity—an aspect that is often scarcely taken into account—, and which depends on a large number of specific factors (institutional environment, access to technology (Tol, 2007 ; Stern, 2006)). That is why, before putting forward estimates of the anticipated costs of the impacts of extreme events from a long-term perspective, it is important to measure the current losses with reference to different countries of the region and their promptness to respond, which will highlight their current adaptation capacity to extreme climate variation and, hence, the progress to be made in order to mitigate the impacts of such variation.

Extreme climate shocks in the Mediterranean over the period 1980-2002

With reference to Stern's works (2006), the periods during which there occurred extreme weather events are identified once the level indicators (temperatures and precipitations) take on a value higher or lower than two standard-deviations with respect to the average.

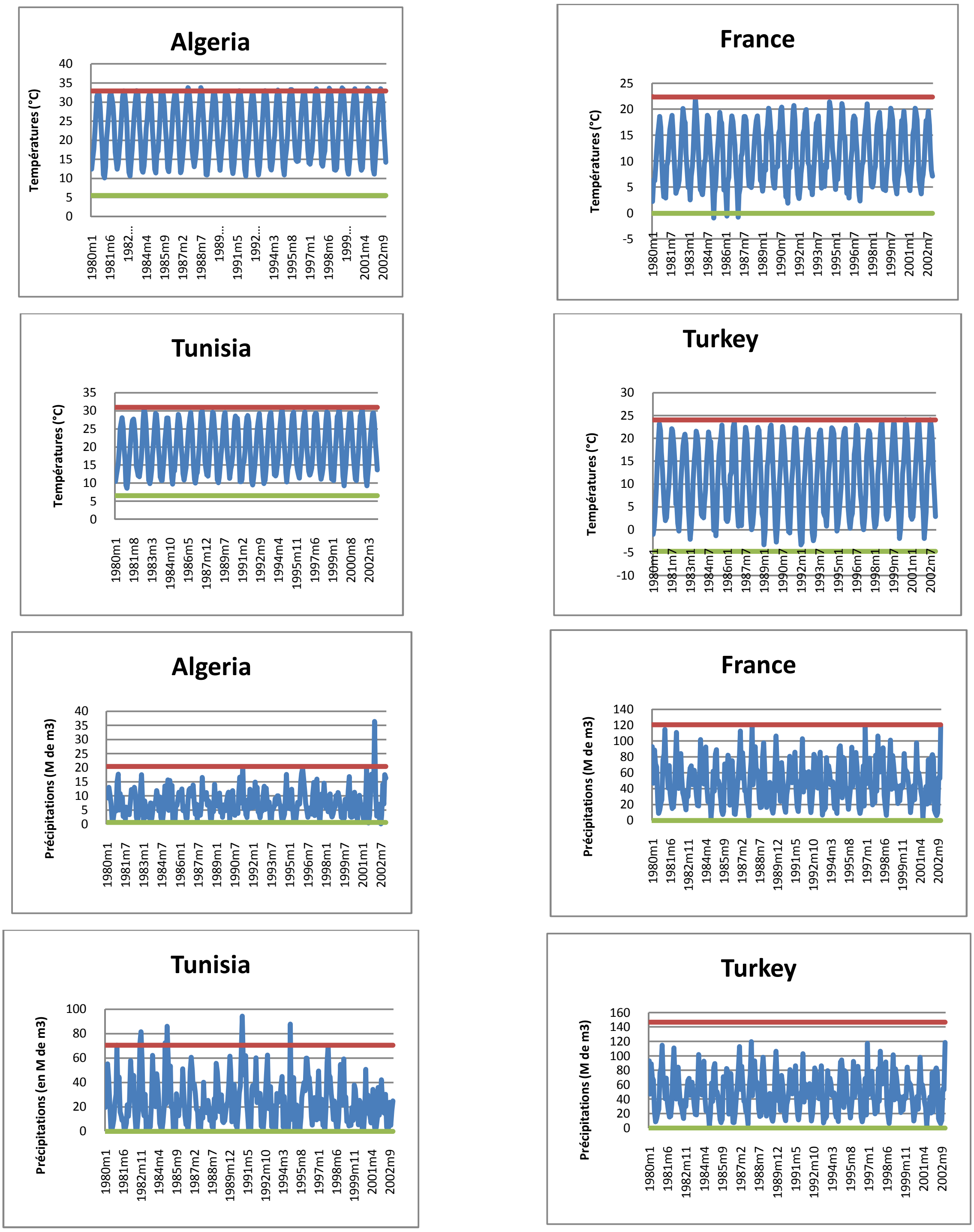
When we compare the evolution of the temperature and the precipitations in the four countries of the sample, many differences emerge. Indeed, the graphs show clearly a greater exposure by the southern countries (Algeria and Tunisia) to higher temperatures and lower precipitations. As regards extreme events, there appears—according to Stern's definition (2006)—a high recurrence of heat waves in the four economies. On the other hand, the countries do not experience cold waves, except for France, the northernmost country of the four, but which remains scarcely impacted by this type of shock.

As for precipitations, the countries are at once subject to periods of high concentration of rain, as well as to drought periods. Thus, extreme events are quite marked as they correspond to an evolution of the variable far beyond or far below the thresholds selected.

It is, therefore, clear that the countries of the region are already largely exposed to extreme climate variations. Climate change will exacerbate this phenomenon. The objective of this study is to highlight the cost related to each type of shock. The losses will significantly increase when we consider the whole set of extreme events over this period.

[6] In order to circumvent this problem, Hallegatte *et al*. (2007) propose a study that allows for the introduction of transitory non-equilibriums, likely to be ascribed to exogenous shocks, and which come to disrupt the growth process of the economies (*non-equilibrium dynamic model* (NEDyM)).

Tables 1 to 8. Climate variations of the temperatures and precipitations of the countries of the sample for the period 1980-2002



Study of the impact of extreme events

The variables

Four countries have been selected within the framework of the study: Algeria, Tunisia, Turkey and France, for the period 1980:1, 2002:12, accordingly to a monthly periodicity.

Five domestic variables and two climate shocks have been selected. As regards the domestic variables, the purpose is to account for the impacts of sudden climate variations on the real sectors—financial and monetary—of each country, as well as the interactions between the various spheres of the economy. The production indicator (y) has been selected according to country specialisation (industrial production for Tunisia, Turkey and France, and oil production for Algeria), the total volume of exports (xpt), the consumer price index (prx), the part of foreign currency held by the Central Bank (res), and the interest rate (interet). These variables are commonly used in the literature pertaining to Structural VAR[7], which facilitates the setting out of short and long term restrictions. The variable (res) has, however, been added in order to study international capital flows into the economies, following the various shocks.[8.]

Regarding the choice of climate variables, it is necessary to distinguish the non climate related natural disasters (earthquakes, tsunamis) from weather related events. The latter may be of several orders: tropical storm, winter storm, hail storm, blizzard, tornado, heat wave, drought, flood, flash flood.

The data related to wind velocity being scarcely available, and tropical storms being not relevant to the region, only an intensified variation of the temperatures and of the precipitations has been selected in this analysis, in a manner similar to the studies on this topic (IPCC, 2001; 2007, Hallegate, 2007; Stern, 2006). The external disturbances selected consist, therefore, in a temperatures and precipitations shock. The variables have been reckoned, as a first step, in terms of level (prec and temp), then the volatility of these indicators has been calculated with a view to accounting for the sudden variations of these indicators likely to reflect periods during which extreme events are the most violent (vprec and vtemp)[9]. A GARCH model which gives the conditional variation of each index has then been used, upon which the typical deviation has been deduced.

All variables have been turned into logarithms, except for the interest rate of the countries and the level-reckoned temperatures which may take on negative values. The domestic values have been disconnected from seasonality. As no short term constraints are imposed, the stationary character of the variables is not an essential criterion[10] (Sims *et al.*, 1990; Hamilton, 1994, p. 557). The same applies to any possible co-integration relations (Engle and Granger, 1987).

Contemporary restrictions

Given $\Delta Y = \begin{pmatrix} \Delta ext \\ \Delta y \\ \Delta xpt \\ \Delta prx \\ \Delta res \\ \Delta iteret \end{pmatrix}$ the endogenous variables vector, and $\varepsilon_t = \begin{pmatrix} \varepsilon_{ext} \\ \varepsilon_s \\ \varepsilon_{ce} \\ \varepsilon_p \\ \varepsilon_{fi} \\ \varepsilon_{ms} \end{pmatrix}$ the structural shocks vector, where

εext represents the exogenous shock, that is the precipitations shock *prec* or the temperatures shock *temp* reckoned in terms of level and of variation (*vprec* and *vtemp*), and εs, εce, εp, εfi, εms, being the domestic real supply shock, the commercial shock, the domestic financial shock, the domestic price shock, and the domestic monetary supply shock, respectively.

[7] Among the main references: Gali's research (1992), Clarida & Gali (1995), Sims & Zha (1995), Cushman & Zha (1997), Kim & Roubini (2000), Canova (2003), Mackowiak (2003)
[8] The macroeconomic and financial data are derived from the IMF *International Financial Statistics Cd-Rom* (2009).
[9] The data are derived from the "Tyndall Centre for Climate Change Research", and the sample is complemented by Plan Bleu data derived from CRU.
[10] On the other hand, this stationary character is indispensable for setting out long term restrictions.

The purpose is to identify the n^2 elements of the matrix P. Statistically, it is necessary to set out 21 identifying constraints. Indeed, as the matrix Ω is symmetrical, n $(n+1)/2$ orthogonalisation constraints are already assumed. In order to determine the remaining n $(n-1)$ 2 constraints, 15 in the model, the economic literature has been used. Only short-term constraints have been selected.

A first hypothesis is that the climate shocks are considered as exogenous (Cushman and Zha, 1997). This assumes that the economies under study are significantly dependent on the climate, without their influence on the variation of the latter being, however, demonstrated, particularly in the short term (Mackowiack, 2007).

Therefore, $P_{12} = P_{13} = P_{14} = P_{15} = P_{16} = 0$.

Besides, the hypothesis of a response time-lag of the economic activity and the exports to internal monetary and financial shocks is selected (Kim *et al*., 2000).

Therefore, $P_{25} = P_{26} = P_{35} = P_{36} = 0$.

Moreover, the response of prices to a shock in international reserves (foreign currency) is deferred by a month, similarly to that of production to a shock related to exports (Kim *et al*., 2000).

Which means that $P_{45} = P_{23} = 0$.

Finally, several authors (Sims and Zha, 1995; Kim and Roubini, 2000) have defined their money supply function as corresponding to the function of the monetary authorities' response, that is, to interest rate, without taking into account the short-time influence of prices and of production. This approach rests on the hypothesis according to which it is indispensable to take into consideration a monetary policy response time-lag due to lack of information. The approach has been to extend this hypothesis by assuming that the financial shock and the shock connected with international trade do not impact the interest rate in the short term. This yields the following $P_{62} = P_{63} = P_{64} = P_{65} = 0$.

Following the tests of Schwartz, Akaike and Hannan-Quinn, two time-lags have been selected for all models. Besides, additional tests have helped assess the absence of self-correlation of residual values[11]. The Stata Statistical Software : Release 9.0. has been used.

Now that all restrictions required have been set, it is possible to interpret the results.

Results

Economic and financial context

When interpreting the results, several factors likely to influence the response of domestic variables must be taken in consideration as preliminaries.

It is important, as a first step, to consider country specialisation, as it may have a significant influence on the cost differences incurred. Agricultural countries are quite vulnerable to extreme events likely to cause a loss of crops. In this case, the adverse impacts may prove to be not just time-bound but extend over the whole year. Also, countries whose industries require a large number of infrastructures, especially when the latter are concentrated in coastal areas, may incur particularly high costs in the event of significant extreme events, such as floods, for instance. Moreover, certain tertiary activities, such as tourism, are quite sensitive to extreme variations of temperature and precipitations likely to discourage travel and, hence, translate into a loss of international reserves (foreign currency) for the country.

France produces and exports mainly services, similarly to Tunisia and Turkey which are also particularly present in the secondary sector. Besides, a large portion of the working population is concentrated in the agricultural sector in most of the Southern and Eastern Mediterranean Countries (SEMCs), especially in Turkey and in Algeria. Algeria, Tunisia and Turkey have a significant industrial production. There is a certain resemblance between the economic structure of the latter two countries. The share of industry (extractive, manufacturing, electricity, gas, water) is dominant. It is also dominant in Algeria where it accounted for nearly

---

[11] Details of the tests may be obtained from the author upon request.

a half of the total value added in 2007, the country being one of the world's major oil exporters. Tunisia and Turkey have tertiary activities focused on trade, catering and hotel industry, the economy being rather based on tourism development. Besides, transport, storage and communication are highly developed in these countries, the latter activities being closely connected (Plan Bleu 2002, 2005).

On the other hand, it must be emphasized that the macroeconomic environment differs quite significantly from one country to the other within the sample, and this can largely influence their vulnerability vis-à-vis international shocks. To begin with, the countries did not initiate their commercial and financial opening up at the same time and, hence, have not reached as of now the same stage of international integration. One can, thus, expect the responses of the variables related to exports and to international reserves to be more marked in the countries that had opened up their economy more early. France is the first country of the sample to have liberalised its economy. In the late 1970s, following the oil crisis, the objective was to draw international savings in order to boost the economic activity, which has resulted in an easing of financial barriers. Besides, the European integration which started in the late 1950s was accompanied by a gradual easing of the barriers to international trade. For the other countries of the sample, commercial opening up actually started in the 1990s, within the framework of the Mediterranean policy, to be later reinforced by the Barcelona agreements in 1995. However, the main partners of these countries are the European economies, trade with the rest of the world remaining still limited. In addition, the financial opening up—dating to the 2000s—is quite recent for these economies.

