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FOOD SECURITY: A PARALLELISM TEST BETWEEN RICE PRODUCTION AND CONSUMPTION SPEEDS IN THE WORLD

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ABSTRACT
According to FAO (2009), the world should increase agricultural production by 70% in order to feed 9 billion people in the world by 2050. The FAO estimates that growth of grain at a rate of 0.7% per year would be sufficient to meet demand in 2050. Although this rate has been achieved for the past five years for rice, it could be not enough to ensure food security. Since 2009, the world rice production growth rate is 0.95% per annum. That of consumption is 01.61% per annum. A comparison of the trends of rice production and consumption speeds series was done. The average acceleration of the production for the period 2008/2009-2013/2014 is decreasing and lowers than the one of consumption compared to the period 2003/2004-2008/2009. The parallelism tests reveal that the trend lines of production and consumption speeds are intersecting and converge over the period 2008/2009-2013/2014 at a level of 10%. Such results reveal that there will be not enough rice to satisfy the aggregate demand in some future and confirm the “new productivism” ideology that, we should increase the production of food in the world by 70-100% in order to feed the world in 2050.

Keywords: food security, new productivism, parallelism test, rice production speed, rice consumption speed.

INTRODUCTION
Global food security is a transversal issue around which politicians, economists, ecologists, agronomists, sociologists and humanists are thinking to find solutions. Indeed, a crisis in the food sector would undoubtedly have a negative impact on social stability (Meutchieye et al, 2013). There is a multitude of food security definition (Roudart, 2002). Formally, food security is defined as existing, when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life (Tomlinson, 2011). Finding a solution to this problem is very important, since it is the first problem to be solved by men in their everyday’s life. Maslow (1943) indeed said that food occupies the first place in the hierarchy of needs that motivate human actions. The satisfaction of this need is however linked to food availability.

The nature offers to man a variety of foods including, starches (manioc, potatoes, and bananas for examples) and cereals (rice, maize, wheat, sorghum). Although the eating habits of men differ from one corner of the globe to another, cereals are the main staple food in the world. It’s also clearly identified that rice is the most consumed food in the world. Indeed, rice is the staple food of more than three billion people, around half of the world population.

According to Zeigler (2010) of the International Rice Research Institute (IRRI), "projected demand for rice will outstrip supply in the near to medium term unless something is done to reverse current trends of slow productivity ". Nwanze (2010), president of the United Nations International Fund for Agricultural Development declared: "We must act now, not next week, not next month, not the next year, but today."

FAO (2009) reported that the world population could grow at a rate of 34% by 2050, with an urbanization rate of 70%. Such growth of the world population suggests an increase in rice consumption in the world. Moreover, Countries of the North could also significantly increase their rice consumption in the coming years. Indeed, the problem of nutrition security is an important issue associated to food security. In other words, it's good to eat, but it's better to eat nutritious food. According to Nicklas et al (2014), rice consumption is associated with better nutrient intake and diet quality. For these authors, people who eat rice have died more consistent with what is recommended in the United States Dietary Guidelines, especially as regards of the amounts of potassium, magnesium, iron, vitamin B9, of folic acid and fiber. They conclude saying that consumption of rice should be encouraged to improve nutrient intake and died quality.

Therefore, someone can logically conclude that the proportion of rice consumers in the North will increase in the coming years. Indeed since May 2014, the publication of results from Nicklas et al (2014) has been subject to great publicity in people’s magazine of United States and Europe. This food which had long been considered as the food of the poor could therefore now be differently perceived by the North. The question that arises is whether the rice production in the world will meet this growing demand or not?

This question is particularly relevant as the evolution of biofuels sector leads to a growth in demand for agricultural products in this industry. This demand comes compete with that of men and animals for their feeding, in a context where the market plays its role in the optimal allocation of resources, goods and services. The main objective of this study is to highlight the need for increased global production of rice, given the risk of rice market failure in the world that empirical observations imply.

