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AGRICULTURAL TRADE LIBERALIZATION, PRODUCTIVITY GAIN AND POVERTY ALLEVIATION: A GENERAL EQUILIBRIUM ANALYSIS

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Abstract

Computable General Equilibrium (CGE) models have gained popularity as an empirical tool for assessing the impact of trade liberalization on agricultural growth, poverty and income distribution. However, conventional models ignore the channels linking technical change in agriculture, trade openness and poverty. This study seeks to incorporate econometric evidence of these linkages into a CGE model to estimate the impact of alternative trade liberalization scenarios on welfare, poverty and equity. The analysis uses the Latent Class Stochastic Frontier Model (LCSFM) and the metafrontier function to investigate the influence of trade openness on agricultural technological change. The estimated productivity gains induced from higher levels of trade are combined with a general equilibrium analysis of trade liberalization to evaluate the direct welfare benefits of poor farmers and the indirect income and prices outcomes. These effects are then used to infer the impact on poverty using the traditional top-down approach. The model is applied to Tunisian data using the social accounting matrix of 2001 and the 2000 household expenditures surveys.

ملخص

لقد حازت نماذج التوازن العام المحسوب علي شعبية متزايدة كأداة تجريبية لتقييم أثر تحرير التجارة على النمو الزراعي والفقر وتوزيع الدخل. إلا أن النماذج التقليدية تتجاهل القنوات التي تربط بين التغيرات التقنية في الزراعة وانفتاح التجارة وبين الفقر. و تسعى هذه الدراسة إلى دمج أدلة الاقتصاد القياسي التي تقدمها هذه الروابط مع نموذج التوازن العام المحسوب و ذلك لتقييم اثر سيناريوهات تحرير التجارة البديلة علي الرفاهية و الفقر و العدالة الاجتماعية. و يستخدم التحليل نموذج الحد العشوائي للفئة الكامنة ودالة الحد الأعلى وذلك لبحث تأثير الانفتاح التجاري علي التغير التكنولوجي الزراعي. وتقترن مكاسب الإنتاجية التي يتم تقديرها و الناتجة عن ارتفاع مستويات التجارة بتحليل التوازن العام فيما يخص تحرير التجارة وذلك لتقييم مزايا الرفاهية المباشرة علي المزارعين الفقراء والدخل غير المباشر والمحصلة النهائية لأسعار السلع والخدمات. وتستخدم هذه النتائج بعد ذلك للاستدلال على تأثيرها على الفقر وذلك عن طريق استخدام منهجية التحليل من أعلى إلى أسفل التقليدية. وهذا النموذج مطبق على بيانات دولة تونس عن طريق تطبيق مصفوفة الحسابات الاجتماعية علي عمليات المسح التي أجريت علي النفقات المنزلية لعام 2001 وعام 2000.

1. Introduction

The Uruguay Round commitments and the recent Doha Round of agricultural trade talks have raised the interest in understanding the main channels through which trade affects the livelihood of the poor in developing countries. The transmission mechanisms linking international trade to poverty are diverse and complex. Technology transfer and productivity growth are identified to be among the key links to sustained poverty reduction[1].

International trade is presumed to foster productivity growth through the transfer of technology from more advanced countries (Winters, 2002; Cline, 2004; Bardhan, 2006, Belhaj Hasssine, 2008). Productivity induced growth in related sectors, such as agriculture and food processing, and elsewhere in the economy would confer strong pro-poor benefits on recipient countries.

The magnitude of the effects of trade liberalization and technological change in agriculture on poverty can be quantified through computable general equilibrium (CGE) models. These models have become popular tools for empirical policy analysis. Unlike econometric methods, CGE models are well suited to analyze the complex trade-poverty nexus and to produce disaggregated results at the microeconomic level, within a consistent macroeconomic framework. Care must however be taken, as the results reached depend on the parameters and functions specified which can barely be tested one-by-one, let alone in combination.

Moreover, despite the existence of a large literature using CGE models to examine the poverty issues of agricultural trade reforms, nearly all available studies ignore or deal poorly with the productivity and growth mechanisms and show divergent results (Bussolo et al., 2005; Winters, 2005; Bouët, 2006). The trade-productivity linkages are gradually being incorporated in some CGE applications, however the most influential frameworks in the policy debate are at some distance from effectively integrating these forces (Cline, 2004; Itakura et al., 2003; Van der Mensbrugghe, 2005; Vos, 2007).