Furthermore, the exchange rate is a key element to take into account, all the more so as the latter is normally related to the country's monetary policy and can, therefore, explain the interest rate response, particularly within the framework of setting up an economic recovery policy. France practically stabilised its interest rate quite early, within the framework of the currency snake, in the beginning, and then, within the framework of the European Currency Snake (ECS), as from 1979. Exchange fluctuations were then controlled by rather restrictive bands (2.25% on average, except during the 1993 crisis). One of the constraints imposed by this target zone system is that the country's credibility depended, to a large extent, on the inflation rate level (Svensson, 1994). The leeway on interest rates was then limited throughout almost the entire study period. Besides, as the objective was to join the Euro zone, the country had had to maintain its interest and inflation rates at a low level in the late 1990s in order to meet the Maastricht criteria. In the beginning of the study period, Algeria had opted for a fixed rate regime which underwent several devaluations. Accordingly, the interest rate room for manoeuvre was very narrow. Since 1996, Algeria has opted for a mixed floating regime, with intervention by the monetary authorities in order to maintain a certain parity with the US Dollar, as the hydrocarbons, which represent the country's main exports, were denominated in this currency. The country has managed to check a significant inflation since the mid 1990s. Since the late 1980s, Tunisia has opted for an intermediary crawling peg system. The country elected to have a rather controlled exchange rate regime, with periodical readjustments, in order to mitigate the inflation rate differentials with partner countries and to stabilise the prices of exports in foreign currency. Actually, Tunisia had experienced a significant inflation requiring it to maintain its interest rates fairly high. This inflation arose in the early 1980s, forcing the country to abandon its system of pegging to a basket of currencies where the dollar was dominant. The same applies to Turkey which experienced several variations of exchange policies: indeed, after a crawling peg regime in 1980-1981, the country had adopted a controlled floating regime until 1999, then back to an intermediary regime, subsequently abandoned following the crisis of 2001. In spite of a high inflation and, hence, of interest rate constraints (the interest rate having been maintained at a very high level for the major part of the study period), it is assumed that this country is, after all, the one with the largest room for manoeuvre in terms of monetary policy to address a climate shock and engage economy recovery.

Impact of extreme events

Regarding the countries' responses to various types of climate shocks, the significance potential of the results is assessed based on the graphs which illustrate the responses of the domestic variables following the variation of an exogenous variable unit (Annex 2). The confidence interval, reckoned based on the bootstrapping procedure, is of 90 %.

A shock in precipitations (prec) impacts directly and significantly the production of the countries (y). An increase in precipitations may have, within an initial phase, favourable impacts, especially for crops, as is the case in France and in Tunisia during the first month. However, the latter positive impacts soon turn into adverse impacts for the economies. They are particularly significant in the short term where the losses are considerable for all countries of the sample. France and Tunisia manage to mitigate these impacts within 4 months. On the other hand, Algeria and Turkey will undergo the difficult impacts of such a shock over a longer period of up to one year. Besides, the adverse impacts will affect exports (xpt) during the first two months following the shock in France and in Turkey and, in the longer term, in Tunisia, with the precipitations having certainly damaged certain agricultural productions. Algeria, which exports mainly oil, will not see its trade balance affected, the precipitations not having had an impact on the hydrocarbons production structures, on the one hand, and the country holding significant stocks, on the other hand. The impact on prices is nil in France (prx). In Algeria, the prices undergo a slight increase during the first two months due to a slowdown of the production of hydrocarbons. Prices drop in Tunisia and in Turkey, under the effect of the countries' monetary policies aimed at containing a general rise in prices, particularly in the case of shocks likely to induce inflationist impacts. A decrease in tourism flows may equally explain this phenomenon. The decrease in exports will slightly affect the international (foreign currency) reserves in France during the first month following the shock (res). Algeria will not experience a decrease in international reserves, as, on the one hand, part of its exports is not affected and, on the other hand, several barriers are there to limit international capital flows. On the other hand, Turkey and Tunisia will incur a high loss of international reserves during the first months subsequent to the climate shock, persisting throughout the year at a slower pace. The monetary policies put in place are limited by macroeconomic constraints, though they lead sometimes (as in Turkey, for instance) to a reduction of the interest rate with a view to boosting the country's economic growth (interet).

When we now consider a variation of the volatility of precipitations (vprec) likely to induce a period of rain surplus which we may relate to floods, or to induce—to the contrary—periods of water deficit, the impacts are particularly negative for the whole economies of the sample. Economic losses (y) are much more marked for Algeria, where the catastrophic results extend over a longer period. The same applies to France where the adverse impacts are considerable during the first two months subsequent to the shock then diminish in intensity as from the fourth month. In Tunisia and in Turkey, the losses are lower. However, except for Algeria, the countries' exports will be largely affected (xpt). This is due to the fact that most of them sell abroad part of their agricultural production, which production is quite vulnerable vis-à-vis extreme climate variations. Similarly to the case of the preceding shock, the impact on prices (prx) is limited in Algeria and in France, where inflation is controlled, and it decreases in Turkey and Tunisia, under the effect of the monetary policy in place, on the one hand, and due to a slowdown of tourism during such instability periods, on the other hand.. This is why Tunisia and Turkey experience the biggest decrease in international reserves (res) in the short term and which continues throughout the year. This impact is limited in France and in Algeria. It is due to the fact that France, having a very open capital market, the drop in trade revenue is compensated by a foreign currency inflow via financial investment. In Algeria, as the exports are slightly affected, the country's financial resources are slightly affected, too. The impacts on the countries' interest rates are low (interet) and, for the major part, almost negligible, the countries' having to maintain such rates at a high level in order to ensure credibility of their economy.

A temperature shock (temp) has a significant adverse impact on France during the first two months. The impacts on the production (y) of Algeria and of Tunisia are limited. In Turkey, the impact is, within a first phase, positive, then—beyond a certain temperature—it becomes negative. These results recall the ricardian analyses concerning the positive, then negative, impacts of a rise in temperature[12] beyond a certain threshold (Mendelson *et al.*, 2000 ; Kurukulasuriya *et al.*, 2006). The countries' exports (xpt) are little affected, except

[12] This type of analysis rests on the hypothesis according to which, for all climate sensitive sectors, there is a temperature that maximises the thriving of such a sector. Below this threshold, an increase in temperature leads to an increase in production. Beyond this maximum, the sector then undergoes significant losses.

for France and Turkey during the second month subsequent to the shock. These limited impacts are due to the fact that, during the 1980s and 1990s, the countries of the region had reported limited temperature rises. However, this temperature is set to rise in the coming years, knowing that it already starts at a fairly high level (Stern, 2006; Plan Bleu, 2008; IPCC, 2007). This will, then, cause a quite considerable damage within a very near future. A simulation of the future losses which these countries will experience, according to a “business-as-usual” scenario, will help highlight these costs. Prices (prx) will respond without much significance in France and in Algeria. On the other hand, they will increase as from the third and fourth months in Tunisia and in Turkey due to a reduction of agricultural production which will be felt throughout the year. Foreign currency reserves (res) will then be little affected. Finally, only in Turkey will the interest rate undergo a downturn as from the second month.

While a temperature shock has a limited impact on the economies of the sample, an extreme variation of this indicator—likely to give rise to intense drought or very cold climate periods—will largely and adversely impact the countries’ economies (vtemp). Indeed, the impacts on production (y) will be immediate and large-scale in France and, to a certain extent, in Tunisia. They will be of a long-term nature in Algeria and in Turkey. The exports of the entire countries of the sample (xpt) will then diminish significantly, particularly during the early months following the shock. Prices (prx) will increase in Tunisia and in Algeria due to a decline in production, notably agricultural production. The trend is rather on the decrease in France and in Turkey. This is due, to a certain extent, to a decrease in tourism flows as a result of drought or cold periods, especially in Turkey, and to a slackening of economic activity in the Northern Mediterranean Countries (NMCs). The impacts in terms of foreign currency reserves (res) are low in Algeria and in France. On the other hand, these report a decrease in Turkey, immediately after the climate shock and, in the longer term, in Tunisia. The interest rate (interet) remains unchanged in France, it being contained by the exchange system in place, while in Algeria, in Tunisia and in Turkey, the monetary authorities will seek to boost economic growth by a response consisting in revising this indicator downwards.

Annex 3 highlights the part played by climate shocks in the overall variation of each indicator. The result is quite striking. Indeed, it emerges from this study that, in the 1980s and 1990s, climate shocks were already responsible for a variation of over 20% of the production of the various countries, in the short and medium term. Extreme shocks account for the decrease in production throughout the period under consideration (8 months). They play a particularly significant role in Turkey and in France. Besides, they may be held responsible for around 10% of the variation of exports and, at times, for over 15% of the variation of prices, notably in Turkey. Only the evolution of interest rates does not depend directly on the climate. Accordingly, there emerges from these tables a great dependence of all the economies of the region on climate variations. Turkey appears to be, however, the country whose production and exports are the most vulnerable to the climate, while Algeria—specialised in the oil sector—seems to be slightly less sensitive. France and Tunisia are in an intermediary position, with Tunisia being relatively less dependent on the climate, though.

Anticipated losses due to climate variation over the period 2010-2030

As a second step, focus will be placed on the period 2010-2030. More precisely, the study has been extended in order to account for the impact of temperature and precipitations shocks on these same countries in the coming years, if no prevention and adaptation measure is implemented.

Most studies that address the future economic impacts of the climate construct their forecasts by taking as reference a given economic situation and, thus, reason from a static point of view (Mendelson *et al*., 2000; Nordhaus *et al*., 2000; Tol, 2002). In order to partly circumvent these limitations, simulations were conducted with regard to the evolution of the countries' domestic variables according to a "business-as-usual" scenario. The latter consists in an increase in production at a constant rate mainly due not only to a more marked economic and financial opening up, but also to maintaining the stability of the monetary and exchange policy. For so doing, the period 1980-2009 has been taken as reference (baseline)[13], and a ARIMA model[14] has helped anticipate the variation of these variables over the period 2010-2030.

As regards the climate variables of temperatures and precipitations (temp and prec), the anticipation of their evolution over the coming 20 years rests on the scenario A1B[15] of IPCC (2007). Broadly speaking, according to this scenario, the increase in temperature in 2020-2030 would reach +1.25°C with respect to the period 1980-1990. Knowing that the Mediterranean region is an area where temperature variation will be the highest, it was assumed, in this study, that the temperatures over the period 2010-2030 would increase by +1.5°C, on average, with respect to the period 1980-1990. Besides, the precipitations were assumed to be higher in France (+1.5%, with respect to the period 1980-1990) and lower in the East (-2.5%) and in the South (-3%) with respect to the period 1980-1990.

The monthly periodicity of the data has been maintained, and the temperature and precipitations variations in the countries follow the same distribution throughout the year as during the period 1990-2010.

Accordingly, it is possible to conduct the same study, as was previously done, based on the same SVAR model to which there will be assigned the same short time constraints. However, the results are much less precise, as they rest on anticipated and not concrete data. Consequently, it is impossible to invoke degrees of significance to control the responses to the shocks as was the case with the preceding test. On the other hand, the volatility of these variables cannot be measured. The purpose is to consider, here, a trend concerning the responses of the countries' production and exports (by means of y and xpt) to a positive temperature and precipitations shock, and to see the extent to which the latter differ from those of the preceding period (annexe 3).

Broadly speaking, there emerges from the study, when we compare the results related to the period 1980-2000 with those of the period 2010-2030, a more marked adverse impact due to a shock of temperature (temp) on the production (y) and the exports (xpt) of the whole countries of the region. Indeed, even though the shock does not immediately entail a fall in production in the northern, eastern and southern Mediterranean countries, the adverse impacts will be largely felt as from the second month following the disturbance. This is due to a short response time-lag by the production, particularly in the agricultural and tourism sectors following a drought period. Besides, the adverse impacts of a temperature shock extend over a much longer period than previously. Indeed, the shock seems to induce a decline in production over an average period of 8 months, while the adverse impact of a temperature shock in the 1980s and 1990s was only transitory and did not exceed a 3-month period. This observation reveals a greater difficulty for the countries in the coming years to address this type of shock. Finally, this shock seems to account for over 30% of the variations of the production and, hence, of the exports, which underscores the fact that these economies have an increased dependence on the climate (annex 5).

Regarding precipitations (prec), in spite of a decrease in three out of the four countries of the region, a precipitations shock which represents a high concentration of rain during a given period always induces an adverse impact on the economies, particularly those specialized in agriculture. These impacts are less significant

[13] Taking into consideration a long reference period helps limit the influence of the *subprimes* crisis on GDP growth in the countries and reason based on a longer term trend.
[14] The model known as ARIMA ("Auto-Regressive – Integrated – Moving Average"), formalised by Box and Jenkins (1976), helps predict the evolution of a variable according to the weighted sum of all the preceding points, plus a random error term. They observed that this model requires a stationary nature of the variables; these have, therefore, been considered in primary difference.
[15] The A1B scenario assumes a high economic and demographic growth and the use of new technologies, with a balance resort to fossil energies.

than during the preceding period, but remain, nonetheless, revealing. There will take place an immediate and significant reduction of production and of exports for all the countries of the region. The same applies to France which, unlike the other countries of the region, experiences higher precipitations. However, this adverse impact causes losses in the short term only, not exceeding 3 months, while in the preceding period the adverse impact extended over a longer period (generally of over 4 months). A precipitations shock accounts, on average, for around 10% of the variation of the countries' production and for over 20% in Tunisia (annex 4). Consequently, despite an average reduction of the precipitations likely to give rise to difficulties for the countries, these remain concentrated within a few months, thus being likely to cause significant losses.