Indeed, if there is not enough rice to distribute between populations in need, the market will fail to resolve the food insecurity problem. To achieve our goal, we compared the slope of the production speeds with the slope of the consumption speeds of rice in the world. Since the achievement of the Agreement Commitments on Agriculture of the Uruguay Round in 1994 was in 2004, we consider data from 2003/2004 to 2013/2014. We compared the trends of two periods of six years each (2003/2004-2008/2009 and 2008/2009-2013/2014). A parallelism test between trends of the two speeds series allowed us to determine the importance of the observed phenomena.

In the next section of this paper we will present a brief review of the literature relating to current debates on FAO projections (2009). We will then make a picture of the rice market in the world. We will end with the conclusion.

WORLD FOOD SECURITY: THE DEBATES AROUND FAO (2009) FORECASTS

During the FAO Forum in Rome the 12th and 13th October 2009, some high-level experts debated about "how to feed the world in 2050". In fact, the world is expected to reach 9 billion inhabitants (FAO, 2009). Will the world agricultural products be enough to feed all this population? Such a situation could lead to the conclusion that Malthus (1798) was right (Wise, 2013). Indeed, in his famous treatise on the Principle of Population, Malthus (1798) predicted a food crisis due to the growth of the world population. He said the evolution of overall production can be considered as an arithmetic sequence, while the population growth can be seen as a geometric sequence. From the Malthusian logic, the overall production will be insufficient to feed the entire world population in some future. His predictions have been widely discredited, but someone could find in FAO (2009) report a support to the Malthusian logic.

In fact, since the publication of FAO (2009) report of the forum, several authors (Conway, 2012, Pretty et al, 2010) gathered around some neo-Malthusian reasoning, stating that we need to double the global food production in the world by 2050. This is a part of the set of ideas call "new productivism" in literature (Tomlinson, 2011). This ideology is on the same direction with the solution proposed by FAO (2009) which is an increase in production by 70%, reduced to 60 % in 2012. This solution is not supported by many authors and practitioners in this rapidly growing field of study of food security.

For skeptics like Rijsberman (2012), head of the Consultative Group on International Agricultural Research (CGIAR), it's impossible to double food production in the world by 2050. He said, "With almost 80 million more people to feed each year, agriculture can't keep up with escalating food demand. FAO estimates that we have to double food production by 2050 to feed the expected 9 billion people, knowing that one billion people are already going to bed hungry every day". How is it possible in a context where the amount of food available could easily feed the entire world population? At this stage, the problem is poverty and access to food. Tomlinson (2011) warn an increase in production by 70% does not guarantee that people who need these foods will have access to its. For her, access to food is a priority compared to the new productivism logic that focuses on increasing production.

Food access refers in this context to the liberalization of the agricultural sector. According to the report of the forum on trade liberalization and food security of 4th June 2002 in Paris, liberalization can best reduce the food insecurity problem, but never solve it (Roudart, 2002). Indeed, the market role is the optimal allocation of resources, goods and services. It therefore plays a distribution role. Since the market could not distribute foods that do not exist, the problem of food security is first a problem of production. Moreover if the overall production volume is less than the offer, the market will not play its role effectively. The need to increase the volume of global food production in the world is not an option but a necessity. Foley (2011) said "So even if we solve today's problems of poverty and access—a daunting task—we will also have to produce twice as much to guarantee adequate supply worldwide". So, could the world produce twice of what is currently produced by 2050.

Someone could think that all we have to do is to clear some tropical forests, farming marginal lands and intensify industrial farming. But the problem is more complicated. Foley (2012) said "Agriculture is among the greatest contributors to global warming, emitting more greenhouse gases than all our cars, trucks, trains, and airplanes combined… Farming is the thirstiest user of our precious water supplies and a major polluter, as runoff from fertilizers and manure disrupts fragile lakes, rivers, and coastal ecosystems across the globe. Agriculture also accelerates the loss of biodiversity. As we've cleared areas of grassland and forest for farms, we've lost crucial habitat, making agriculture a major driver of wildlife extinction". So clearing forest for farming appears to be the worst solution. The problem here is sustainability. As Brunner (2008) said, increasing food production will not automatically contribute to the world's food security, and it might even increase hunger in the world. So if we need to increase productivity we should do it in a sustainable way so that natural resources are not destroyed over time.