This paper attempts to explore the poverty implications of agricultural trade liberalization in Tunisia. The study incorporates econometric evidence of the productivity linkages into a general equilibrium model to capture the additional poverty alleviation that could be expected from the improvement of agricultural technology induced by higher levels of trade. The CGE model we use takes also into account the complexity of the labor market and explores the interaction between labor productivity and the wage rate determination.

Agriculture is an economically and socially important sector in Tunisia and is currently strongly distorted due to the heavy use of trade barriers and support policies. High levels of protection are imposed on agricultural and agri-food commodities, such as cereals, dairy and livestock products, deemed as sensitive and for which the impact of foreign competition can have serious domestic economic and social consequences. Over the last decade, Tunisia has implemented sweeping economic and agricultural reforms and has taken steps towards greater integration in the global economy. Under the Euro-Mediterranean Partnership launched in 1995, ongoing and future free trade agreements between Tunisia and the European Union would lead to further agricultural trade liberalization.

As Tunisia presses ahead with liberalization within the framework of the Barcelona-Agreement, speculations have risen regarding the impact of liberalization in accelerating agricultural development via technology transfer and in alleviating poverty. In a country with limited natural resources, adoption of new technology can raise labor and land productivity, as well as enhance employment creation through increased yields and improve the welfare of smallholder growers and poor households via food prices (Graff et al., 2006).

To shed some light on these issues, we base our approach on two steps. In the first step, we start by sketching a conceptual framework for exploring the role of international trade in promoting

[1] See Winters, (2004); Winters et al., (2004) and Nissanke and Thorbecke, (2006) among others.

technology transfer from more advanced trading partners of Tunisia and in enhancing agricultural productivity growth. For this purpose, we compute agricultural total factor productivity (TFP) indexes for Tunisia and its main trading partners. We use panel data for 14 countries involved in the EU-Mediterranean partnership and estimate a latent class stochastic frontier model to account for cross country heterogeneity in production technologies. We evaluate the contribution of international trade to productivity growth through the speed of technology transfer using the distance from the technological frontier to capture the potential for technology transfer. In the second step, we incorporate econometric evidence of the productivity effects into a CGE model to arrive at a comprehensive evaluation of alternative trade liberalization scenarios on commodity prices and factor prices, as a basis for then calculating the corresponding impact on households' income, poverty and inequality.

The structure of the paper is as follows. Section 2 outlines the plan for empirical investigation and presents the procedure to measure total factor productivity. Section 3 describes the CGE model and explains how the link between productivity and trade policy is incorporated. Section 4 reviews the data, and Section 5 reports the empirical results. Finally, Section 6 synthesizes the main findings and draws some conclusions.

2. Econometric Model

2.1 International trade and productivity dynamics

Our approach to investigate the importance of international trade in stimulating technology transfer and productivity growth in the agricultural sector is based on the work of Griffith et al. (2004) and Cameron et al. (2005). Productivity growth, in an economy behind the technological frontier, is assumed to be driven by both domestic innovation and technology transfer. The technology gap, measured by a country's distance from the technological frontier, is used to capture the potential for technology transfer. We examine whether the effect of international trade on productivity depends upon technology gap. The larger the deviation from the best practice technology, the greater the potential for trade to increase productivity growth through technology transfer from more developed countries.

Advanced technologies might not however automatically affect the host country's productivity. The adaptability and local usability of foreign technologies depend on the skill content of the recipient country's workforce. New technologies might prove ineffective in countries without sufficient educated labor force to absorb international knowledge. Many studies in the endogenous growth literature pointed to the importance of human capital in enhancing the country's innovative capacity as well as its ability to adopt foreign technology (Xu, 2000; Benhabib and Spiegel, 2002; Cameron et al., 2005). We examine also the role played by human capital on stimulating innovation and on facilitating the adoption of new technologies.

We consider a model in which agricultural productivity may grow as a result of domestic innovation or technological spillovers from more advanced countries. The innovation part is related to the level of human capital, while the transfer part is captured via a term capturing the degree of openness with human capital and the technology gap to the frontier. The growth rate of agricultural productivity in country i at time t is then given by:

$$\dot{A}_{it} = \alpha_i + \alpha_1 H_{it}^{\alpha_H} + \alpha_2 IT_{it}^{\alpha_{op}} H_{it}^{\alpha_H} \left(1 - GAP_{it}\right) + \upsilon_{it} \qquad (1)$$

where A is agricultural total factor productivity (TFP), H is the human capital level, IT is an index of international trade, and GAP is the technology gap. , , and are parameters to be estimated. is a country-specific constant and is an error term. The dot indicates the growth rate.