Economic losses due to each extreme climate event

The results of the study concur with those of the economic literature. Indeed, the total cost connected to extreme events during the second half of the XXth century is estimated as 0.1% of GDP, on average. These losses are likely to increase with climate change in the years to come, reaching between 0.5 and 1% of total GDP for an increase in temperature by 2°C (Stern, 2006). Besides, this climate variation would be likely to induce an increase in high intensity weather storms by between 25 and 30%. The losses would, then, be huge, if we were to consider them based on the observation that an increase in intensity of these events by between 5 and 10% induces an average cost of 0.13% of GDP for the country[16] (Nordhaus, 2006).

The impact of the shocks has been standardised in such a way as to allow for measuring the response of the variables to a shock of a climate variable unit (annex 6). The interpretations of the responses are quite precise within the framework of a SVAR, since the definition of the model rests on economic theory. The exercise consists in bringing out the losses induced by each type of extreme event which will, then, be multiplied by the occurrence of the shocks.

A sudden increase by 10% of precipitations that may be associated with flood periods has induced a cost of around 0.3% of the total GDP of the four countries, that is, an aggregate amount of around 3398 million US Dollars over the period 1980-2002 within the 3 months following the disturbance. The countries most impacted are Turkey (0.8% of GDP) and France (0.2% of GDP). The countries' exports then decline by 0.2% in France, 0.12% in Tunisia and 0.03% in Turkey, over this same study period. These losses will be lower during the 20 coming years due to a decrease in precipitations which would, however, result in a significant drought period.

On the other hand, one observes the inverse phenomenon with regard to temperatures. A sudden increase by 5°C with respect to the seasonal mean value (that is, about a standard deviation with respect to the average), which may be associated with a heat wave, results in a decrease in the countries' production by 0.01% during the first month, which is absorbed as of the third month subsequent to the shock for the period 1980-2002. The cost incurred by the four countries amounted to 209 million US Dollars for a temperature shock during that period. If no preventive measure is taken, the impact of this shock will be more difficult to absorb and will cost 0.1% of GDP for the fifth month following the shock, thus amounting to around 381 million US Dollars by 2030 for all the four countries. The economies most impacted are those of Tunisia and of France (0.01% of GDP over the period 1980-2002) and of Turkey during the future period (0.01% of GDP)[17].

Climate change is likely to increase the costs entailed by these extreme weather events. Not only will the temperature variations be multiplied, but also the probability distribution will increase (more heat waves). Besides, climate change intensifies the water cycle, in such a way that severe floods, droughts and storms will occur more often and with a more significant scope (Stern, 2006). The costs of extreme events, in the coming years, are likely to reach between 0.5 and 1% of total GDP, for a temperature increase by 2°C (Stern, 2006). The Mediterranean will be particularly sensitive to an increase in drought periods and heat waves. Yet, certain studies (Wigley, 1985; Stern, 2006) predict that an increase by 1°C could multiply by 10 the periods of heat waves. The future impact of extreme events in this region would, thus, entail a particularly high cost, if we were to base our

[16] For the USA, this would amount to between 100 and 150 billion US Dollars.
[17] Which amounts to around 152.99 million US Dollars, for France, 1.28 million US Dollars, for Tunisie and 81.31 million US Dollars, for Turkey, in the case of an exogenous shock.

prediction on the hypothesis that the losses highlighted in our study due to a shock would be multiplied by ten in the future.

Conclusions and recommendations

The objective of this study has been to highlight the economic costs incurred by climate variation for Mediterranean countries. Emphasis has been placed more particularly on the impact of the extreme events undergone by the countries over the past two decades. The choice of the countries has been made in such a way as to consider economies with different profiles and geographical positions. The evolution of the temperatures and precipitations in each of the four countries has been reckoned from a monthly periodicity perspective, and the volatility of these indicators reflecting extreme climate variations has been calculated.

This study reveals considerable losses due to the climate during the 1980s and 1990s in all countries of the sample. Irrespective of the geographical position of the country and its economic specialisation, all of the countries largely undergo the adverse impacts of an extreme variation of temperatures and precipitations. This induces, in particular, a reduction of the countries' production. Consequently, their exports decline significantly, especially in agricultural areas and when extreme events affect often badly-located production infrastructures. In this case, it is very difficult for the country to address such a shock in the short term, and the losses, then, extend over a whole year. Besides, the reduction of production may induce a price rise, especially of raw materials. Such a situation is particularly difficult for the poorer categories of the population which will have to grapple with additional difficulties to obtain food. This may give rise to epidemics and massive migration by the population from the country to cities that may not be equipped to receive a significant inflow of people. Apart from the economic impacts, the social effects are disastrous. A reduction of exports minimises the countries' international (foreign currency) reserves. This gives rise to difficulties, especially when the countries have opted for a fixed, or quasi-fixed, exchange rate. They will, then, experience destabilising pressures likely to cause exchange rate depreciations. Therefore, they will have an even narrower room for manoeuvre, all the more so as all the countries of the sample have big constraints in terms of stability of interest rates, which leaves the authorities with a very low capacity to boost economic growth.

The study has revealed that, as of now already, climate change—and, more particularly, extreme temperature and precipitations variations—has incurred the countries quite significant economic losses likely to hamper their economic development. These climate shocks already account for over 20% of the variation of production and over 10% of the variation of exports of each of them. The fact that all countries are impacted and that the impacts are significant, irrespective of the country's geographical position and specialisation, reveals that the latter are by no means prepared to confront the future climate variations. This study, therefore, reveals a lack of anticipation and adaptation measures in all the countries of the sample, such as would prevent or mitigate climate shocks.

A complementary analysis has helped bring out a set of trends with regard to the responses of the countries' production and exports over the coming 20 years according to an intermediary climate scenario A1B. The results reveal an aggravation of the countries' economic situation in the event of a temperature shock, together with considerable economic losses, even as the average annual precipitations decline. While it takes more than a year to absorb the adverse impacts of these shocks and that they become more recurrent, it will not be possible for the countries of the Mediterranean region to address them in the future. It is, therefore, necessary to set up a regional cooperation with a view to strengthening the countries' capacity to address such shocks based on adopting region-wide prevention and adaptation measures.

Annexes

Annex 1 - Model

The representation of the reduced form of the vector auto-regression model VAR(q) is:

$$Y_t = \sum_{i=1}^{q} A_i Y_{t-i} + e_t \qquad (1)$$

Where q is the number of lags, e_t is a white noise.

In order to simplify the representation, the variables are divided into two blocks: y_{1t} represents the exogenous variable and y_{2t} the domestic variables.

We, therefore, have:

$Y_t = \begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix}$ with Y_{t-1} the vector of lagged variables,

$A_i = \begin{pmatrix} a_{11}^{(i)} & a_{12}^{(i)} \\ a_{21}^{(i)} & a_{22}^{(i)} \end{pmatrix}$ the n x n matrix of the model's parameters,

$e_t = \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix}$ the error vector whose variance-covariance matrix has no restrictions;that is to say, $E(e_t, e_t^T) = \Omega$ and $E(e_t) = 0$.

L is the lag operator. Consequently, the VAR(q) model can be written as:

$$A(L)Y_t = e_t \qquad (2)$$

In order to obtain the shock response functions and the forecast error variance decomposition, it is necessary to write the process in the Moving Average infinite structural form. An intermediate step consists in "reversing" the canonical VAR model according to the Wold Theorem in order to obtain its moving average form:

$$Y_t = \sum_{j=0}^{\infty} C_j e_{t-j} = C(L)e_t \qquad (3)$$

Where it represents the vector of canonical innovations.

Thus, the structural Moving Average representation is:

$$Y_t = \sum_{j=0}^{\infty} \Theta_j \varepsilon_{t-j} = \Theta(L)\varepsilon_t \qquad (4)$$

with $$e_t = P\varepsilon_t \qquad (5)$$

Where P is an invertible matrix n x n which has to be estimated in order to identify the structural shocks. The short-run constraints are imposed directly on P and correspond to some elements of the matrix set to zero. The Θj matrix represents the response functions to shocks εt of the elements of Yt[18]. The different structural shocks are supposed to be non-correlated and to have a unitary variance:

$$E(\varepsilon_t, \varepsilon_t^T) = I_n \qquad (6)$$

Ω is the variance-covariance matrix of the canonical innovations et, thus :

$$E(e_t, e_t^T) = PE(\varepsilon_t, \varepsilon_t^T)P^T = PP^T = \Omega \qquad (7)$$

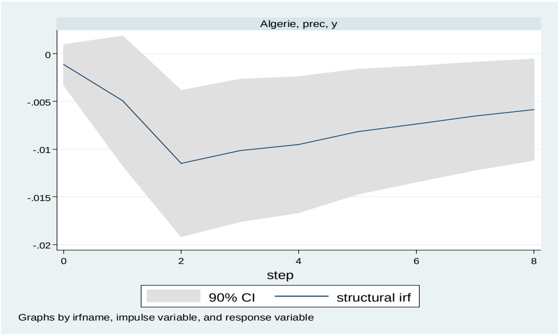
[18] The absence of response in the long term of a certain number of variables Y_t to the shocks ε translates into the nil value of the corresponding dynamic long-term multiplier.

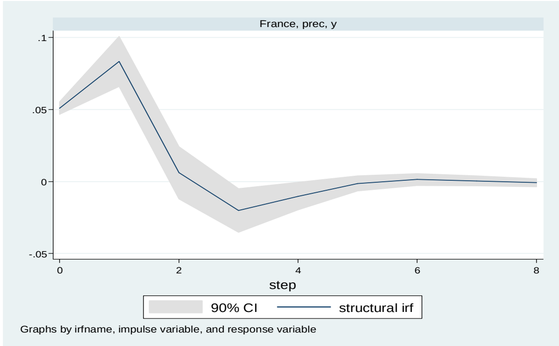
Annex 2 - Country response to climate shocks

Graph 2.1 Response to a shock of precipitations (prec)

