Relationship between exports, imports, and economic growth in France: evidence from cointegration analysis and Granger causality with using geostatistical models

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Abstract

This paper introduces a new way of investigating linear and nonlinear Granger causality between exports, imports and economic growth in France over the period 1961-2006 with using geostatistical models (kiriging and inverse distance weighting). Geostatistical methods are the ordinary methods for forecasting the locations and making map in water engineerig, environment, environmental pollution, mining, ecology, geology and geography. Although, this is the first time which geostatistics knowledge is used for economic analyzes. In classical econometrics there do not exist any estimator which have the capability to find the best functional form in the estimation. Geostatistical models investigate simultaneous linear and various nonlinear types of causality test, which cause to decrease the effects of choosing functional form in autoregressive model. This approach imitates the Granger definition and structure but improve it to have better ability to investigate nonlinear causality. Results of both VEC and Improved-VEC (with geostatistical methods) are similar and show existance of long run unidirectional causality from exports and imports to economic growth. However the F-statistic of improved-VEC is larger than VEC indicating that there are some exponential and spherical functions in the VEC structure instead of the linear form.

Keywords: Granger causality; Exports; Imports; Economic growth; Geostatistical model; Kiriging; Inverse distance weighting; Vector auto-regression; France

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1. Introduction

Disagreements persist in the empirical literature regarding the causal direction of the effects of trade openness on economic growth. Michaely (1977), Feder (1982), Marin (1992), Thornton (1996) found that countries exporting a large share of their output seem to grow faster than others. The growth of exports has a stimulating influence across the economy as a whole in the form of technological spillovers and other externalities. Models by Grossman and Helpman (1991), Rivera-Batiz and Romer (1991), Romer (1990) posit that expanded international trade increases the number of specialized inputs, increasing growth rates as economies become open to international trade. Buffie (1992) considers how export shocks can produce export-led growth. Oxley (1993), using Portuguese data, finds no support for the ELG hypothesis, quite the reverse, adding fuel to the controversy concerning programs for growth. Export growth is often considered to be a main determinant of the production and employment growth of an economy. This so-called hypothesis of export-led growth (ELG) is, as a rule, substantiated by the following four arguments (Balassa, 1978; Bhagwati, 1978; Edwards, 1998). First, export growth leads, by the foreign trade multiplier, to an expansion of production and employment. Second, the foreign exchange made available by export growth allows the importation of capital goods which, in turn, increase the production potential of an economy. Third, the volume of and the competition in exports markets cause economies of scale and an acceleration of technical progress in production. Fourth, given the theoretical arguments mentioned above, the observed strong correlation of export and production growth is interpreted as empirical evidence in favor of the ELG hypothesis (Ribeiro Ramos, 2001). Export expansion and openness to foreign markets is viewed as a key determinant of economic growth because of the positive externalities it provides. For example, firms in a thriving export sector can enjoy the following benefits: efficient resource allocation, greater capacity utilization, exploitation of economies of scale, and increased technological innovation stimulated by foreign market competition (Helpman and krugman, 1985).

In the GLE case, export expansion could be stimulated by productivity gains caused by increase in domestic levels of skilled-labor and technology (Bhangwati, 1988; Krugman, 1984). Neoclassical trade theory typically stresses the causality that runs from home-factor endowments and productivity to the supply of exports (Findlay, 1984). The product life cycle hypothesis developed by Vernon (1996) has also attracted considerable attention among international trade theorists in recent years. Segerstrom et al. (1990), for example, use the product life cycle hypothesis as a basis for analyzing north_south trade in which research and development competition between firms determines the rate of product innovation in the north.

The third alternative is that of import-lead growth (ILG) suggests economic growth could be driven primarily by growth in imports. Endogenous growth models show that imports can be a channel for long-ran economic growth because it provides domestic firms with access to needed intermediate and foreign technology (Coe and Helpman, 1995). Growth in imports can serve as a medium for the transfer of growth-enhancing foreign R&D knowledge from developed to developing countries (Lawrence and Weinstein, 1999; Mazumdar, 2000).