The first term captures a direct effect on rates of innovation and the interaction term captures an effect on the speed of technology transfer. The trade interaction captures the effect of international openness on productivity growth through the speed of technology transfer, while the human capital interaction reflects a country's capacity to adopt advanced technology. The further the country lies behind the frontier, the greater the potential for technologies to be transferred through international trade and the higher the rates of productivity growth.

2.2 Productivity measurement

In order to estimate equation (1), measures of agricultural TFP and of the technology gap are required. The common approach to estimating agricultural efficiency and multifactor productivity is the stochastic frontier model. Based on the econometric estimation of the production frontier, the efficiency of each producer is measured as the deviation from maximum potential output. Productivity change is computed as the sum of technology change, factor accumulation, and changes in efficiency. A major limitation of this method is that all producers are assumed to use a common production technology. However, farmers that operate in different countries under various environmental conditions and resource endowments might not share the same production technologies. Ignoring the technological differences in the stochastic frontier model may result in biased efficiency and productivity estimates as unmeasured technological heterogeneity might be confounded with producer-specific inefficiency (Orea and Kumbhakar, 2004).

The recently proposed latent class stochastic frontier model (LCSFM) has been suggested as suitable for modeling technological heterogeneity. This approach combines the stochastic frontier model with a latent sorting of farmers (or countries) in the data into discrete groups. Individuals within a specific group are assumed to share the same production possibilities, but these are allowed to differ between groups. Heterogeneity across countries is accommodated through the simultaneous estimation of the probability for class membership and a mixture of several technologies (Orea and Kumbhakar, 2004; Greene, 2005).

The latent class framework assumes the simultaneous coexistence of J different production technologies. There is a latent clustering of the countries in the sample into J classes, unobserved by the analyst. We assume that a country from class j is using a technology of the Cobb Douglas form:

$$\ln(y_{it}) = \ln f(x_{it}, \beta_j) + v_{it|j} - u_{it|j} \qquad (2)$$

subscript *i* indexes countries (*i: 1…N*), *t* (t: *1…T*) indicates time and *j* (*j*: 1, …, *J)* represents the different groups. β_j is the vector of parameters for group *j*, y_{it} and x_{it} are, respectively, the production level and the vector of inputs. $v_{it|j}$ is a two-sided random error term which is independently distributed of the non-negative inefficiency component $u_{it|j}$.[2]

In this model, the unconditional likelihood for country *i* is constructed as a weighted average of the conditional on class *j* likelihood functions:

$$ln\, LF = \sum_{i:1}^{N} ln \left\{ \sum_{j:1}^{J} P_{ij} \prod_{t:1}^{T} LF_{ijt} \right\} \qquad (3)$$

where, LF_{ijt} is the conditional likelihood function for country *i* at time *t*, and representing the contribution of country *i* to the conditional likelihood. is the prior probability attached by the econometrician to membership in class j and which reflects his uncertainty about the true partitioning in the sample. These class probabilities can be parameterized as a multinomial logit form:

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[2] We adopt the scaled specification for the inefficiency component: $u_{it}|_j = exp(z_{it}'\delta_j)\,\omega_{it}|_j$. z_{it} is a vector of country's specific control variables associated with inefficiencies, δ_j is a vector of parameters to be estimated, and $\omega_{it}\,|_j$ is a random variable following the half normal distribution.

$$P_{ij} = \frac{\exp(\lambda_j ' q_i)}{\sum_j \exp(\lambda_j ' q_i)} \qquad \lambda_1 = 0 \qquad \sum_j P_{ij} = 1 \tag{4}$$

where, q_i is a vector of country's specific and time-invariant variables that explain probabilities and λ_j are the associated parameters.

Maximum likelihood parameter estimates of the model can be obtained by using the Expectation Maximization (EM) algorithm (Caudill, 2003; Green, 2005). [3] Using the parameters estimates and Bayes' theorem, we compute the conditional posterior class probabilities from:

$$P_{j|\mathrm{i}} = \frac{LF_{ij} P_{ij}}{\sum_j LF_{ij} P_{ij}} \tag{5}$$

Each country is assigned to a specific group based on the highest posterior probability. Each country's efficiency estimate can be determined relative to the frontier of the group to which that country belongs. This approach ignores however the uncertainty about the true partitioning in the sample. This somewhat arbitrary selection of the reference frontier can be avoided by evaluating the weighted average efficiency score as follows[4]:

$$ln\, TE_{it} = \sum_{j:1}^{J} P_{j|i}\, ln\, TE_{it}(j) \tag{6}$$

where, is the technical efficiency of country i using the technology of class j as the reference frontier.