Numerous authors have suggested that increasing crop yields, rather than clearing more land for food production, is the most sustainable path for food security (Ray et al, 2013). Foley (2011) said "Improving yield also sounds enticing. Yet our research team found that average global crop yield increased by about 20 percent in the past 20 years—far less than what is typically reported. That improvement is significant, but the rate is nowhere near enough to double food production by midcentury." In other words, current crops yield trends are insufficient to reach the new productivism target of producing twice of the current food production by 2050.

Ray et al (2013) confirmed that results for maize, rice, wheat and soybeans. They made some projections using bootstrapping and found that a growth rate of 2.4% each year is needed to double production of these four crops that produce according to Tilman et al (2011) about two-thirds of the current harvested global crops calories. Unfortunately, the global average rates of yield increase across are 1.6% for maize, 1.0% for rice, 0.9% for wheat, and 1.3% for soybean. They concluded that yield trends are insufficient to guarantee food security by 2050.

It appears very difficult to find a universal accepted solution to this food insecurity problem, but the FAO formally accepted one is the one proposed by Nwanze et al (2012), who stated that: "we need to improve people's access to food in their communities, increase production by 60% by 2050, drastically reduce huge losses and waste of food and manage our natural resources sustainably, so that it flourishes for future generations."

FAO estimates that the average yield of grain in the world need to grow by 0.7% each year to meet the expected demand for 2050 (Alexandratos and Bruinsma, 2012). Is this rate enough? In the next section, we show empirically the need to increase the global production of rice in metric tons, this given the risk of rice market failure in the world. Indeed, the demand for rice in the world has evolved much faster than supply this last 5 years. Furthermore, there was a rapid change in demand for rice in the world. From 412,985,000 t in 2003/2004, we went to 472,879,000 t in 2013/2014. That is an increase in demand for nearly 60 million tons in 10 years. If the aggregate world demand grows similarly in the next 10 years, could the global rice production keep satisfy people needs. An observation of this market allows us to support the "new productivism" ideology.

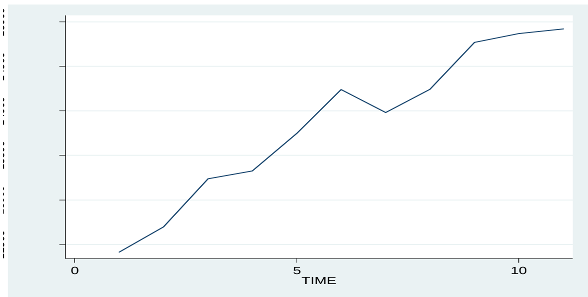
MATERIALS AND METHODS

The data used in this study are the data from the United States Department of Agriculture (USDA). They represent the annual volume of production and consumption of rice in the world. We calculated the relative volumes of production and consumption per second in the world. In this study, we have only used 11 annual observations to study the trends. Since the achievement of the Agreement on Agriculture of the Uruguay Round was in 2004, we considered only observation from 2003/2004 to 2013/2014. That is because the market was supposed to play its role fully from that period. We used Excel 2007 for data treatment and Stata 10.1 for analysis. Table 1 shows the evolution of the production and consumption of rice in the world (by annual volume and speed)

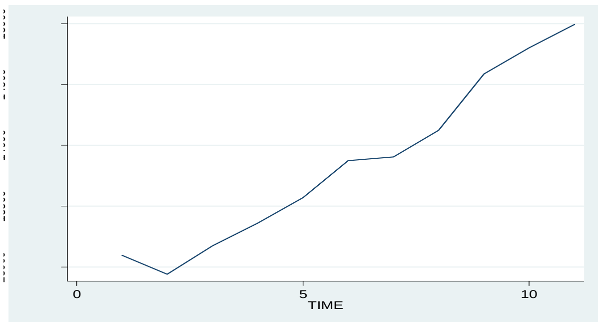
Table 1: Evolution of production and consumption of rice in the world