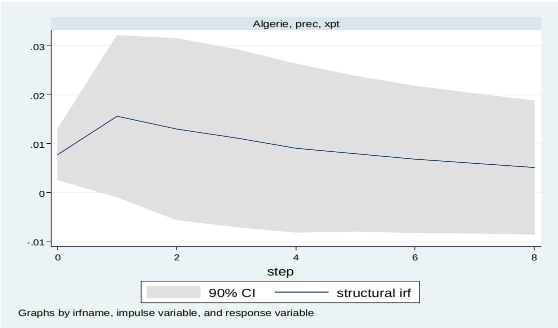
Algeria **France**

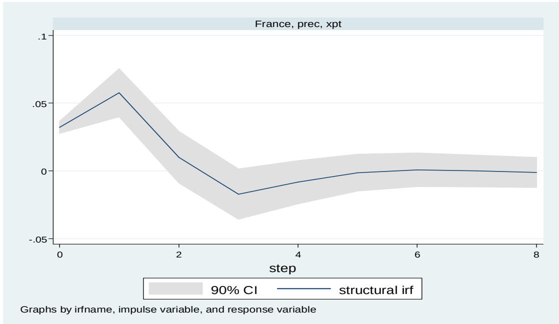
y



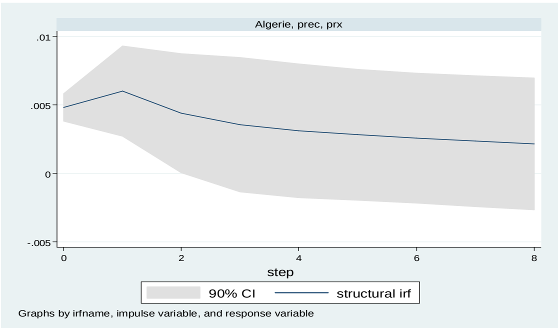


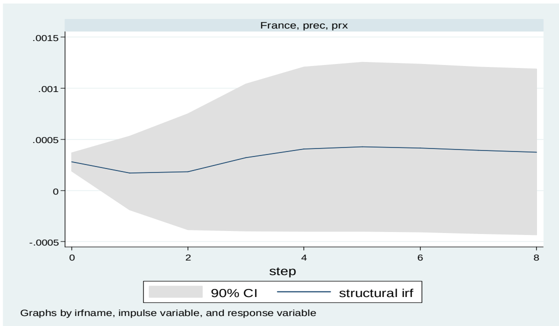
xpt



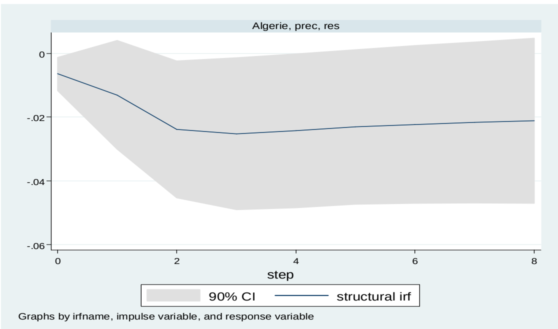


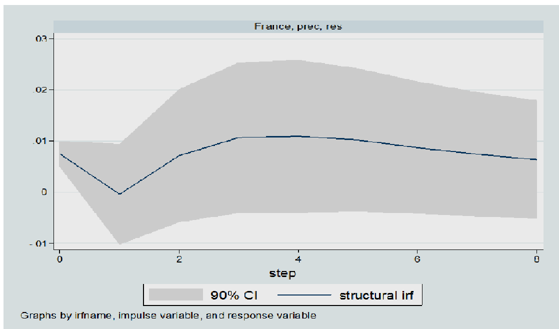
prx



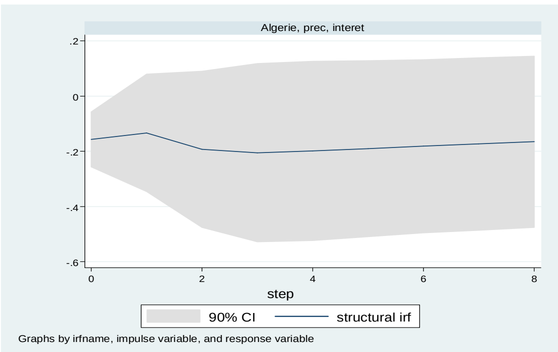


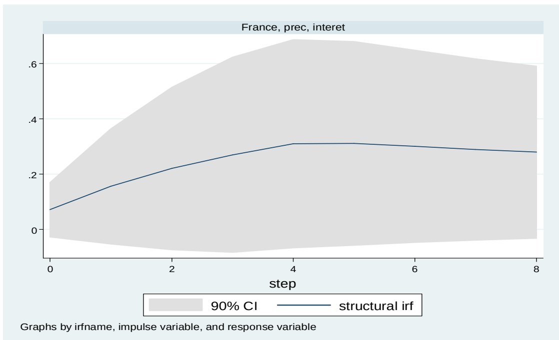
res





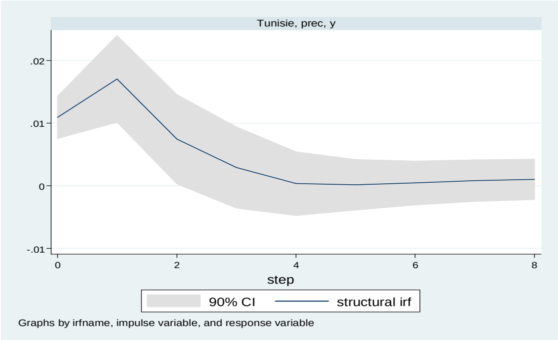
intere t

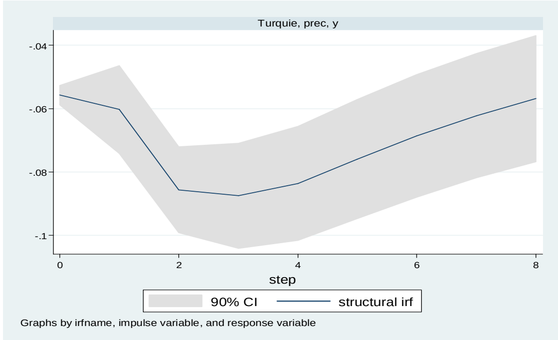




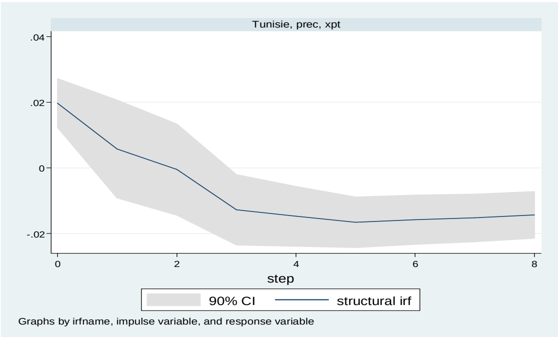
	Tunisia	**Turkey**

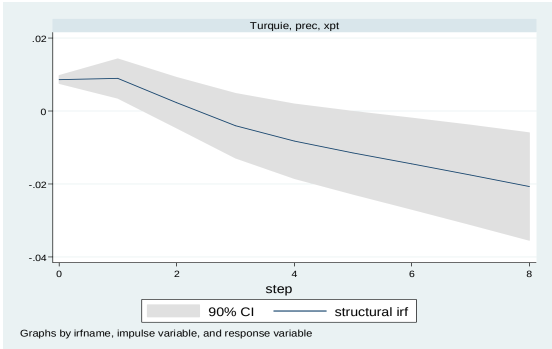
y



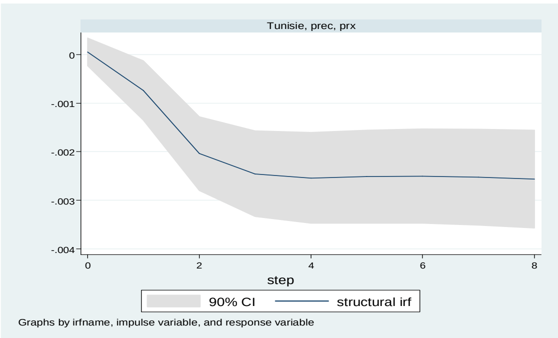


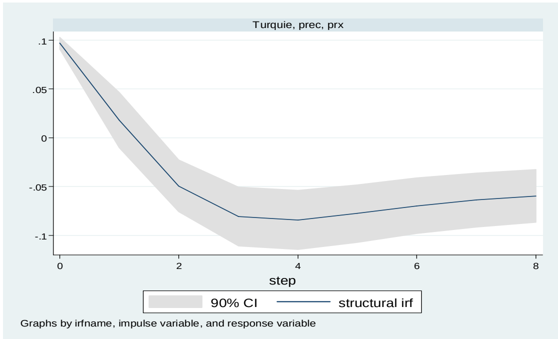
xpt



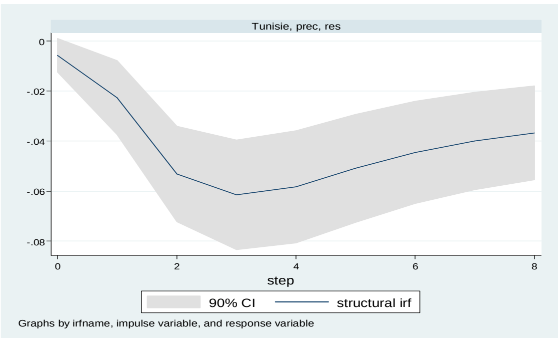


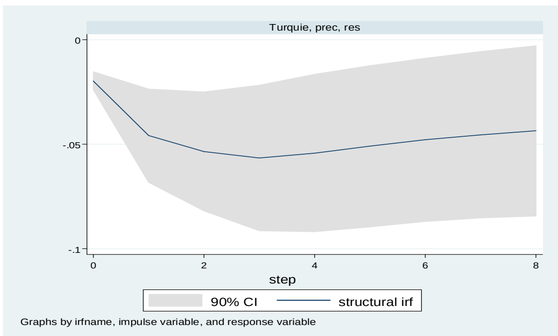
prx



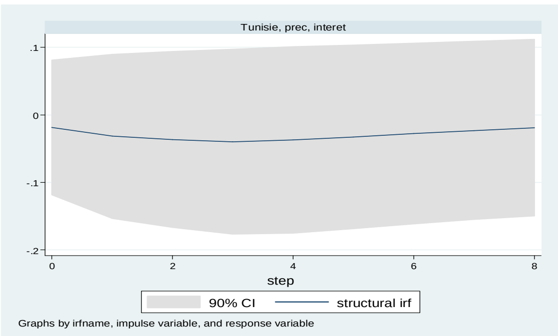


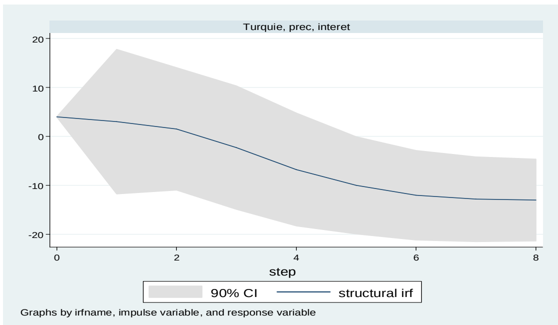
res





intere
t





Graph 2.2 Country response to a shock of variations of precipitations (vprec)