The most interesting economic scenarios suggest a two-way causal relationship between growth and trade. According to Bhagwati (1988), increased trade produces more income (increased GDP), and more income facilitates more trade _ the result being a ‘virtuous circle’. This type of feedback has also been noted by Grossman and Helpman (1991).in their models of north_south trade.

However, they point to a causal relationship between international trade and exports and economic growth. Finally and crucially, for the purpose of this paper, the strong correlation of export (import) and GDP growth rates has nothing to say about a relationship between the export (import) and the GDP trend development. In order to test for the existence of a long-run or trend relationship among GDP and exports and imports, the theory of cointegration developed by Pesaran and Shin (1995) among others has to be applied. To this end, we analyze annual data for France, using the developed multivariate cointegration Engle and Granger (1987) approach with applying geostatistical models[1].
In time series analysis, all ordinary classical methods and tests apply linear estimators, such as OLS. If the null hypothesis of testing causality is not rejected using linear methods, our conclusion is that no causal linear relationship exists between the variables of interest. But it is essential to analyse and see if there exist nonlinear relationships between the variables during the time. This paper suggests a more general test using stronger nonlinear regressors like geostatistical methods in order to test the null hypothesis of causality with no particular reference to the functional form of the relationship.
In this paper, a new application of using geostatistical methods for testing causality in economics is suggested. In this improved method, geostatistical models are used for predicting VEC structures. There are some evidences[2] that results from this geostatistical methods which are more exact and supportive than OLS, such as, geostatistical models which decreases the probable effects of choosing linear regressor, because they choose the best functional form between Linear, Linear to sill, Spherical, Exponential and Gaussian[3]. Geostatistical models have ability to mix different functional forms for Engle and Granger's structure, then, Engle-Granger method will be improved to have ability of investigating linear and nonlinear structures simultaneous[4].
On the empirical side, over 90% of Granger causality in energy economics was investigated in linear forms, and our paper is worthwhile to report an important issue in the fields of international trade, economic growth, and policies toward international trade.

2. Methodology

Whether exports cause GDP gains or losses or whether GDP gains cause exports or whether there are a two-way causal relationship between exports and GDP can be determined only empirically. Our investigation proceeds by studying the integration properties of the data, undertaking a systems cointegrating analysis, and examining Granger causality tests.

2.1. The data

The data are annual France observations on logarithm of real GDP, logarithm of exports of goods and services (current US$), and logarithm of imports of goods and services (current US$).

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[1] Geostatistical methods are the ordinary methods for forecasting the locatins and making map in water engineerig, environment, environmental pollution, mining, ecology, geology and geography.
[2] Geostatistical models are mentioned as strong nonlinear estimators on the empirical works in other fields. For empirical works see Van Kuilemberg et al. (1982), Voltz and Webster (1990), and Bishop and McBratney (2001).
[3] see David (1977), Krige (1981), Cressie (1985, 1991), Isaaks and Srivastava (1989), and Hill et al. (1994).
[4] There is no research which uses geostatical models to investigate nonlinear causality test. But there are some researches which suggest new nonlinear approaches in Granger causality, such as, Chen et al. (2004) and, Diks and Panchenko (2006).

Annual data on all variables are available from 1961 to 2006 from World Development Indicators 2008.

2.2. Testing for normality

Primary statistical analyses such as frequency distribution, normality tests and mean comparisons were conducted using MINITAB and Kolmogrov–Smirnov was applied the test normality, it was essential for using geostatistical models. Results show that all Primary statistical analyses are success and all data can be estimated with geostatistical models.

2.3. Testing for integration

In order to investigate the stationarity properties of the data, a univariate analysis of each of the three time series (GDP, exports, and imports) was carried out by testing for the presence of a unit root. Dickey_Fuller (DF), Augmented Dickey_Fuller (ADF) *t*-tests (Dickey and Fuller, 1979) and Phillips and Perron (1988) $Z(t\hat{\alpha})$-tests for the individual time series and their first differences are shown in Table 1. The lag length for the ADF tests was selected to ensure that the residuals were white noise. It is obvious from the DF, ADF and Phillips and Perron (PP) tests that at conventional levels of significance. DF, ADF and PP test computed using the first difference of *y*, *x*, and *m* indicate that these tests are individually significant at the 1% level of significance. As differencing once produces stationarity, I conclude that both of the series *x* and *m* are integrated in order 1, *I*(1), and *y* is integrated in order 0, *I*(0).