Years	Production volume in Tons	Production speed in kg/s	Consumption volume in Tons	Consumption rate in kg / s	Difference in Speed Kg / s
2003/2004	391, 510,000	12,414	412, 985,000	13,095	-681
2004/2005	400, 432,000	12,697	408, 090,000	12,940	-243
2005/2006	417, 531,000	13,239	415, 450,000	13,173	66
2006/2007	420, 297,000	13,327	421, 305,000	13,359	-32
2007/2008	433, 645,000	13,750	427, 973,000	13,570	180
2008/2009	449, 129,000	14,241	437, 574,000	13,875	366
2009/2010	440, 929,000	13,981	438, 486,000	13,904	77
2010/2011	449, 230,000	14,244	445, 437,000	14,124	120
2011/2012	465, 816,000	14,770	460, 042,000	14,587	183
2012/2013	468, 961,000	14,870	466, 818,000	14,802	68
2013/2014	470, 600,000	14,922	472, 879,000	14,994	-72
Moyenne	437, 682,091	13,860	437, 003,545	13,856	3

Source: Authors based on data from the United States Department of Agriculture (USDA)



Graph1: Rice production speeds in the world
Source: Authors based on data from the United States Department of Agriculture (USDA)



Graph 2: Rice consumption speeds in the world
Source: Authors based on data from the United States Department of Agriculture (USDA)

The graphical observation of the two series allows us to deduce that they are linear trended as generally recognized in the literature (Ray et al, 2013). A simple linear regression for each series over time provides the linear trend of each. The regression model is given by:

$$Vprod_t = \alpha_1 + \beta_1 t + \varepsilon_t \qquad t = 1year, 2years\ldots \qquad (1)$$

$$and \quad Vcons_t = \alpha_2 + \beta_2 t + \varepsilon_t \qquad t = 1year, 2years\ldots \qquad (2)$$

Where $Vprod_t$ is the production speed at time t, $Vcons_t$ is the consumption speed at time t, α_1 and α_2 are the constant terms that represent $Vprod_0$ and $Vcons_0$; β_1 and β_2 are the coefficients of the linear regression that represent the average acceleration of production and consumption. Let call acc_{pro} the average acceleration of production, and acc_{con} the average acceleration of consumption. So if we replace α_1 and α_2 by $Vprod_0$ and $Vcons_0$, β_1 and β_2 by acc_{pro} and acc_{con}, (1) and (2) can be rewrite as follow:

$$Vprod_t = Vprod_0 + acc_{pro}.t + \varepsilon_t \qquad t = 1year, 2years\ldots \qquad (3)$$

$$and \quad Vcons_t = Vcons_0 + acc_{con}.t + \varepsilon_t \qquad t = 1year, 2years\ldots \qquad (4)$$

Parallelism test allowed us to compare the slopes of different speed series, considering the periods defined. According to Degras and al (2011) it is a very common approach in applied sciences for the comparison of trends in multiple time series. However, this approach was never used till now to study if the production of some product will always meet consumption. The reason is simple. Consumption depends on production. But in this case there are some stocks that helped to cover demand when production was insufficient. Production line could therefore be nonparallel to the consumption line.

In our case, if the trend lines are parallel or intersecting and divergent, it would mean that the overall rice production can satisfy demand. Indeed, the slope of the production speed should be greater or equal to that of the consumption to ensure food security. If the lines are intersecting and converging, then the market would be in a critical situation. Such a situation will appear only if the rice consumption speeds series have a slope greater than that of production. The implication is that the amount of rice produced is or will be insufficient to meet global demand.

According to Dagnelie (2011), parametric comparison of the slopes of the two linear regression lines (or parallelism test) can be performed from a test on the regression coefficients of the two lines. The test statistic is the one of Student, and is calculated as follows:

$$T_{cal} = |\beta_1 - \beta_2| / (s^2_{\beta_1} + s^2_{\beta_2})^{1/2} \qquad (5)$$

Where β_1 is the slope (acceleration) of the production speeds series; β_2 represents the slope of the rice consumption speeds series; $s^2_{\beta_1}$ is the variance of β_1, and $s^2_{\beta_2}$ the variance of β_2. The null hypothesis assumes that the two lines are parallel. The critical value read from the student table is given by: $T\left(1 - \frac{\alpha}{2}, n1 + n2 - 4\right)$. For $T_{cal} > T(1 - \alpha/2, n1 + n2 - 4)$. The null hypothesis is rejected at a level of 5%, but we also considered the level of 10% to look if the lines converge.