Algeria **France**

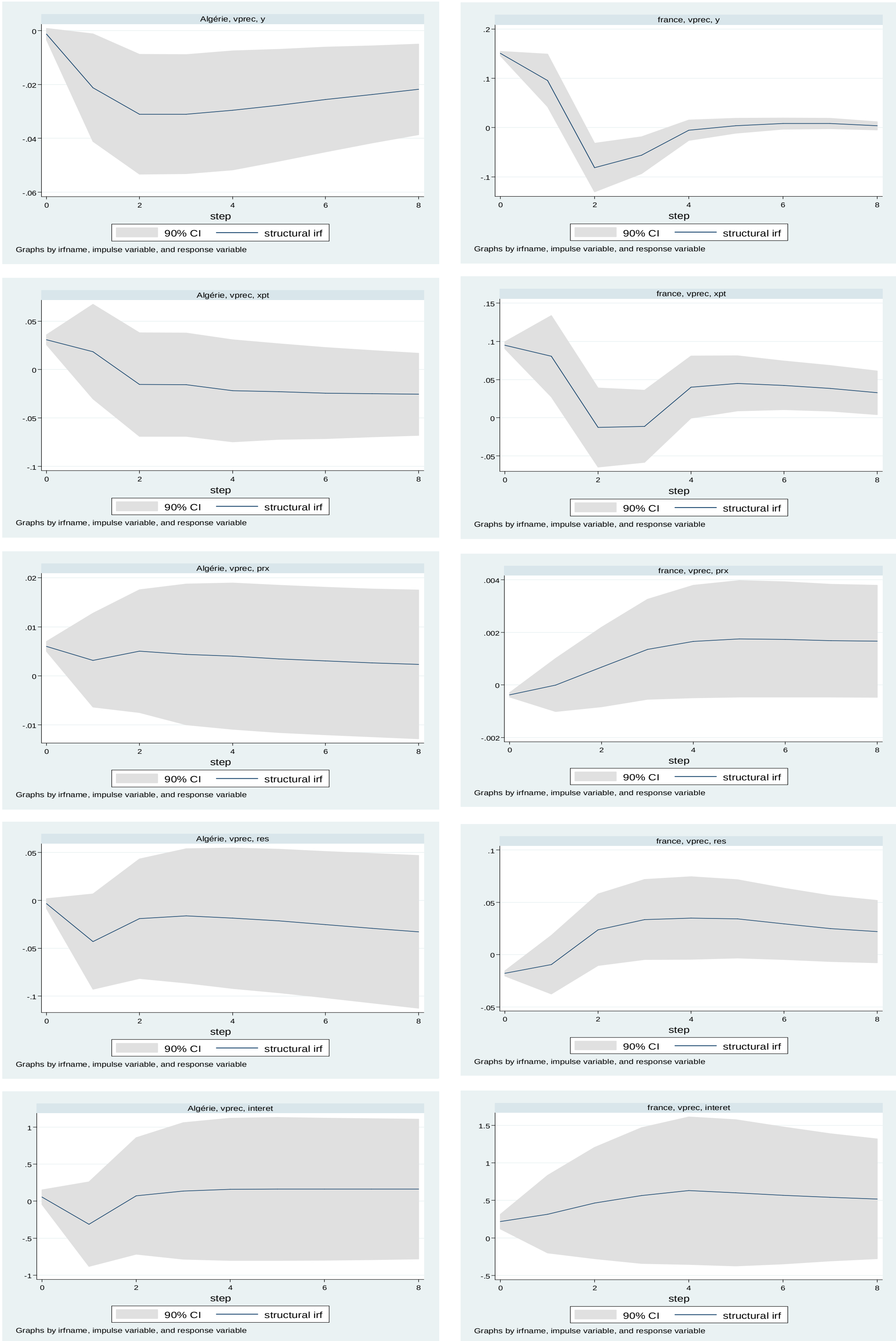
y

xpt

prx

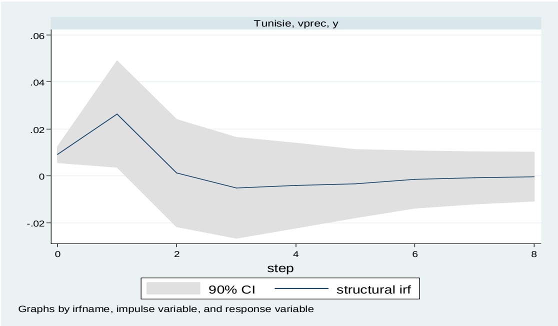
res

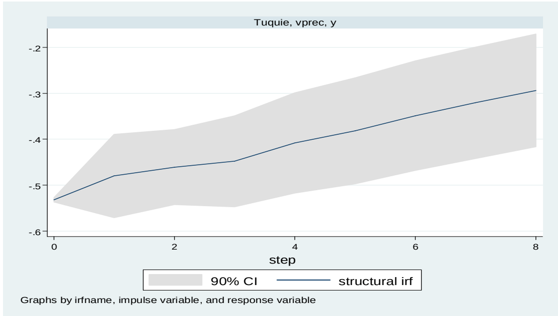
Intere t



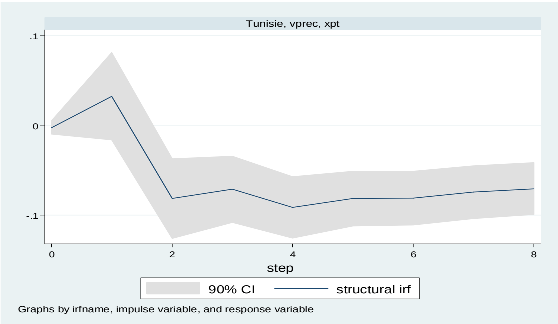
Tunisia | **Turkey**

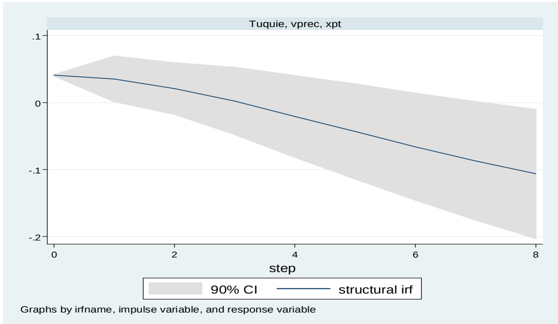
y



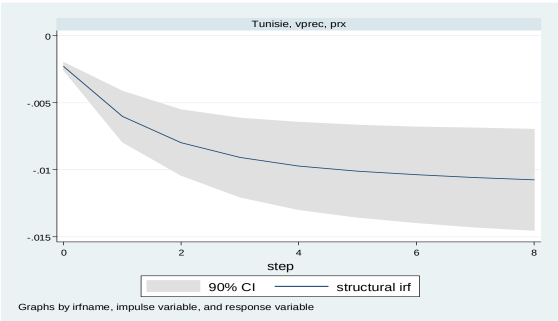


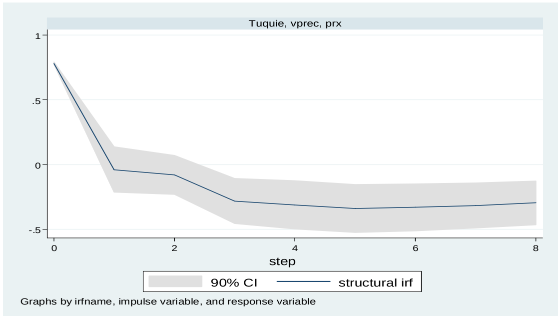
xpt



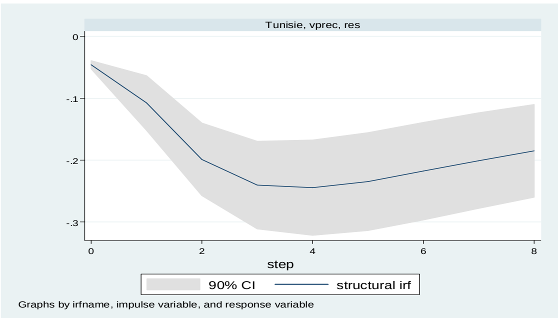


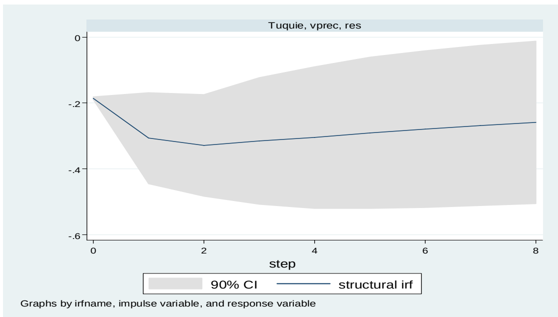
prx



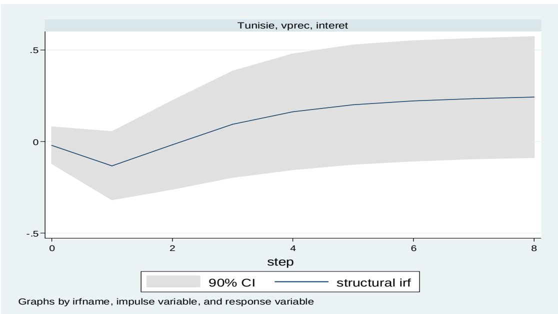


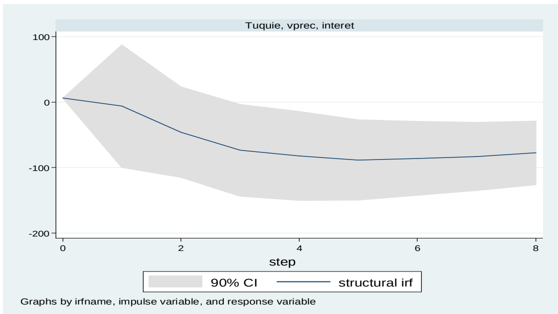
res



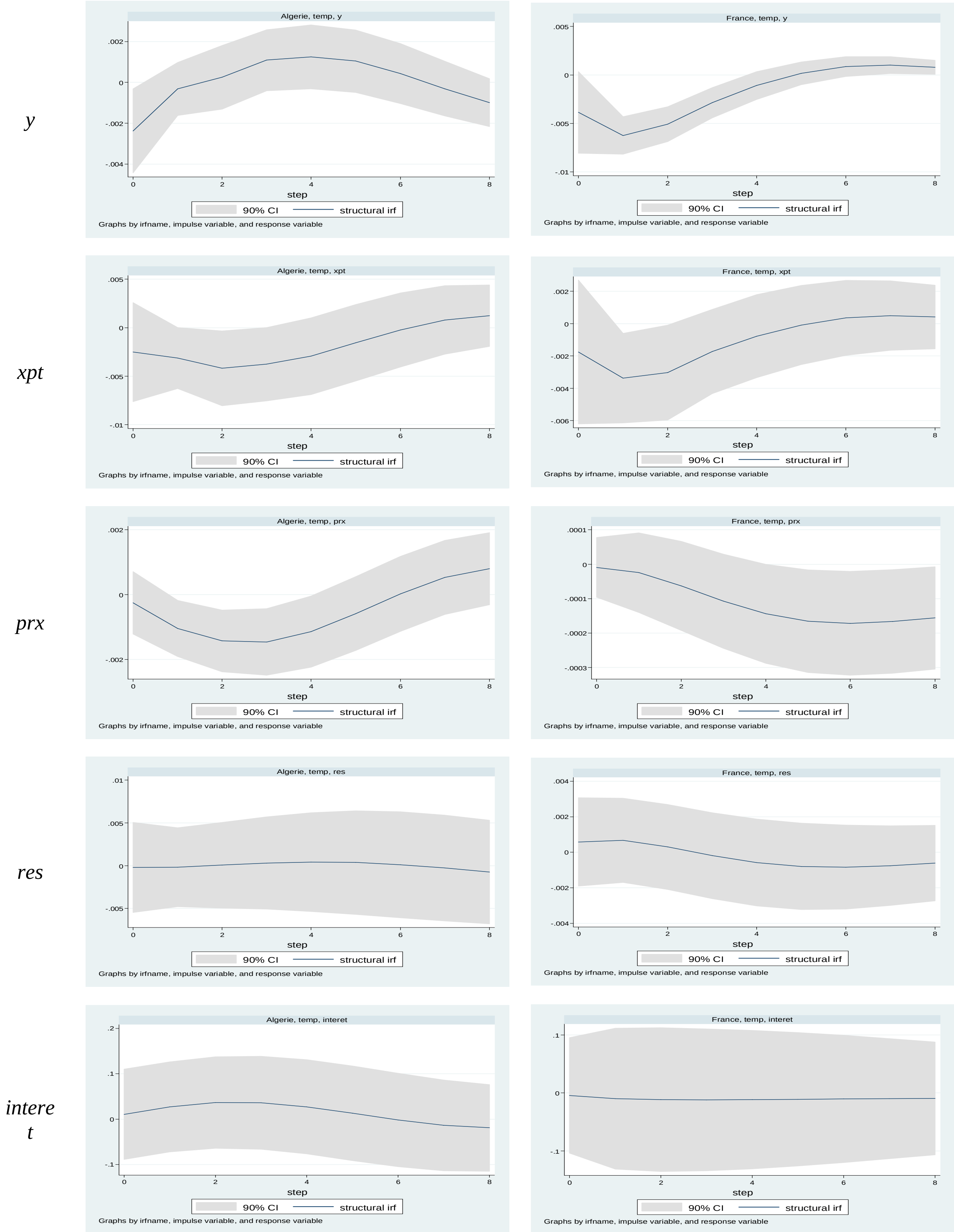


interet



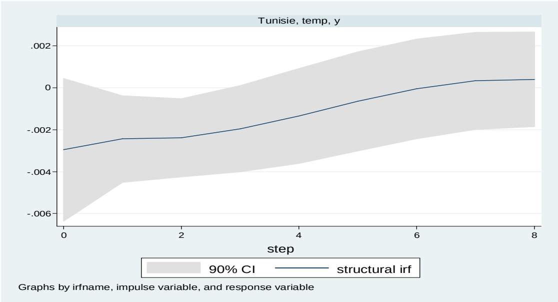


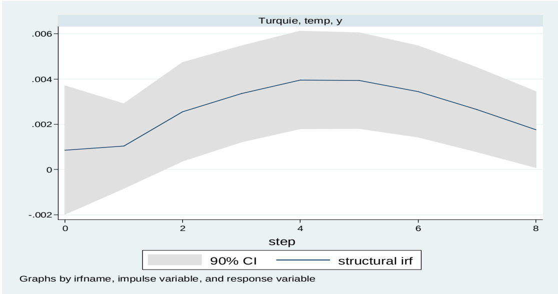
Graph 2.3 Country response to a shock of temperatures (temp)