Table 1
Tests for integration

Series	Single unit root			Second unit root		
	DF	ADF	PP	DF	ADF	PP
Y	-4.47*	-4.37*	-4.38*	-8.78*	-4.57*	-15.37*
X	-1.65	-1.69	-1.04	-3.81*	-3.72*	-3.68*
M	-1.49	-1.69	-1.28	-4.50*	-4.46*	-4.29*

[a]*Notes*. Statistically significantly different from zero at the 0.01 significance level. The optimal lag used for conducting the ADF test statistic was selected based on an optimal criterion Akaike's FPE , using a range of lags. The truncation lag parameter *l* used for PP tests was selected using a window choice of $w(s, l) = 1\text{-}s/(l+1)$. where the order is the highest significant lag from either the autocorrelation or partial autocorrelation function of the first differenced series (see Newey and West, 1987).

Therefore, exports and imports series are integrated processes of order one. This is a necessary step in order to test the cointegration of the variables.

2.4. Testing for cointegration

Using the concept of a stochastic trend, we may ask whether our series are driven by common trends (Stock and Watson, 1988) or, equivalently, whether they are cointegrated (Engle and Granger, 1987). A hypothesis on investigating cointegrating relationship and certain linear restrictions were tested with using ARDL which proposed by Pesaran and Shin (1995), Pesaran and Pesaran (1997), and Pesaran et al. (2001). Table 2 contains the results obtained by the application of Pesaran's procedure. Thereby, the lag length of the level ARDL (Autoregressive Distributed Lag) system was determined by minimizing the Akaike Information Criterion (AIC).

The results support the existence of a cointegrating relation with growth-exports and growth-imports.

Table 2
ARDL test for univariate cointegrating relationship

Relations	F-statistic value with using intercept no trend	Long ran coefficients reltionships
Growth-exports	6.5122*	$y = 8.0669 – 0.28334\, x$
Growth-imports	5.4832*	$y = 8.2444 – 0.28958\, m$

Note: the optimal lag structure of the ARDL was selected by minimizing the Akaike's FPE criterion. Pesaran critical values are chosen, which are $I(0) = 4.042$ and $I(1) = 4.778$ for using intercept no trend in 10% probability, for testing the existence of cointegration relationships. Results reject null hypothesis which says there is not a long run relationship between variables.

2.5. Investigating Granger causality

In this section we will first review the basic idea of Granger causality formulated for analyzing linear systems and then propose a generalization of Engle Granger's idea to attractors reconstructed with geostatistical models coordinates.

2.5.1. Linear Granger causality test

Cointegration implies the existence of Granger causality. However, it does indicate the direction of the causality relationship. Therefore, the vector error correction (VEC) model is employed to detect the direction of the causality. Engle and Granger (1987) argued that if there is cointegration between the series, then the vector error correction model can be written as

$$\Delta y_t = C_0 + \sum_{i=1}^{k} \beta_i \Delta y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta x_{t-1} + \rho_i ECT_{t-1} + u_t$$
$$\Delta x_t = C_0 + \sum_{i=1}^{k} \gamma_i \Delta x_{t-1} + \sum_{i=1}^{k} \zeta_i \Delta y_{t-1} + \eta_i ECT_{t-1} + \varepsilon_t \tag{1}$$

where Δ is the difference operator; k, is the numbers of lags, α_s and ς_s are parameters to be estimated, $ECT_{,s-1}$ represents the error terms derived from the long-run cointegration relationship, $y_t = \alpha + \beta x_t + \varepsilon_t$, and u_t and ε_t the serially uncorrelated error terms.
In each equation, the change in the dependent variable is caused not only by the lag, but also by the previous period's disequilibrium level. The joint significance indicates that each dependent variable is responding to short-term shocks to the stochastic environment; the long-run causality can be tested by looking at the significance of the speed of adjustment, which is the coefficient of the error correction term. The significance indicates that the long-run equilibrium relationship is directly driving the dependent variable (Yoo, 2006).The results of the Granger causality tests of the model are reported in Table 3, which also reports the tests used to choose the lag lengths.