The productivity change can be estimated using the tri-partite decomposition (Kumbhakar and Lovell, 2000):

$$\dot{A} = TC + \dot{TE} + Scale \tag{7}$$

where $\dot{A}$ is the growth rate of agricultural TFP, $TC = \frac{\partial\, ln\, f}{\partial t}$ is technical change which measures the rate of outward shift of the best-practice frontier, $\dot{TE} = \frac{-\partial u_{it}\,|_j}{\partial t}$ represents the change in the inefficiency component over time, and $Scale = \frac{(\varepsilon_j - 1)}{\varepsilon_j} \sum_k \varepsilon_{kj}\, \dot{x}_k$ is the scale effect when inputs expand over time. ε_j is the sum of all the input elasticities ε_{kj}.[5]

In addition to estimating agricultural technical efficiency and productivity for each country, this approach allows for measuring technology gap. Once the group specific frontiers are estimated, we use the outer envelope of these group technologies to define the best practice technology or metafrontier, $f(x_{it}, \beta^*) = \max_j f(x_{it}, \beta_j)$. The deviation of group frontiers from the metafrontier is viewed as technology gap, which can be measured by the ratio of the output for the frontier production function

[3] EM is an iterative approach where each iteration is made up of two steps: the Expectation (E) step which involves obtaining the expectation of the log likelihood conditioned over the unobserved data, and the Maximization (M) step which involves maximizing the resulting conditional log likelihood for the complete dataset (Green, 2001).

[4] See Orea and Kumbhakar (2004) and Green (2005).

[5] Since input elasticities vary across groups, productivity change estimates from equation (7) are group-specific. Unconditional productivity measures can be obtained as a weighted sum of these estimates.

for group j relative to the potential output defined by the best practice technology, $GAP_{it} = \frac{f(x_{it}, \beta_j)}{f(x_{it}, \beta^*)}$.[6]

3. The General Equilibrium Model

We develop a CGE model including productivity change to capture the transmission mechanisms from agricultural trade liberalization to inequality and poverty in Tunisia. The framework is a small open economy model with constant returns to scale and perfectly competitive markets designed for trade policy analysis with a large disaggregation of the agricultural sector. The model draws from Decaluwé *et al*. (2001) and incorporates some features used in Rattsø and Stokke (2005) to capture the skill biased technological change.

3.1 The model structure

The model's production functions are of the nested structure. Perfect complementarity is assumed between value added and the intermediate consumptions in each sector. Value added is a Cobb Douglas (CD) function of aggregated labor input, capital and an aggregate land bundle. In order to differentiate land according to the perennial features of the crops and the irrigation intensity, we assume the land bundle to be a constant-elasticity-of-substitution (CES) combination of annual and perennial land aggregates. Each land aggregate is a CES function of land (rain-fed agriculture) and a land-water composite (irrigated agriculture). The land-water composite, in turn, is produced by a CES production function to incorporate the possibility of substitution between land and water.[7] Labor is disaggregated into five categories and is classified by the level of qualification, skilled and unskilled. Labor is assumed to be fully mobile, although some labor types are not used in all sectors. Agricultural labor type is only used in agricultural sectors. Land is agriculture-specific and capital is sector-specific.

Output is differentiated between goods destined for the domestic and export markets. Exports are further disaggregated according to whether they are destined for the EU or the ROW. This relationship is characterized by a two-level constant elasticity of transformation frontier. Composite output is an aggregate of domestic output and composite exports; composite exports are aggregates of exports for the EU and ROW markets.

In the demand side, the consumers' preferences across sectors are represented by the Linear Expenditure System (LES) function to account for the evolution of the demand structure with the changes in disposable income level. The consumption choices within each sector are a nesting of CES functions. The sub-utility specifications are designed to capture the particular status of domestic goods, together with product differentiation according to geographical origin, namely European Union (EU) or the Rest of the World (ROW). Total demand is made up of final consumption, intermediate consumption and capital goods.