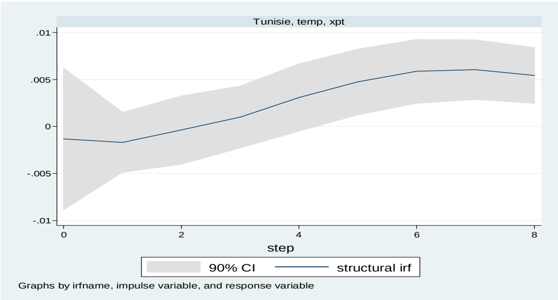
Tunisia | Turkey

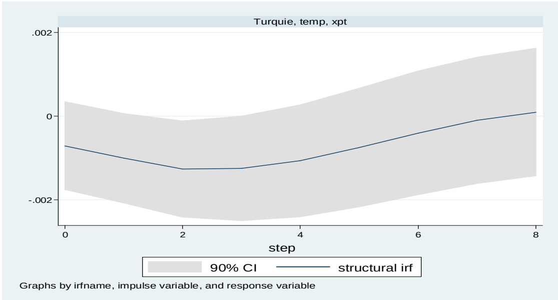
y



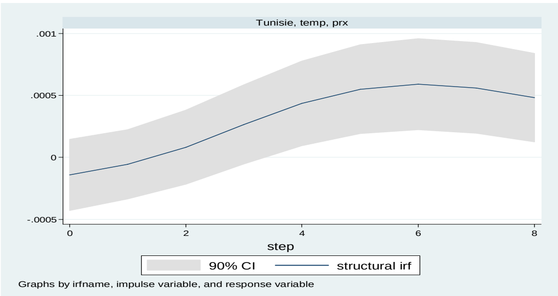


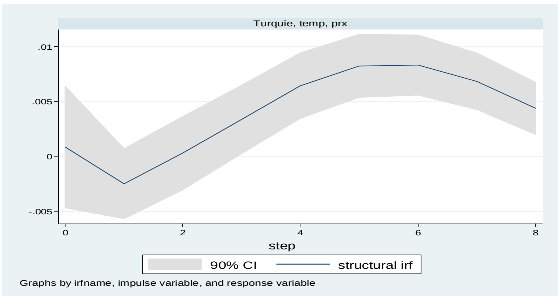
xpt



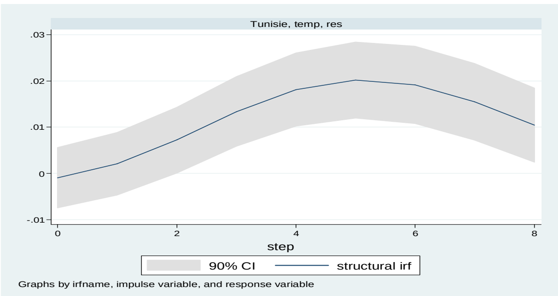


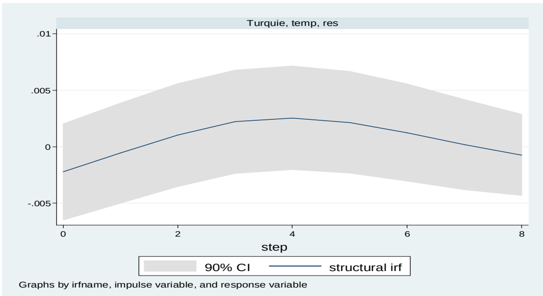
prx



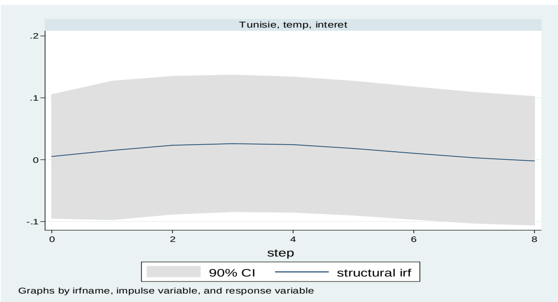


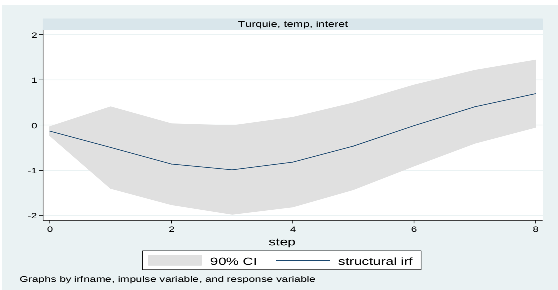
res



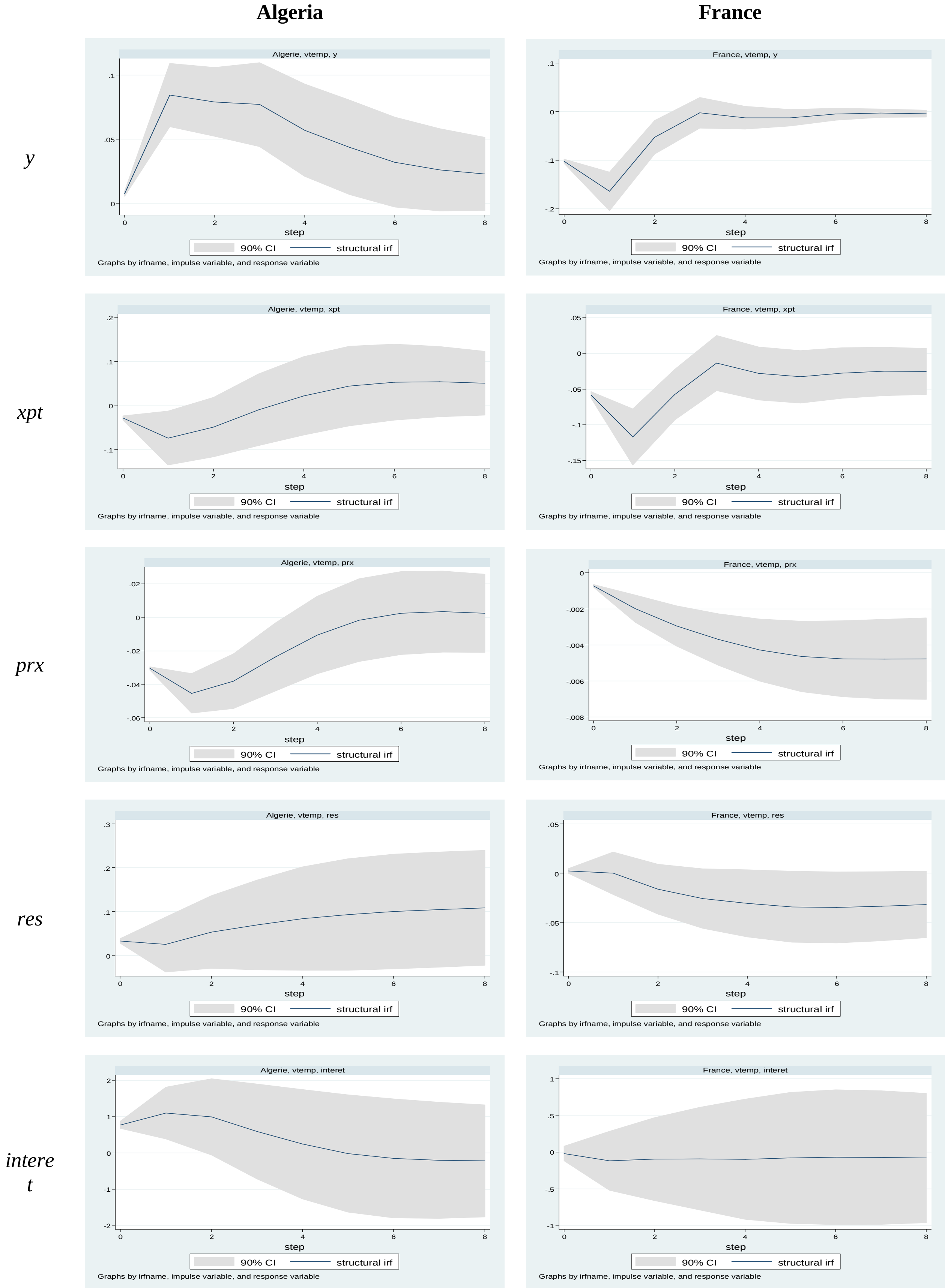


interet



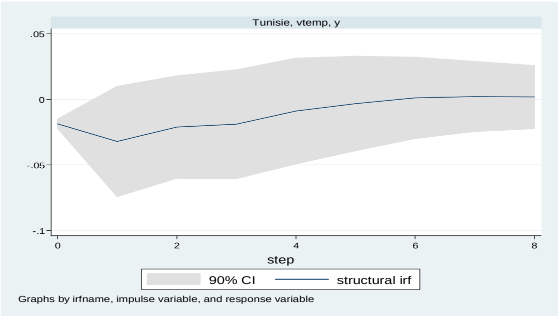


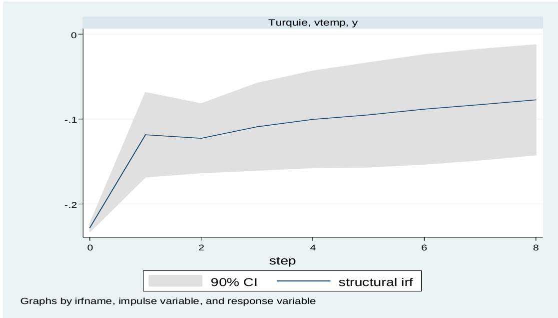
Graph 2.4 Country response to a shock of variations of temperatures (vtemp)



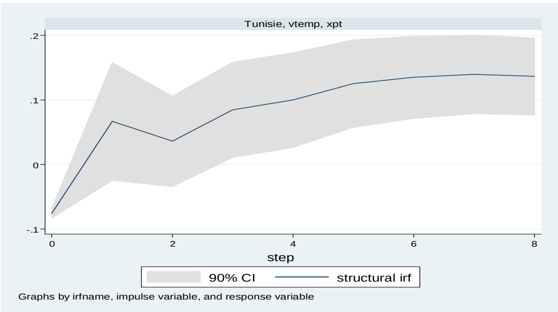
Tunisia | **Turkey**

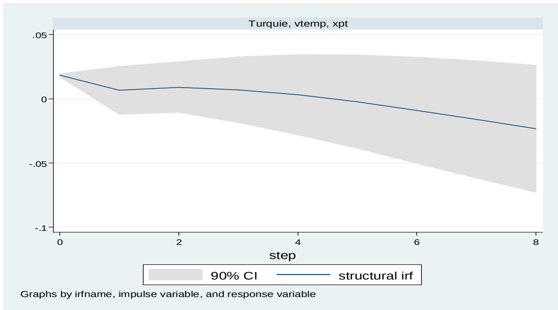
y



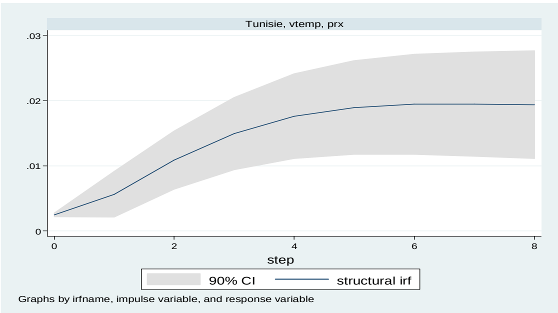


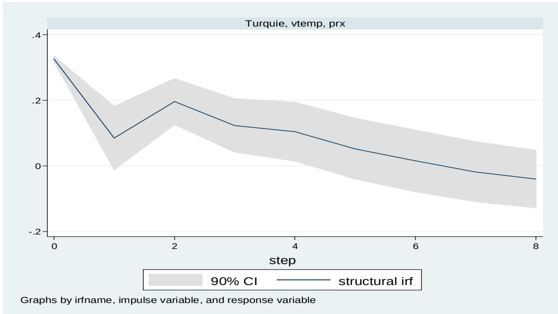
xpt



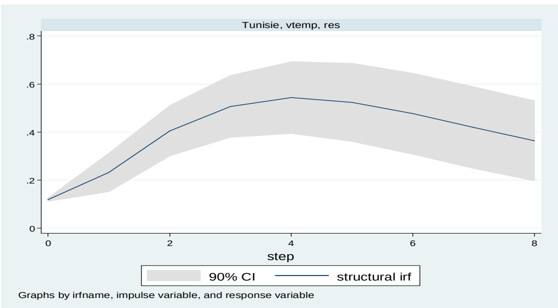


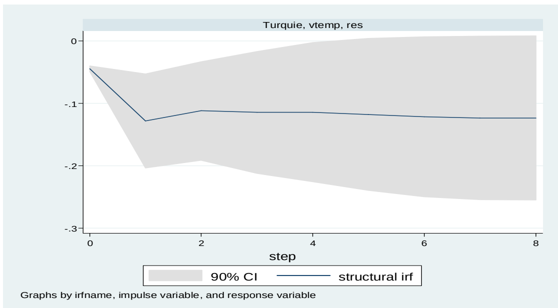
prx



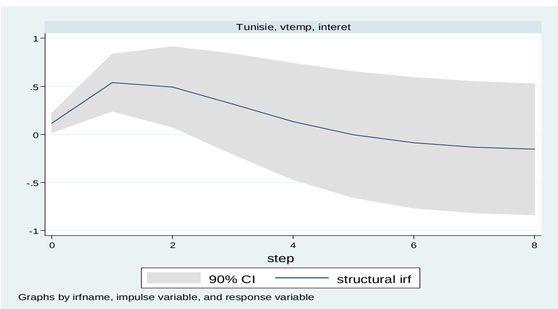


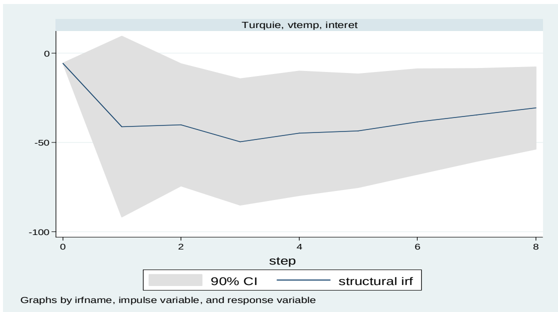
res





intere t





Annex 3 - Breakdown of variation

Table 3.1. Breakdown of variation following a shock of precipitations (prec)

Period	Algeria	France	Tunisia	Turkey
	y	Y	y	y
1	.000289	.082402	.025455	.000084
2	.004063	.236094	.069573	.026908
3	.018628	.232019	.070968	.113043
4	.025999	.238528	.06885	.166088
5	.030657	.239464	.066689	.199757
6	.033123	.238536	.06527	.215824
7	.03468	.237718	.064185	.224751
8	.03562	.236973	.063349	.229875
	xpt	Xpt	xpt	xpt
1	.002199	.031485	.017135	.012368
2	.008299	.102629	.017511	.009264
3	.009645	.08872	.015547	.007936
4	.01026	.084453	.020384	.014538
5	.010179	.078405	.026345	.021917
6	.010016	.072959	.033745	.02805
7	.009768	.068666	.039795	.033102
8	.009508	.065211	.045055	.037809
	prx	Prx	prx	prx
1	.022283	.006286	.000092	.003689
2	.030807	.003323	.009464	.002991
3	.027912	.002589	.054154	.064038
4	.024922	.003172	.091826	.118961
5	.022418	.004066	.116349	.157488
6	.020411	.004788	.131324	.17792
7	.018719	.005213	.141301	.189138
8	.017254	.005431	.148811	.195825

Period	Algeria	France	Tunisia	Turkey
	res	res	res	res
1	.001464	.005803	.001819	.000022
2	.004428	.003158	.015084	.003755
3	.011265	.00431	.063768	.006811
4	.01558	.007071	.10467	.009402
5	.017658	.009219	.12914	.010382
6	.018546	.010574	.14083	.010726
7	.018834	.011164	.146169	.010782
8	.018808	.011344	.148527	.010793
	int	int	int	int
1	.006725	.001664	.001675	.001414
2	.005701	.003876	.002846	.002572
3	.007184	.006438	.003611	.00472
4	.008292	.009219	.004261	.005344
5	.008868	.012173	.004513	.005219
6	.009146	.014438	.004508	.005436
7	.009248	.016094	.004349	.006253
8	.009248	.017378	.004124	.007412

Table 3.2 Breakdown of variation following a shock of variations of precipitations (vprec)

Period	Algeria	France	Tunisia	Turkey
	y	Y	y	y
1	.000039	.072138	.001519	.044244
2	.00789	.088896	.011541	.140914
3	.018392	.103758	.010389	.160032
4	.026044	.11088	.010264	.172653
5	.031123	.110347	.010165	.176449
6	.034896	.109817	.010095	.177445
7	.037552	.109516	.009956	.17713
8	.039592	.109303	.009823	.176326
	xpt	Xpt	xpt	xpt
1	.00384	.029222	.000031	1.1e-06
2	.003929	.04037	.003909	.007949
3	.003494	.03506	.025088	.020376
4	.00343	.03181	.039284	.033322
5	.003804	.032095	.060266	.045329
6	.004208	.033362	.075074	.05559
7	.004681	.034297	.088321	.064053
8	.005164	.034858	.098456	.070974
	prx	Prx	prx	prx
1	.003703	.00133	.014128	.004031
2	.002561	.000515	.059453	.090875
3	.002723	.001241	.101408	.18186
4	.002643	.003511	.135309	.236189
5	.002524	.005746	.161196	.26697
6	.00236	.007441	.181199	.282073
7	.002191	.008535	.196727	.288961
8	.002027	.009244	.209151	.291379

Period	Algeria	France	Tunisia	Turkey
	res	res	res	res
1	.000043	.003727	.010275	.003663
2	.004243	.002644	.033957	.00816
3	.003525	.004481	.089914	.00794
4	.003017	.007665	.141872	.006651
5	.002761	.010244	.178445	.005672
6	.002667	.012146	.2027	.005026
7	.002711	.013036	.218391	.004584
8	.002852	.01337	.228796	.004258
	int	int	int	int
1	.00009	.001724	.000185	.005374
2	.001482	.002181	.003384	.008239
3	.001041	.003352	.002215	.007223
4	.000929	.004641	.002437	.00751
5	.000908	.005908	.00388	.008332
6	.000902	.006705	.005736	.009092
7	.000899	.007235	.007561	.009724
8	.000899	.007632	.009242	.010197

Table 3.3 Breakdown of variation following a shock of temperatures (temp)