2.5.2. Extended Granger causality with geostatical models

The above structure (1) includes nonlinear or both linear and nonlinear functional forms. Thus we suggest estimating the structures of Engle and Granger method with geostatistical models, i.e. since this may improve a more careful estimation with new functions which is used for investigating the causality. Below we model the new shapes which will estimated with Kriging and Inverse Distance Weighting (IDW), which all *f*, *h*, g_i, l_i, m_i, n_i, q_i and p_j are different functions, which may be linear or nonlinear (linear, linear to sill, spherical, exponential and Gaussian) functions. These functions are chosen using Kiriging and IDW.

$$\Delta y_t = f\left[\sum_{i=1}^{k} g_i(\Delta y_{t-1}) + \sum_{i=1}^{k} m_i(\Delta x_{t-1}) + n(ECT_{t-1})\right] + u_t$$

$$\Delta x_t = h\left[\sum_{i=1}^{h} l_i(\Delta x_{t-1}) + \sum_{i=1}^{k} P_i(\Delta y_{t-1}) + q(ECT_{t-1})\right] + \varepsilon_t \tag{2}$$

2.6. Geostatistical analysis

Each variable: independent or dependent, their lags, are defined with a dimension in spatial structure. For example, if we want to determinate an unrestricted structure of VEC with one lag we face a 4D space for investigation with geostatistics approaches. In other words, in geostatistics the characteristics of location are the same as variables (exogenous and endogenous) in econometrics.

Geostatistics can be used to determine an unknown value, estimate endogenous variables, produce a map of parameters and confirm sampling process and make a more accurate sample. The first step is to analyze the spatial structure in which semivariogram is the essential tools. Describing and modeling are two parts of analysis structure for predicting semivariogram. The semivariogram is a mathematical description of the relationship between the variance of pairs of observations and the distance separating them (h or dependent variable), i.e. for a 3D space (one endogenous and two exogenous variables), it explains the relationships between population variance within a distance class (y-axis) according to the geographical distance between pairs of populations (x-axis). The semivariance is an autocorrelation statistic defined as:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i + h) - Z(x_i)]^2 \tag{3}$$

where: $\gamma(h)$ is the semivariance for interval distance class, $N(h)$is the whole number of sample pairs of observations separated by a distance h, $Z(x_i)$ is the measured sample value at point i, $Z(x_i + h)$ is the measured sample value at point i+h. Semivariance is evaluated by calculating g(h) for all possible pairs of points in the data set and assigning each pair to a lag or distance interval class h.

It can provide better resolved variograms when there are sufficient pairs of points at shorter separation distances. In Figure 6, there exists a shape of semivariance calculated in a 3D space where sill is$(C + C_0)$, the nugget variance (or constant amount) is$(C_0)$and the scale (or differences between nugget and observations separated by distance) is(C).

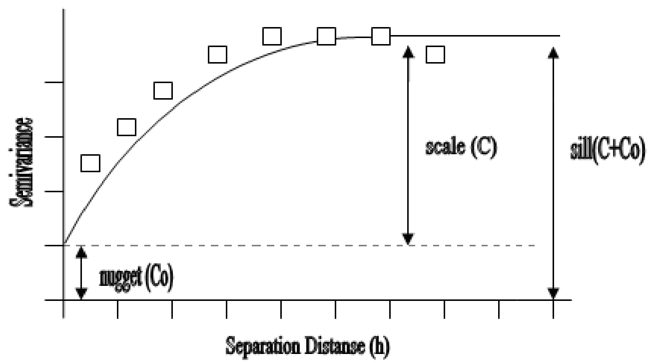

Figure 1: semivariance parameters in on surface.