Government expenditures and investment demand are exogenous. Public consumption is balanced with revenue. The model allows tariff rates, export and import prices to differ depending on the trading partner, EU or ROW. Import supplies and export demands are infinitely elastic at given world prices. The current account balance and the nominal exchange rate are also exogenous to the model. The current account balances the value of exports at world price plus net transfers and factor payments in addition to net capital inflows to the value of imports at world price.

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[6] For details see, Battese *et al*., (2004) and Kumbhakar (2006).

[7] The substitution between land and water has been estimated in some studies and, while relatively low, it was found significantly different from zero.

3.2 Trade openness and productivity gains

Our framework integrates endogenous productivity relationships to capture the poverty alleviation that might arise from trade induced agricultural productivity gains.

The agricultural production function is defined as:

$$Y = A\ L^{\beta^L}\ LD^{\beta^D}\ K^{\beta^K} \tag{8}$$

where *Y* is agricultural value added and *A* is agricultural TFP. *L* indicates labor, *LD* land and *K* capital. β^L, β^D and β^K are the labor, land and capital elasticities respectively.[8]

We express agricultural TFP as a function of labor augmenting technical progress, A_L, and land augmenting technical progress, A_D :[9]

$$A = A_L^{\beta^L}\ A_D^{\beta^D} \tag{9}$$

In line with the productivity growth model sketched out in the previous section, the growth rate of agricultural TFP is related with the stock of human capital, the degree of trade openness and the technology GAP. This association is tested by estimating the model in equation (1) econometrically. A similar equation for agricultural TFP gain of the following form is incorporated in the CGE model:

$$\hat{A} = \alpha_1\left(\frac{G}{GDP}\right)^{\alpha_H} + \alpha_2\left(\frac{G}{GDP}\right)^{\alpha_H}\left(\frac{Trade}{XS}\right)^{\alpha_{op}}\left(1-\frac{A}{A^F}\right) \tag{10}$$

where $\hat{A}$ is the proportional change in domestic agricultural TFP, A^F is the level of agricultural productivity in the frontier country, *G* is public expenditure, *Trade* is total trade, *GDP is* gross domestic product and *XS* is aggregate output. The ratio of public expenditure to GDP captures the share of public expenditures on education and is used to proxy the level of human capital. The share of trade to aggregate output measures the degree of openness. A/A^F is the technology gap and captures the potential for technology transfer. α_1, α_2, α_H, α_{op} and A^F are estimated econometrically from equation (1) in the previous section.

3.3. The labor market and technological bias

As increased openness may lead to skill biased productivity growth, we investigate this effect through the following CES specification of aggregate labor demand. Following Rattsø and Stokke (2005), aggregate labor demand is specified as:

$$L_i = \left[\gamma_{1,i} A_L^{\rho_l - 1/2\eta} UL^{\rho_l} + \gamma_{2,i} A_L^{\rho_l + 1/2\eta} SL^{\rho_l}\right]^{\frac{1}{\rho_l}} \tag{11}$$

The direction and degree of technological bias is introduced through the parameter η, which gives the elasticity of the marginal productivity of skilled relative to unskilled labor with respect to labor augmenting technical progress. For η equal to zero, technical change is neutral and does not affect the relative efficiency of the two labor skill types. With a positive value of η, technical change favors skilled workers, while negative values imply that improvements in technology are biased towards unskilled labor.

The reduced form specification of technological bias is assumed to be an increasing and convex function of trade share:

[8] See Diao *et al*. (2005) for a similar specification.

[9] TFP in the industrial and services sector is assumed to be equal to labor augmenting technical progress.

$$\eta = \alpha^{bias}\left(\left(\frac{\hat{Trade}}{XS}\right)^2 - 1\right) \tag{12}$$

where α^{bias} is a constant parameter.

Recalling the model structure, labor is assumed to be perfectly mobile although some labor types are not used in all sectors. Wage differentials by skill level are allowed to coexist reflecting specific institutional features related to the domestic labor markets. Minimum wage by skill level binds and is calibrated to the wage rate of the initial period. The model allows also for the unemployment rate to be positive. This rate is determined endogenously.

3.4 Income distribution and poverty

This section discusses incomes distribution and attempts to provide a brief overview on the methodology used to analyze the external shock effects on poverty and inequality.