RESULTS AND DISCUSSION

The average speed of rice production in the world for the past 11 years is 13,860 kg/s, against an average consumption speed equal to 13,856 kg/s. We see from these data that the average difference between the speed of production and consumption is 4kg/s. This difference is positive. That mean it's possible to satisfy the rice needs of people in the world through the market. If production and consumption speeds remained constant forever, the market could be so efficient in meeting the rice needs of the world population so that the risk of market failure would be nonexistent.

Unfortunately, the production and consumption speeds are inconstant over time. They even seem to grow with time. The average growth rate that was 3% each year for the first period fell to 0.95% for the second period. In other words, compared to the theory of the production cycle, we would be in the growth phase at decreasing rate. Meanwhile, consumption rather increased from 1.19% to 1.61%. In other words, demand continues to grow at an increasing rate.

If we stick to these results, the average growth rate of rice production in the last five years can achieve the objectives of FAO in 2050 (0.7% needed < 0.95% realized). However, the fact that the average acceleration of rice production in the world is decreasing on the two periods may raise concerns about the stability of this rate according to FAO's objectives.

Econometric analysis of these series also allows us to reach the same conclusions. Tables 2 and 3 provide a summary of the results of the linear regressions. The coefficients of determination indicate that the calculated trends correspond to data (near 100%). The coefficients also are significant at a level of 5%. These coefficients actually represent the slope of the trend line. Since our observations consist of speeds, this slope is the average acceleration of each series on the different periods.

Table 2: Results of the regression production speeds by time

Period	$\alpha = constant$	$\beta(acceleration)$	T calculate β	R^2
2003/2004 to 2008/2009	12,039.08 kg/s	353.7714kg/s^2	13.52 > $T_{5/2}lu$ (2.201)	0.9786
2008/2009 to 2013/2014	12,902.3 kg/s	188.6143kg/s^2	3.85 > $T_{5/2}lu$ (2.201)	0.7875

2003 to 2014	12,338.27kg/s	253.5455 kg/s^2	13.74 > $T_{5/2}\,lu\ (2.201)$	0.9545

Source: Authors based on data from the United States Department of Agriculture (USDA)

Table 3: Result of the regression consumption speeds by time

Period	$\alpha = constant$	$\beta(acceleration)$	**T calculate** β	R^2
2003/2004 to 2008/2009	12,737.73 kg/s	170.7429 kg/s^2	5.15> $T_{5/2}\,lu\ (2.201)$	0.8687
2008/2009 to 2013/2014	12,255.51 kg/s	250.0571 kg/s^2	9.28 > $T_{5/2}\,lu\ (2.201)$	0.9556
2003 to 2014	12,599.42 kg/s	209.5344 kg/s^2	15.43> $T_{5/2}\,lu\ (2.201)$	0.9536

Source: Authors based on data from the United States Department of Agriculture (USDA)

Table 4 : Parallelism test results

Period	**T calculate** β	$T\ lu\ (\alpha = 5\%)$	**Decision**
2003/2004 à 2008/2009	4.3308501	$t(0.95;\ 8) = 2.306$	Intersecting
2008/2009 à 2013/2014	1.1012065	$t(0.95;\ 8) = 2.306$	Parallels*
2003 to 2014	1.9204288	$t(0.95;\ 18) = 2.101$	Parallels

Source: Authors based on data from the United States Department of Agriculture (USDA)