In spatial structures we can calculate uncounted Semivariance in every degree. Collection of four semivariances in space is called variogram[5]. The next step is to analyse the variogram and find the type of variogram for our observation.
To create a ‘trustworthy’ variogram, different steps must be respected. Different lag distances have to be tested until a sufficient number of pairs to represent the model are found. Four representative groups of pairs are sufficient to represent a relevant variogram with a significant R^2 and a good ‘nugget-to-sill’ ratio. The effective lag distance cannot be more than half of the maximum distance between data (see Isaaks and Srivastava, 1989).
Burgos et al. (2006) explain that direct dependence has to be tested in the spatial autocorrelation. The isotropic (no directional dependence) or anisotropic (directional dependence) characteristic of the variogram has to be determined. If no anisotropy is found, it means that the value of the variable varies similarly in all directions and the semivariance depends only on the distance between sampling points.
At last the best variogram model (exponential, linear, etc.) and its parameters (nugget, sill, scale, range, etc.) have to be determined in order to validate the modeling of the spatial autocorrelation through the variogram’s parameter optimization. The last step is to challenge between ordinary geostatistical methods (Kriging and IDW) for predicting dependent variable.

2.6.1. Kriging

Kriging provides a means of interpolating values for points not physically sampled using knowledge about the underlying spatial relationships in a data set to do so. Variograms provide this knowledge. Kriging is based on regionalized variable theory and is superior to other means of interpolation because it provides an optimal interpolation estimate for a given coordinate location, as well as a variance estimate for the interpolation value (Gamma Design Software, 2004). In Kriging, before determining the models, it is necessary to evaluate variogram to realize whether it is isotropic or anisotropic. The best way to evaluate anisotropy is to view the anisotropic semivariance surface (Semivariance Map), if anisotropic semivariance surface was symmetrical variogram would be isotropic, and if it was asymmetrical variogram would be anisotropic. The differences between variogram types, isotropic and anisotropics, lead to calculate same or various weights in space for Kriging model. After the variogram estimation, the interpolation between the measurement points was carried out. To do this, ordinary Kriging

[5] In geostatistics it is ordinary to calculate four semivariances in 0, 45, 90 and 135 degrees.

method was used to interpolate a great number of local scour maps of exogenous and endogenous variables[6]. Geostatistical and spatial correlation analyses of basic infiltration rate redistribution were performed with version 5.1 of GS^{+} software (Gamma Design Software, 2004).

2.6.2. Inverse distance weighting (IDW)

IDW is interpolation techniques in which interpolated estimates are made based on values at nearby spatial locations of our observation weighted only by distance from the interpolation location. IDW does not make assumptions about spatial relationships except the basic assumption that nearby points ought to be more closely related than distant points to the value at the interpolate location. Similar to Kriging, IDW, exactly implements the hypothesis that a value of an attribute at an unsampled location (variable) is a weighted average of known data points within other local neighborhoods surrounding the unsampled location (Robinson and Metternicht, 2006). In other word an improvement on simplicity giving equal weight to all samples is to give more weight to closet samples and less to those that are farthest away. One obvious way to do this is to make the weight for each estimated as follows:

$$\hat{Z}(x_0) = \frac{\sum_{i=1}^{n} Z(x_i) d_{ij}^{-r}}{\sum_{i=1}^{n} d_{ij}^{-r}} \tag{4}$$

Where x_0 is the estimation point and x_i are the data points within a chosen neighborhood. The weights (r) are related to distance by d_{ij}, which is the distance between the estimation point and the data points. The IDW formula has the effect of giving data points close to the interpolation point relatively large weights whilst those far away exert little influence.

3. Results

In this section we will first attention to results of the basic Granger causality formulated for analyzing linear systems and then probe a generalization of Engle and Granger’s idea to attractors reconstructed with geostatistical analyzing coordinates.

3.1. Results of linear Granger causality test with VEC

The empirical results with using ordinary VEC suggest that trade stimulates economic growth of France in long run. The empirical results do not confirm a bilateral causality between the variables considered. There is a unidirectional effect between exports_growth and imports_growth in long run. More interestingly, there is no kind of significant causality between growth_exports and growth_imports. Results are available in Table 3.

[6] For more explanation of Kriging method see Isaaks and Srivastava (1989).