The common poverty measures can be formally characterized in terms of per capita income and relative income distribution as follows:

$$P = P(Y, L(p)) \tag{13}$$

where *Y* is per capita income and *L(p)* is the Lorenz Curve. *P* denotes the poverty measure which we assume to belong to the Foster-Greer-Thorbecke class (1984): $P_\theta = \int_0^z \left(\frac{z-y}{z}\right)^\theta f(y)dy$, where θ is a parameter of inequality aversion, *z* is the poverty line, *y* is income, and *f(.)* is the density function of income. P_0, P_1 and P_2 are respectively the headcount ratio, the poverty gap and the squared poverty gap.

The CGE model complemented by a micro-simulation approach is the core methodology of the analysis of the poverty impacts of agricultural trade liberalization and productivity gains. The interaction between the gain in labor productivity on one hand and the behavior of the labor market (downward nominal wage rigidity) will determine the outcome in terms of fluctuation in employment, households' income and cost of the consumption basket of households. The vectors of commodity and factor prices obtained from the different simulation scenarios are then fed into a micro-simulation framework to analyze income distribution and poverty at the household level using the micro data from the Tunisia household survey.

Our approach uses the concept of equivalent income defined as the level of income that would allow achieving the same utility levels under different budget constraints. Assuming a Stone Geary utility function, the equivalent income for each household *h* can be written as:

$$Y_e(p_0, p, y^h) = \prod_i \left(\frac{p_{i,0}}{p_i}\right)^{\beta_{h,i}} \left(y^h - \sum_i p_i C_{i,h}^{\min}\right) + \sum_i p_{i,0} C_{i,h}^{\min} \tag{14}$$

where $p_{i,0}$ p_i are the prices of commodity *i* at the base year and obtained from the simulation respectively, y^h the income of household *h*, $C_{i,h}^{\min}$ is the minimum level and $\beta_{h,i}$ the budget share devoted to the consumption of commodity *i* by household *h*.

In order to better capture the effects of prices and income variations on poverty, we write the poverty measures in terms of equivalent income as follows:

$$P_{\theta} = \frac{1}{N}\sum_{h\in \mathrm{P}} n_h \left(\frac{z - Y_e^h}{z}\right)^{\theta} \qquad (15)$$

where n_h is the household size, N is the population size and P is the set of all poor individuals.

The basic requirement for the measurement of poverty is the definition of a poverty line in order to delineate the poor from the non-poor. We follow Decaluwé *et al.* (1999) , Sánchez Cantillo (2004) and several others, by using endogenous poverty lines produced by the CGE model in order to capture the change in the nominal value of the poverty line following a change in relative consumption prices of goods and services . The poverty line is computed as

$$z = \sum_{f} p_f C_f^{\text{basic}} \qquad (16)$$

where C_f^{basic} and p_f are the quantities and consumption prices of the basic needs by commodity[10].

The standard Gini and Theil coefficients are used to measure inequality at the individual household level. They are respectively defined as follows:

$$GINI = \frac{N+1}{N-1} - \frac{2}{N(N-1)\mu}\sum_{h} \kappa_h Y_e^h \qquad (17)$$

$$THEIL = \sum_{h} \left({Y_e^h}/{Y} \right) \ln \left(\frac{Y_e^h}{Y/N} \right) \qquad (18)$$

where μ is the mean of household income, κ is the rank of the household in the distribution of income and Y is total income of households.

4. Data

Our study requires an important database to conduct the econometric and the CGE analysis. The following sections give an overview of the data used to conduct the analyses.

4.1 The econometric analysis

Our empirical application is based on country-level panel data referring to nine Southern Mediterranean Countries (SMC) involved in partnership agreements with the EU (Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Syria, and Turkey in addition to Tunisia) and five EU Mediterranean countries (France, Greece, Italy, Portugal and Spain) during the period 1990-2005. These countries are the leading trading partners and competitors of Tunisia. The data set includes observations on agricultural production and input use, international trade, income distribution, and a number of other variables that are frequently associated with agricultural productivity and growth. We estimate the stochastic production frontier using data on production of thirty-six agricultural commodities belonging to six product categories (fruits, shell-fruits, citrus fruits, vegetables, cereals and pulses) and on the corresponding use of five inputs (cropland, irrigation water, fertilizers, labor and machines). These product categories include the main produced and traded commodities in the Mediterranean region and are obtained from FAOSTAT and FEMISE reports.

The inefficiency effect model and the productivity change equation incorporate an array of control variables representing trade openness, human capital, land holdings, agricultural research effort, and institutional quality.