Period	Algeria	France	Tunisia	Turkey
	y	Y	y	y
1	.034514	.057475	.022365	.004799
2	.026983	.172976	.030656	.008643
3	.020477	.220682	.038411	.028813
4	.020958	.235929	.043384	.054628
5	.022307	.236649	.045144	.08284
6	.022724	.235771	.044913	.104585
7	.021431	.236411	.044172	.117372
8	.020366	.237734	.043714	.121991
	xpt	Xpt	xpt	xpt
1	.006422	.011244	.000943	.023213
2	.012538	.042426	.002351	.033805
3	.019446	.054558	.002146	.043129
4	.023232	.054305	.002508	.045223
5	.023867	.050575	.00623	.042362
6	.022408	.04701	.014744	.036812
7	.020592	.044365	.026826	.030981
8	.019398	.042444	.038797	.026126
	prx	Prx	prx	prx
1	.00187	.000762	.007296	.001271
2	.019372	.002552	.004694	.009414
3	.036335	.010318	.004213	.007896
4	.045883	.025536	.01091	.018209
5	.046084	.044834	.025183	.052858
6	.040884	.063086	.042549	.101267
7	.035381	.077057	.057385	.143023
8	.03235	.086156	.06651	.1671

Period	Algeria	France	Tunisia	Turkey
	res	res	res	res
1	.000038	.003896	.000634	.01431
2	.000041	.005002	.00194	.007563
3	.00003	.003982	.015679	.006209
4	.000052	.003311	.049961	.008585
5	.000085	.003822	.096543	.01137
6	.000098	.005067	.139185	.01262
7	.000085	.006281	.16692	.012258
8	.000086	.007039	.177966	.011388
	int	int	int	int
1	.000892	.000737	.001584	.000108
2	.003227	.00175	.006586	.00145
3	.005585	.00238	.013285	.004834
4	.006711	.002743	.018475	.009196
5	.006583	.00298	.020716	.011974
6	.00578	.003121	.020237	.012804
7	.00502	.003211	.018345	.012695
8	.004633	.003282	.016293	.013303

Table 3.4 Breakdown of variation following a shock of variations of temperatures (vtemp)

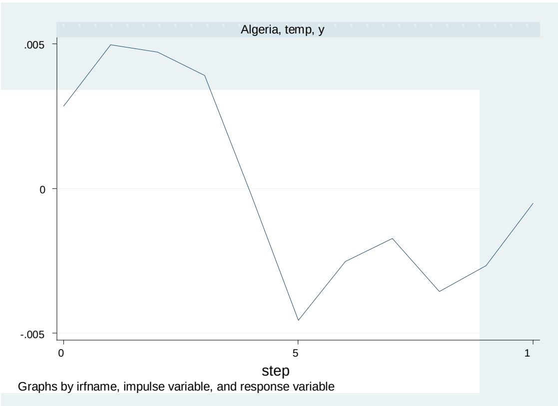
Period	Algeria	France	Tunisia	Turkey
	y	Y	y	y
1	.000731	.082694	.001684	.014796
2	.065373	.233229	.005497	.07688
3	.089551	.241015	.006572	.101979
4	.108648	.239947	.007485	.126713
5	.111001	.239224	.007507	.141777
6	.109522	.239308	.007378	.152554
7	.105801	.238717	.00726	.159637
8	.102279	.238042	.007179	.164367
	xpt	Xpt	xpt	xpt
1	.001581	.02704	.006003	.000348
2	.00937	.105573	.00997	.00838
3	.009635	.105359	.010031	.008126
4	.008203	.095541	.015492	.006231
5	.007569	.090452	.022449	.004727
6	.008299	.088318	.033075	.004323
7	.00956	.085884	.044492	.004907
8	.010808	.083735	.055938	.006168
	prx	Prx	prx	prx
1	.05176	.011767	.004193	.000348
2	.090114	.038434	.014457	.00838
3	.09118	.067087	.040489	.008126
4	.07961	.095689	.073108	.006231
5	.066922	.122405	.103886	.004727
6	.056977	.144606	.128502	.004323
7	.049572	.161312	.1467	.004907
8	.043832	.173583	.159667	.006168

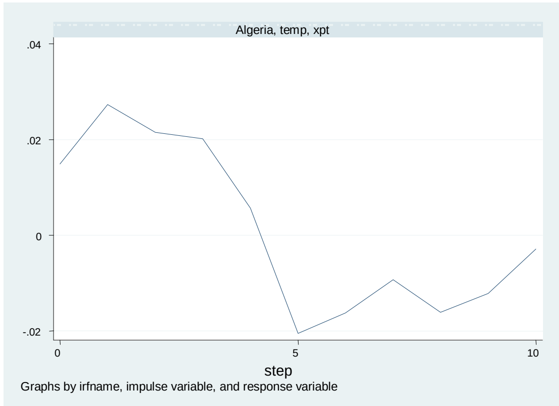
Period	Algeria	France	Tunisia	Turkey
	res	res	res	res
1	.002093	.000144	.019129	.047804
2	.001949	.000079	.048266	.043509
3	.003591	.002812	.112889	.050665
4	.00562	.007757	.17811	.058963
5	.007902	.013115	.229169	.066571
6	.010044	.018687	.261441	.071871
7	.01192	.023556	.27945	.075025
8	.01352	.027393	.287842	.076521
	int	int	int	int
1	.008985	.000026	.001657	.00198
2	.013426	.000479	.015487	.014628
3	.013931	.000497	.01772	.01774
4	.011897	.000494	.01557	.02046
5	.009833	.000521	.012865	.020997
6	.008308	.00051	.010834	.020927
7	.007267	.000496	.009511	.020762
8	.006522	.000496	.008651	.020943

Annex 4 - Country response to a shock of temperatures (temp) and of precipitations (prec) based on simulations related to the period 2010-2030, according to scenario A1B

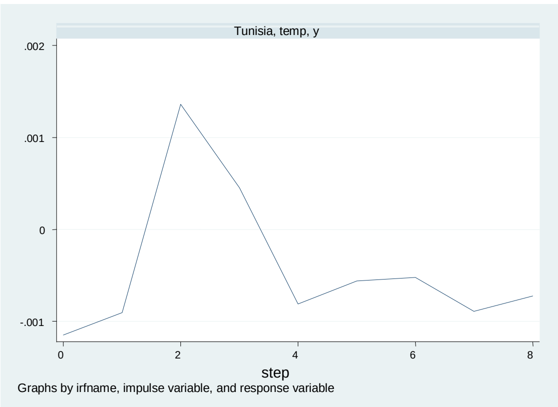
Graph 4.1 Country response to a shock of variations of temperatures (temp)

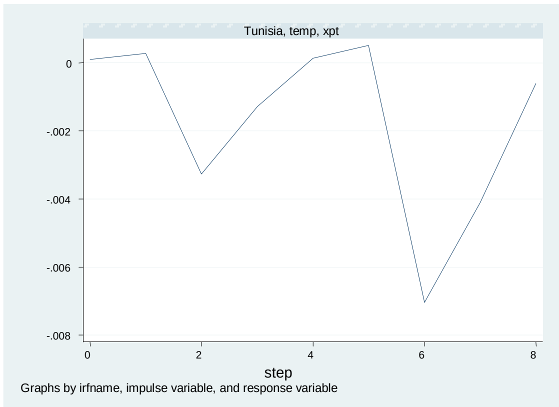
Algeria



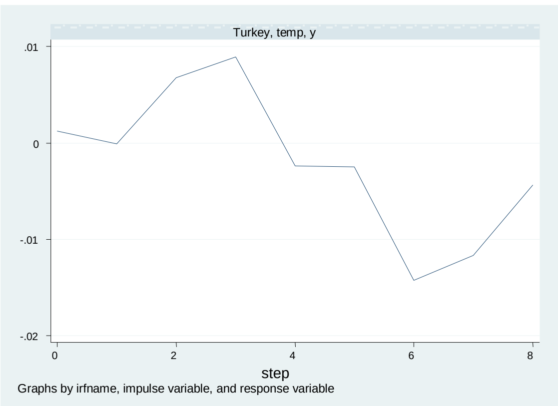


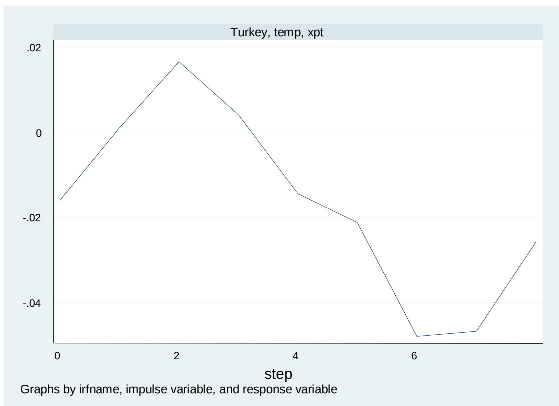
Tunisia



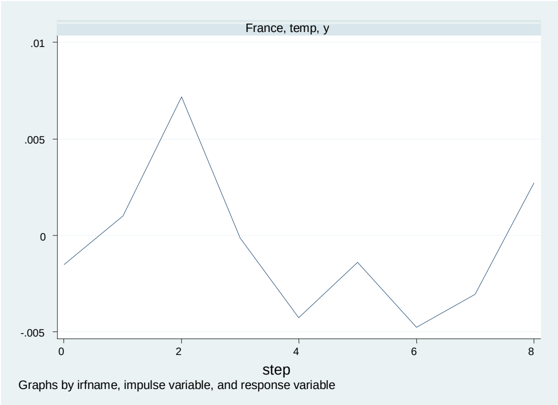


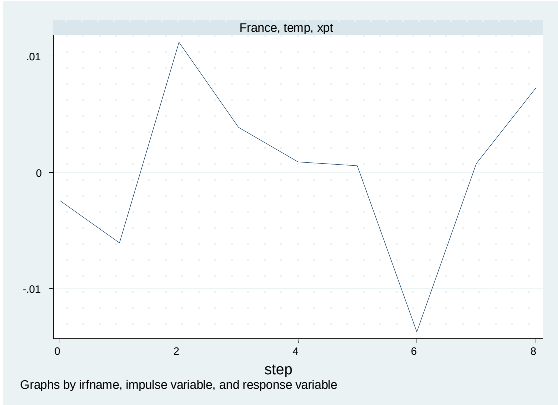
Turkey





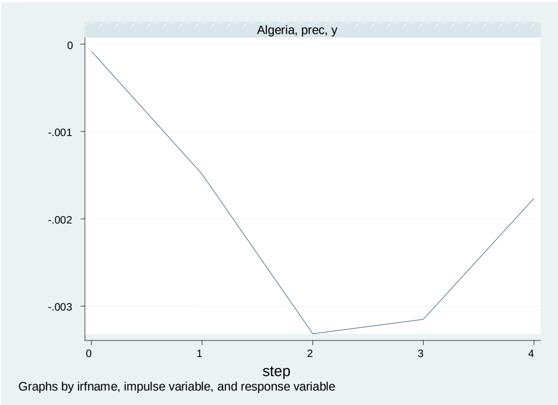
France

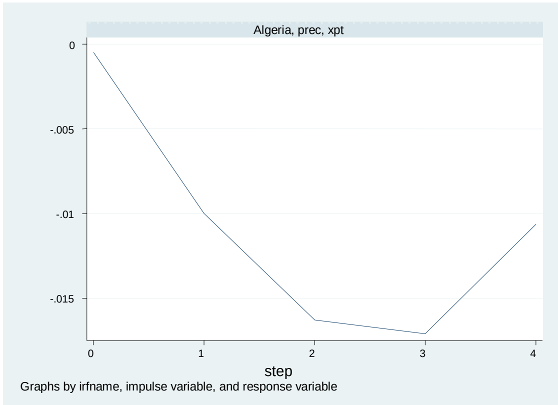




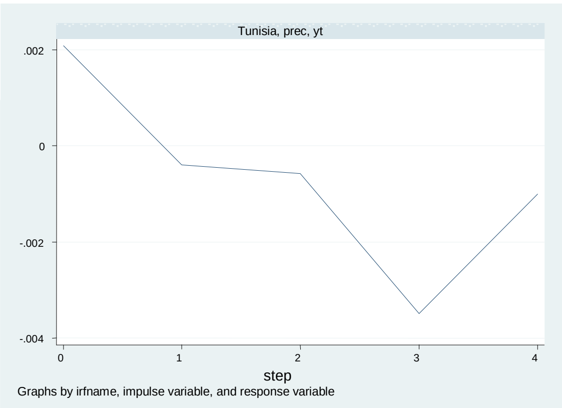
Graph 4.2 Country response to a shock of variations of precipitations (prec)