Table 3
Results of causality tests based on VEC

Null hypotheses	Short run F-statistic	Long run F-statistic	Direction of short run causality	Direction of long run causality
Growth ⇏ Exports	0.436149	0.065958	Growth ⇏ Exports	Growth ⇏ Exports
Exports ⇏ Growth	0.199168	12.76313*	Exports ⇏ Growth	Exports ⇒ Growth
Growth ⇏ Imports	0.052140	0.054971	Growth ⇏ Imports	Growth ⇏ Imports
Imports ⇏ Growth	1.952792	10.06903*	Imports ⇏ Growth	Imports ⇒ Growth

Notes: the lag lengths are chosen by using the AIC criterion; the statistics are F-statistic calculated under the null hypothesis of no causation. The coefficient of lag of error correction term is equal to zero is null hypothesis of long run causality test. ⇏ denotes statistical insignificance and, hence fails to reject the null hypothesis of non-causality. ⇒ denotes the rejection of the null hypothesis of non-causality.

3.1. Results of nonlinear Granger causality test with Improved-VEC

The results of using Improved-VEC are close to results of VEC (Table 5). But in half of the estimated relationships, spherical and exponential forms are investigated instead of linear type. The Granger-Newbold test is applied to choose best method between Kriging and IDW. In 90% of relations, with basing the results of Granger and Newbold (1976) test, geostatistical method have a better ability of investigation. Best structure of Improved-VEC is available in Table 4.

Table 4
Best structure of geostatistical methods for testing causality based on Improved-VEC

Relations	Method	Type of Variogram	Model of Variogram
Δx_t is a function of Δy_{t-1} (unrestricted)	IDW	Anisotropic	Linear
Null hypotheses: $\Delta y_{t-1} = 0$	Kriging	Isotropic	Spherical
Null hypotheses: $ECTx_{t-1} = 0$	IDW	Isotropic	Linear
Δy_t is a function of Δx_{t-1} (unrestricted)	IDW	Anisotropic	Linear
Null hypotheses: $\Delta x_{t-1} = 0$	IDW	Anisotropic	Linear
Null hypotheses: $ECTx_{t-1} = 0$	Kriging	Anisotropic	Spherical
Δm_t is a function of Δy_{t-1} (unrestricted)	IDW	Isotropic	Linear
Null hypotheses: $\Delta y_{t-1} = 0$	Kriging	Isotropic	Exponential
Null hypotheses: $ECTm_{t-1} = 0$	Kriging	Isotropic	Spherical
Δy_t is a function of Δm_{t-1} (unrestricted)	IDW	Isotropic	Spherical
Null hypotheses: $\Delta m_{t-1} = 0$	IDW	Anisotropic	Linear
Null hypotheses: $ECTm_{t-1} = 0$	Kriging	Anisotropic	Exponential

Notes: the Granger-Newbold test was estimated for choosing best method between IDW and ordinary kriging.

Table 5
Results of causality tests based on Improved-VEC (with geostatistical methods)

Null hypotheses	Short run F-statistic	Long run F-statistic	Direction of short run causality	Direction of long run causality
Growth ⇏ Exports	1.873079	0.920629	Growth ⇏ Exports	Growth ⇏ Exports
Exports ⇏ Growth	2.131004	29.30539*	Exports ⇏ Growth	Exports ⇒ Growth
Growth ⇏ Imports	5.002322	0.308393	Growth ⇏ Imports	Growth ⇏ Imports
Imports ⇏ Growth	1.688384	13.43674*	Imports ⇏ Growth	Imports ⇒ Growth

Notes: the lag lengths are chosen by using the AIC criterion; the statistics are F-statistic calculated under the null hypothesis of no causation. The coefficient of lag of error correction term is equal to zero is null hypothesis of long run causality test. ⇏ denotes statistical insignificance and, hence fails to reject the null hypothesis of non-causality. ⇒ denotes the rejection of the null hypothesis of non-causality.

4. Conclusions

There has been much interest in applying endogenous growth theory to economic policy. An important example is international trade policy. Indeed, this is an area where the new research has been used in practice and has influenced public debate. However, while intending to arrive at a tractable framework allowing us to define a testable hypothesis about the configuration of the relationships between economic growth and international trade liberalisation, the models are generally limited to the consideration of a single external factor. For testing the Granger causality two methods were applied (VEC and Improved-VEC with using geostatistical methods). Results from these two methods were similar; both show existence of long run unidirectional causality from exports and imports to economic growth. But in IVEC there exist some different forms instead of linear (which is used in ordinary VEC) in Engle and Granger structures. Thus, the results of this improved-VEC are more exact and supportive than ordinary linear VEC method.

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