[10] Noted that the basic needs correspond to the minimum vital needs and are therefore different and inferior to the minimum consumption level in the utility function.

Two different measures are used to proxy the degree of trade openness of each country: the share of total agricultural trade in GDP and agricultural trade barriers. Agricultural commodities are currently protected with a complex system of ad-valorem tariffs, specific tariffs, tariff quotas, and are subject to preferential agreements. The determination of the appropriate level of protection is a fairly complex task. The MacMaps database constructed by the CEPII provides ad-valorem tariffs, and estimates of ad-valorem equivalent of applied agricultural protection, taking into account trade arrangements (Bouët *et al*. 2004). Our data on agricultural trade barriers are drawn from this database[11].

Human capital is proxied by the average years of schooling in the population over age 25 from the updated version of Barro and Lee (2000). Agricultural research effort is measured by public and private R&D expenditures obtained from Pardey *et al*. (2006). Land holdings include land fragmentation, which is controlled for by the percent of holdings under five hectares; inequality in operational holdings, measured by the land Gini coefficient; land quality, measured by the percent of land under irrigation and average holdings approximated by the average farm size. These data are constructed from the decennial agricultural censuses of the FAO. Institutional quality includes various institutional variables considered as indicators of a country's governance, namely, political stability, government effectiveness and control of corruption. These variables reflect the ability of the government to provide sound macroeconomic policies and impartial authority to protect property rights and enforce contracts are thought to enhance farming efficiency and productivity. Data on these variables are drawn from Kaufmann *et al*. (2007).

As determinants of the latent class probabilities, we consider country averages of five separating variables: total agricultural machinery, total applied fertilizers, agricultural land, average holdings and rainfall levels. These variables help to identify countries endowed with modern inputs and to capture the differences in the scale of agricultural holdings across countries. Observations on these data are from FAOSTAT and WDI.

4.2 The CGE analysis

The model is calibrated to data from a Tunisian social accounting matrix (SAM) for 2001. The SAM distinguishes 33 production sectors, including 23 agricultural and food activities with 10 urban industries and services; 5 types of labor; 4 types of land; capital; and natural resources.[12] Institutions include rural and urban households, companies, government and foreign trading partners. This SAM provides a consistent set of relationships showing intermediate, final demand, value added and foreign transactions. The sectors, factors and institutions of the model are described in Table A3 in the appendix along with their label.

The modeling analysis in this work is static by nature. As our SAM contains data on only two representative household groups, rural and urban households, the poverty and distributional impact from any simulation in the model cannot be computed with enough precision. To overcome this shortcoming, the CGE model is complemented by a micro-simulation methodology using the traditional "top-down" approach. We measure the distributional and poverty effects of agricultural trade policy changes using the 2000 expenditures household survey.[13]

5. Main Estimation Results

The ambition of our empirical investigation is to incorporate econometric evidence of the trade-productivity linkages into the CGE model to examine the impact of agricultural trade liberalization on poverty and inequality taking account of the farming productivity gains channel and the relationship between labor productivity and rigidities in the labor market.

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[11] Available at http://wits.worldbank.org/witsweb/default.aspx.

[12] Labor types are: family agricultural workers, skilled and unskilled agricultural workers and skilled and unskilled nonagricultural workers. Land is composed of annual irrigated and non irrigated land and perennial irrigated and non irrigated land.

[13] Access to the household survey of 2000 was impossible. We use the 1990 and 1995 household surveys and the INS publications on the 2000 survey to generate the missing data.

We start by estimating the econometric model in Section 2, and then incorporate the parameter estimates in the CGE model to investigate the inequality and poverty outcomes under different agricultural trade liberalization scenarios.

5.1 The econometric estimations

This empirical application involves basically a three-step analysis. First, the latent class model of equation (2) is estimated using maximum likelihood via the EM algorithm[14]. Second, efficiency and productivity levels and growth are computed for each country. Third, the technology gap among the different countries is measured, and the determinants of agricultural productivity growth are investigated focusing on the role of international trade.

In each country, we carried out estimations at different levels of aggregation, both for each agricultural commodity group and for the whole agricultural sector. The results of estimating the input elasticities of the production frontier are reported in Table A1 in the appendix[15].