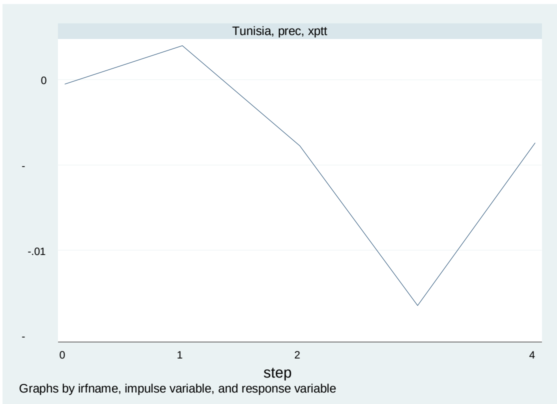
Algeria



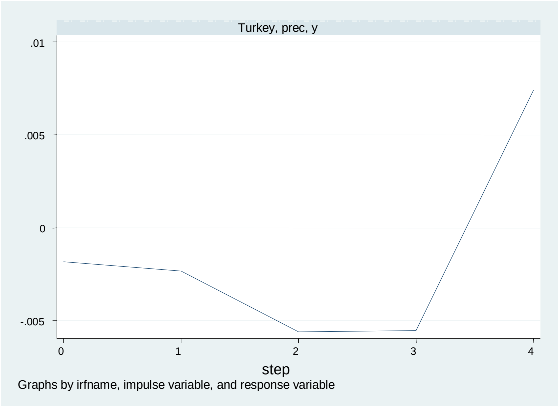


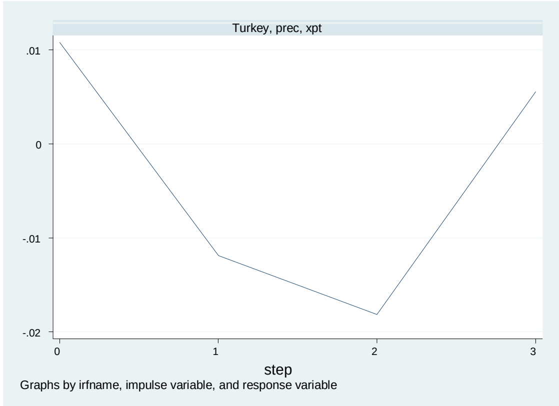
Tunisia



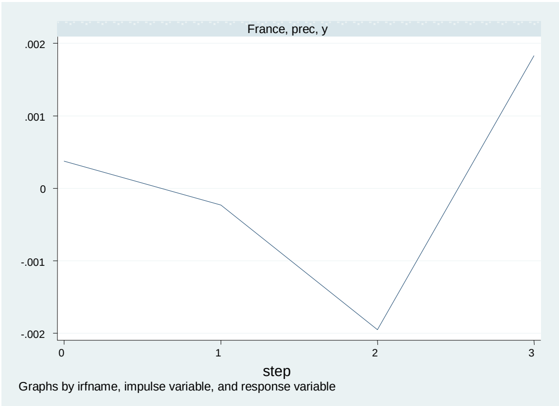


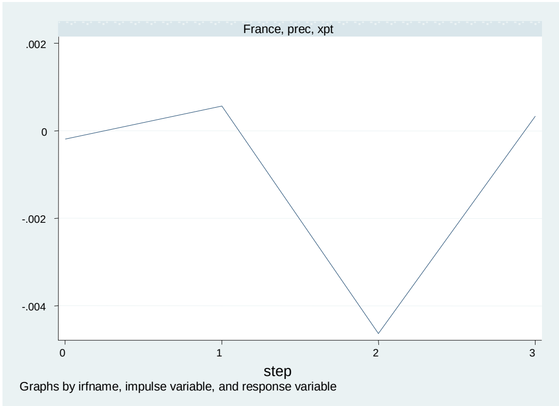
Turkey





France





Annex 5 - Breakdown of variation following a shock of precipitations (prec) and of temperatures (temp) based on simulations related to the period 2010-2030, according to two scenarios

Table 5.1 Breakdown of variation following a shock of temperatures (temp) and of precipitations (prec)

	Algeria				Tunisia			
	Prec		temp		prec		temp	
period	y	Xpt	y	xpt	y	xpt	y	xpt
1	.000063	.000113	.259028	.34628	.345155	.032591	.112831	.000104
2	.012883	.025533	.499309	.616002	.284081	.380055	.116289	.001442
3	.058789	.068807	.481435	.527332	.135832	.128731	.171605	.053871
4	.078227	.092725	.487464	.551893	.307626	.517434	.173491	.052383
5	.086465	.103645	.435314	.502459	.303733	.43965	.1612	.032387
6	.078002	.095748	.46997	.522762	.312231	.366488	.162572	.028275
7	.075529	.092467	.452512	.525136	.327701	.403464	.168287	.116438
8	.075153	.090294	.449647	.515846	.405966	.489429	.171029	.12254
9	.080791	.094148	.462461	.527957	.366603	.456626	.159545	.117236
10	.08721	.09961	.445225	.497408	.362792	.452199	.183954	.168073
11	.088998	.100999	.44529	.495608	.351932	.449881	.27494	.212476
12	.088078	.099754	.448102	.496541	.349563	.448452	.260995	.213487

	Turkey				France			
	Prec		temp		prec		temp	
period	y	Xpt	y	xpt	y	xpt	y	xpt
1	.015913	.14676	.028615	.189919	.004697	.0004	.098289	.179944
2	.031199	.144745	.024743	.167055	.0028	.001012	.088482	.218751
3	.09393	.197037	.27384	.240218	.015597	.036388	.266589	.35286
4	.050548	.174335	.364664	.218534	.024463	.03347	.22844	.341771
5	.079451	.213995	.350842	.260802	.067562	.069991	.237856	.326491
6	.102756	.146608	.291205	.279239	.060576	.042925	.232893	.234591
7	.115504	.135825	.462341	.492943	.058225	.039985	.277068	.280923
8	.109826	.118232	.539772	.597547	.049203	.03935	.270121	.274251
9	.111893	.114756	.520555	.605608	.054977	.042998	.27066	.26676
10	.112657	.109621	.520324	.614091	.057306	.045077	.275405	.26829
11	.111588	.109304	.488361	.592994	.05746	.046377	.279584	.26728
12	.114967	.109405	.487797	.593572	.056481	.048487	.277134	.266797

Annex 6 - Standardised responses to shocks (impact of a exogenous shock unit)

Table 6.1 Impact of a rise in temperature by 1°C over the periods 19980-2002 and 2010-1030

temp	Algeria	France	Tunisia	Turkey	Algeria	France	Tunisia	Turkey
	y	Y	y	y	Xpt	xpt	xpt	xpt
1	-0,002374	-0,00386	-0,00296	0,000858	-0,002504	-0,001763	-0,001328	-0,000708
3	0,00109	-0,002854	-0,001956	0,003349	-0,003765	-0,001727	0,001031	-0,00125
5	0,001037	0,000173	-0,000651	0,003935	-0,001559	-0,000083	0,004755	-0,000751
8	-0,000989	0,000802	0,000405	0,001763	0,001247	0,000408	0,005437	0,000096
temp	Algeria	France	Tunisia	Turkey	Algeria	France	Tunisia	Turkey
	y	Y	y	y	Xpt	xpt	xpt	xpt
1	0,005078	0,001025	-0,000846	-0,00009	0,028326	-0,006064	0,000428	0,000978
3	0,004109	-0,000117	0,000459	0,008939	0,020936	0,003875	-0,001146	0,003975
5	-0,004492	-0,00139	-0,000608	-0,002464	-0,01998	0,000594	0,000284	-0,021229
8	-0,003663	0,002716	-0,000774	-0,00436	-0,016783	0,007276	-0,000621	-0,025848

Table 6.2 Impact of an increase in precipitations by 10% over the periods 19980-2002 and 2010-1030

prec	Algeria	France	Tunisia	Turkey	Algeria	France	Tunisia	Turkey
	y	Y	y	y	Xpt	xpt	xpt	xpt
1	-0,1156	-0,050925	-0,0109	-0,55715	0,007772	-0,032067	0,19758	-0,08698
3	-0,10147	-0,20067	-0,002912	-0,87566	0,011133	-0,17114	-0,12769	-0,03997
5	-0,08168	-0,0141	0,000169	-0,75948	0,00794	-0,01445	-0,16603	-0,11443
8	-0,05863	-0,00817	0,001026	-0,56872	0,005121	-0,01247	-0,1434	-0,20665
prec	Algeria	France	Tunisia	Turkey	Algeria	France	Tunisia	Turkey
	y	Y	y	y	Xpt	xpt	xpt	xpt
1	-0,01488	-0,00226	-0,0081	-0,02325	-0,09996	0,00564	-0,010981	-0,01187
3	-0,03154	0,01835	-0,01647	-0,05523	-0,17112	0,00338	-0,000155	0,005564
5	-0,00389	-0,00583	0,00394	0,08412	-0,03699	0,00325	-0,000563	0,030204
8	0,02063	-0,01885	0,00805	-0,03517	0,09772	-0,03416	-0,002659	0,000695

References

Blanchard, O., Quah, D. (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances. *American Economic Review* 79, 655-673.

Boer, G., G. Flato, and D. Ramsden (2000). A transient climate change simulation with greenhouse gas and aerosol forcing: projected climate for the 21st century. *Climate Dynamics* 16, 427–450.

Box, G.E.P. & Jenkins, G.M. (1976). *Time series analysis: Forecasting and control*. Oakland, CA : Holden-Day.

Buckle, R.A., Kim, K., Kirkham, H., McLellan, N., Sharma, J. (2002). *A structural VAR model of the New Zealand business cycle.* (New Zealand Treasury Working Paper, 02/06).

Clarida, R. et Gali, J. (1994). *Sources of Real Exchange Rate Fluctuations: How Important are Nominal Shocks?*(NBER Working Papers 4658).

Cushman, D.O., and T. Zha (1997). Identifying Monetary Policy in Small Open Economy under Flexible Exchange Rate. *Journal of Monetary Economics* 39, 433-448.

Emori, S., Nozawa, T., Abe-Ouchi, A., Namaguti, A., Kimoto, M. (1999). Coupled ocean-atmospheric model experiments of future climate change with an explicit representation of sulphate aerosol scattering. *Journal Meteorological Society Japan* 77, 1299–1307.

Engle, R.F. and C.W.J. Granger (1987). Co integration and Error-Correction: Representation, Estimation and Testing. *Econometrica* 55, 251-276

Gali, J. (1992). Does the IS-LM Model Fit US Postwar Data ? *Quarterly Journal of Economics*, CVII, 708-738.

Giannakopoulos C., Bindi, M., Moriondo, M., P. LeSager and T. Tin. (2005). *Climate change impacts in the Mediterranean resulting from a 2°C global temperature rise*. *WWF Report*.

Hallegatte, S., Hourcade, J.C., Dumas, P. (2007). Why economic dynamics matter in assessing climate change damages: Illustration on extreme events. *Ecological Economics* 62(2, 20), 330-340.

Hamilton, J.D. (1994). *Time Series Analysis*. Princeton University Press.

IPCC (2007). *Climate Change 2007, the Fourth IPCC Assessment report*.

Kim, S. and N. Roubini (2000). Exchange Rate Anomalies in the Industrialized Countries: A Solution with a Structural VAR Approach. *Journal of Monetary Economics* 45, 561-586.

Linnerooth-Bayer, J., Mechler, R. (2006). Insurance for assisting adaptation to climate change in developing countries: a proposed strategy. *Climate Policy* 6, 621–636.

Lack, C. et Lenz, C. (2000). *A Program for the Identification of Structural Var Models*. WWZ-Studie, 58, april.

Mackowiak, B. (2007). External Shocks, US Monetary Policy and Macroeconomic Fluctuations in Emerging Markets. *Journal of Monetary Economics* 54, 2512-2520.

Mendelson, R. (2007). Measuring climate impact with cross-sectional analysis. *Climatic Change* 81(1).

Mendelson, R., Morrison, W., Schlesinger, M. E., Andronova, N.G. (2000). Country-specific market impacts of climate change. *Climatic change* 45, 553-569.

Munich Re (2009). *Topics Geo Natural catastrophes 2008*. Munich Reinsurance Group, Munich.

Nordhaus, W.D. (2006). Geography and macroeconomics: New data and new findings. *Proceedings of National Academy of Sciences* 103(10), 3510-3517.

Nordhaus, W.D., Boyer, J.G. (2000). *Warming the World: The Economics of the Greenhouse Effect*. Cambridge, MA: MIT Press.

Plan Bleu, PAM-PNUE, BEI (2008). *Climate Change, Energy and the Mediterranean*.

Plan Bleu, Benoit, G, Comeau, A (2005). *Méditerranée : les perspectives du Plan Bleu sur l'environnement et le développement*. éditions de l'Aube.

Sims, C.A. (1986). Are Forecasting Models Usable for Policy Analysis. Federal Reserve Bank of Minneapolis. *Quarterly Review*, 10, 2-16.

Sims, C.A., J.H. Stock and M.W. Watson (1990). Inference in Linear Time Series Models with Some Unit Roots. *Econometrica*, 58, 113-144.

Sims, C.A. and T. Zha (1995). *Does monetary policy generate recessions? :Using less aggregate price data to identify monetary policy*. Yale University, CT. (Working paper).

Smith, J.B. Schellnhuber, H.-J., Mirza, M.M.Q., Fankhauser, S., Leemans, R., Lin, E., Ogallo, L., Pittock, B., Richels, R.G., Rosenzweig, C., Tol, R.S.J., Weyant J.P., Yohe, G.W. (2001). Vulnerability to climate change and reasons for concern: a synthesis. In *Climate Change 2001: Impacts, Adaptation and Vulnerability. Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press, 913-967.

Stern, N. (2006). *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

Svensson, L.E.O. (1994). Fixed Exchange Rate as a Means to Price Stability: What have we Learned? *European Economic Review* 38, 447-468.

Swiss Re, (2007). *Sigma, Natural Catastrophes and Man-Made Disasters in 2006*. Swiss Reinsurance Company, Zurich.

Tol, R.S.J. (2002). Estimates of the damage costs of climate change – part II: dynamic estimates. *Environmental and Resource Economics* 21, 135-160.

Tol, R.S.J. (2006). *Integrated Assessment Modelling*. (Working Paper FNU-102).

Tol, R.S.J. (2007). *Why Worry About Climate Change? A Research Agenda*. Fondazione Eni Enrico Mattei. (Nota di Lavoro 136).

Wigley, T.M.L. (1985). Impact of extreme events. *Nature* 316, 106-107.

Plan Bleu pour l'Environnenement et le Développment en Méditerranée
15 rue Beethoven, Sophia Antipolis, 06560 Valbonne
+33 (0)4 92 38 71 30 - www.planbleu.org

ISBN 978-2-912081-20-9