*The trend lines are intersecting for the period 2008/2009-2013/2014 at a level of 10%. $T(\alpha = 10\%) = 1.86$.

```
. line loge TIME

. reg production TIME

      Source |       SS       df       MS              Number of obs =      11
-------------+------------------------------           F(  1,     9) =  188.72
       Model |  7071382.73     1  7071382.73           Prob > F      =  0.0000
    Residual |      337232     9  37470.2222           R-squared     =  0.9545
-------------+------------------------------           Adj R-squared =  0.9494
       Total |  7408614.73    10  740861.473           Root MSE      =  193.57

------------------------------------------------------------------------------
  production |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        TIME |   253.5455   18.45639    13.74   0.000     211.7942    295.2967
       _cons |   12338.27   125.1773    98.57   0.000      12055.1    12621.44
------------------------------------------------------------------------------

. predict erreur1, resid

. dfgls erreur1

DF-GLS for erreur1                                       Number of obs =     4
Maxlag = 6 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------
    6               .             -3.770           -57.590           -42.679
    5               .             -3.770           -30.168           -20.823
    4               .             -3.770           -12.961            -7.263
    3               .             -3.770            -3.663            -0.093
    2            -0.051           -3.770             0.033             2.589
    1            -3.597           -3.770             0.432             2.688

Opt Lag (Ng-Perron seq t) = 0 [use maxlag(0)]
Min SC   =   9.09928 at lag  2 with RMSE  56.24851
Min MAIC =  9.912798 at lag  2 with RMSE  56.24851

. dfuller erreur1, lag(2)

Augmented Dickey-Fuller test for unit root         Number of obs   =         8

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.092            -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7182

. reg production TIME if tin(1,6)

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  1,     4) =  182.77
       Model |  2190198.91     1  2190198.91           Prob > F      =  0.0002
    Residual |  47933.0857     4  11983.2714           R-squared     =  0.9786
-------------+------------------------------           Adj R-squared =  0.9732
       Total |     2238132     5    447626.4           Root MSE      =  109.47

------------------------------------------------------------------------------
  production |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        TIME |   353.7714   26.16789    13.52   0.000     281.1177    426.4251
       _cons |    12039.8   101.9093   118.14   0.000     11756.85    12322.75
------------------------------------------------------------------------------

. reg production TIME if tin(6,11)

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  1,     4) =   14.82
       Model |  621908.629     1  621908.629           Prob > F      =  0.0183
    Residual |  167822.705     4  41955.6762           R-squared     =  0.7875
-------------+------------------------------           Adj R-squared =  0.7344
       Total |  789731.333     5  157946.267           Root MSE      =  204.83

------------------------------------------------------------------------------
  production |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        TIME |   188.5143   48.96394     3.85   0.018      52.5686      324.46
       _cons |    12902.3    424.511    30.39   0.000     11723.66    14080.93
------------------------------------------------------------------------------
```

```
. reg consumption TIME

      Source |       SS       df       MS              Number of obs =      11
-------------+------------------------------           F(  1,     9) =  237.95
       Model |  4829603.65     1  4829603.65           Prob > F      =  0.0000
    Residual |    182672.9     9  20296.9889           R-squared     =  0.9636
-------------+------------------------------           Adj R-squared =  0.9595
       Total |  5012276.55    10  501227.655           Root MSE      =  142.47

------------------------------------------------------------------------------
 consumption |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        TIME |   209.5364   13.58374    15.43   0.000     178.8078    240.2649
       _cons |   12599.42   92.12943   136.76   0.000     12391.01    12807.83
------------------------------------------------------------------------------

. predict erreur2, resid

. dfgls erreur2

DF-GLS for erreur2                                       Number of obs =     4
Maxlag = 6 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------
    6               .             -3.770           -57.590           -42.679
    5               .             -3.770           -30.168           -20.823
    4               .             -3.770           -12.961            -7.263
    3               .             -3.770            -3.663            -0.093
    2            -1.001           -3.770             0.033             2.589
    1            -2.090           -3.770             0.432             2.688

Opt Lag (Ng-Perron seq t) = 0 [use maxlag(0)]
Min SC   =  9.213202 at lag  1 with RMSE  70.81191
Min MAIC =  16.76803 at lag  1 with RMSE  70.81191

. dfuller erreur2, lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =         9

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.550            -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.5085

. reg consumption TIME if tin(1,6)

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  1,     4) =   26.47
       Model |  510179.657     1  510179.657           Prob > F      =  0.0068
    Residual |  77089.6762     4   19272.419           R-squared     =  0.8687
-------------+------------------------------           Adj R-squared =  0.8359
       Total |  587269.333     5  117453.867           Root MSE      =  138.83

------------------------------------------------------------------------------
 consumption |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        TIME |   170.7429   33.18556     5.15   0.007     78.60498    262.8807
       _cons |   12737.73   129.2392    98.56   0.000     12378.91    13096.56
------------------------------------------------------------------------------

. reg consumption TIME if tin(6,11)

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  1,     4) =   86.14
       Model |  1094250.06     1  1094250.06           Prob > F      =  0.0007
    Residual |  50809.9429     4  12702.4857           R-squared     =  0.9556
-------------+------------------------------           Adj R-squared =  0.9445
       Total |     1145060     5      229012           Root MSE      =  112.71

------------------------------------------------------------------------------
 consumption |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        TIME |   250.0571   26.94172     9.28   0.001     175.2549    324.8594
       _cons |   12255.51   233.5813    52.47   0.000     11606.99    12904.04
------------------------------------------------------------------------------
```

The average acceleration over the entire period from 2003/2004 to 2013/2014 is larger for production compared to consumption $(253.5455\ \mathrm{kg/s^2} > 209.5344\ kg/s^2)$. However, when we consider the coefficients for the two periods of six years, there is a decrease in production acceleration (β_1 decreased from $353.7714\ \mathrm{kg/s^2}$ to $188{,}6143\ \mathrm{kg/s^2}$), and an increase for the consumption acceleration (β_2 increased from $170.7429\ \mathrm{kg/s^2}$ to $250.0571\ \mathrm{kg/s^2}$). The acceleration is also higher for consumption than for production for the period 2008/2009-2013/2014 $(\beta_2 = 250.0571\ \mathrm{kg/s^2} > \beta_1 = 188.6143\ \mathrm{kg/s^2})$. Furthermore, the difference between the constant terms is no greater than 1t per second. These results explain why the overall production volume was less than the aggregate consumption of 2013/2014. Indeed, observations show that in 2013/2014, the overall volume of production was lower than consumption. Fortunately, there were some reserves that helped to meet the aggregate demand. However, the reserve stock is not unlimited. At the end of the period 2013/2014, there were only 104,273t.

Table 4 summarizes the results of the parallelism tests performed. That results show that trends lines of the period 2003/2004-2008/2009 are significantly intersecting but divergent. That means that production was greater than consumption during that period. The trends lines from other periods are significantly parallel at a level of 5%. In other words, the negative difference of the acceleration of the speed of production over consumption has not yet reaches a critical value. So we can say that the rice market in the world is still efficient for solving the problem of food insecurity. However, the trends lines are intersecting and converge for the period 2008/2009-2013/2014 at a level of 10%. That is an alarming situation that means that production will not be enough to meet the aggregate demand in some future. In fact, if the actual slope of rice production trend line remains the same during the next 10 years, then we can be sure we will not reach 2050 without a food crisis in the world. That means the rice market in the world will be in default at some point, following the depletion of stocks. These results are consistent with those of Ray et al (2013) mentioned above. We can question ourselves about the fact that if the rice quantity produced is just sufficient to meet actual aggregate demand, then how could we feed 9 billion people in the world in 2050?

It is important to note that these results may contain bias. Indeed, this study does not take into account the non-stationarity of the error term. The relatively small number of observations does not allow us to rule clearly non-stationary residuals.

CONCLUSION

The aim of our study was to highlight the need to increase rice production to prevent the failure of rice market in the world. Certainly the market effectively solves the problems associated with the distribution and allocation of resources, goods and services. However it does not solve the problems of production. The rice market in the world allowed us to highlight this fact. Indeed, if the global rice production does not quickly evolves the next 35 years, the world will face certainly by 2050 a food crisis causing by rice market failure.

The results also reveal that the annual growth rate of production of grains desired by FAO is reached (0.95% > 0.7%). However, the fact that this rate is decreasing in the first period to the second may raise some concerns. We can also see that the trend lines are intersecting and converge for the period 2008/2009-2013/2014 at a level of 10%. That means that the average acceleration of production is significantly lower than the one of consumption over that period. As a consequence, production will be insufficient to meet demand by 2050. We could find in these results a supports to the “new productivism” ideology. Then, all countries that are factors endowed to produce rice should be encouraged to do so, since it is the staple food of a half of world population.

It would be interesting to study wheat, maize, and soybean market to see if trends are the same with rice market. Moreover, since the demand for agricultural products in the biofuels industry compete men and animals demand for feeding, it would also be interesting to determine the real impact of that industry on the aggregate consumption of rice in the world.

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