The results show relatively important differences of the estimated factor elasticities among classes and seem to support the presence of technological differences across the countries. The input elasticities are globally positive and significant at the 10% level. Water and cropland have globally the largest elasticity, indicating that the increase of Mediterranean agricultural production depends mainly on these inputs. The estimated technology frontiers provide a measure of technical change. A positive sign on the time trend variable reflects technical progress. Significant shifts in the production frontier over time were found in the pooled and specific commodity models, indicating gains in technical change for the selected countries.

The determinants of agricultural production efficiency among the selected countries proved significant. International trade, educational attainment, land quality, agricultural research effort and institutional factors appear to contribute to enhancing efficient input use. As expected, the unequal distribution of agricultural land and to a lesser extent land fragmentation have significant adverse effects on efficient resource use.

The investigation of the estimation results of the latent class probability functions shows that the coefficients are globally significant, indicating that the variables included in the class probabilities provide useful information in classifying the sample. The sign of the parameters estimates indicate whether the separating variable increases the probability of assigning a country into the corresponding class or not. For example, increasing total applied fertilizers increases the probability of a country to belong to class three.

The average efficiency scores and TFP changes, estimated using equations (6) and (7) respectively, are reported in Table A2 in the appendix. The results show productivity increases in the Mediterranean agricultural sector, on average, with SMC registering relatively better average rates of productivity gain than EU countries. On average, over the period under consideration, EU countries exhibited better efficiency levels than SMC.

Variation of agricultural performance across countries opens the possibility of investigating the factors contributing to productivity improvement and facilitating the catching up process between high-performing and low-performing countries. Two of the key concerns here are the relevance of international trade as a channel for technology spillovers and the importance of human capital for absorbing foreign knowledge and driving rates of productivity growth. To tackle this issue, we first measure the technology gap ratio (*GAP*), defined in section 2, using the metafrontier approach, and then estimate the model in equation (1) that links agricultural

[14] The estimation procedure was programmed in STATA 9.2.

[15] In the interest of space limitation we describe the results using pooled data. Estimates for specific crops are available from the authors upon request.

productivity growth to technology gap, international trade, and human capital using the nonlinear least squares approach.

The estimation of this model poses several challenges relating to unobserved heterogeneity, potential endogeneity, and measurement error. The computational difficulties of the nonlinear fixed effect models preclude the introduction of individual specific effects to control for the differences between the countries. We add a set of institutional factors, including investment in research and development, institutional quality and average agricultural holdings, to the baseline specification. This strategy enables us to control for heterogeneity in certain observed variables and to check the robustness of the results.

Another econometric concern is that measurement error and endogeneity of some explanatory variables, such as technology gap, could lead to bias in the estimated coefficients. One way of dealing with this problem is to regress the technology gap against the lagged gap and use the predicted value as an alternative to the technology gap in the model.

Table 1 reports the estimation results considering the two proxies of international trade, namely the ratio of agricultural exports plus imports to GDP (column 1), and agricultural trade barriers (column 2).

Regardless of the international trade measure, the results lend strong support to the positive effect of trade openness on agricultural productivity growth. Across the regressions, TFP growth rate increases with higher trade shares and decreases with more trade barriers. These estimates provide interesting insights into the agricultural productivity dynamics. The interaction term highlights the role of international trade in promoting technology transfer and point to the importance of education in facilitating the assimilation of foreign improvement of technology. The findings suggest that countries lying behind the frontier enjoy greater potential for TFP growth through the speed of technology transfer.

The linear effect of human capital on TFP provides also some support to the role of educational attainment in enhancing domestic innovation in agriculture.

There are also interesting results regarding the effect of the control variables on agricultural productivity growth. The findings provide evidence on the positive contribution of agricultural research efforts and larger farm sizes to productivity improvement. Control of corruption, government effectiveness and regularity quality enter with positive and statistically significant coefficients, indicating a positive role of institutional quality in enhancing agricultural growth.

5.2 Simulation of agricultural trade policy reform

The analysis aims to investigate the inequality and poverty impacts of agricultural trade liberalization and to examine the additional poverty alleviation that could be expected from the trade induced agricultural productivity gains. Two sets of scenarios are considered and under each scenario we abstract from the productivity gains and then take these gains into account. In what follows, we report the results for these scenarios:

1. Scenario 1: Cutting tariffs on agricultural products and abstracting from the productivity link.
2. Scenario 2: Cutting tariffs on agricultural products and taking account of the productivity link.
3. Scenario 3: This scenario extends Scenario 1 to all products.
4. Scenario 4: This scenario extends Scenario 2 to all products.

The trade policy simulation analysis focuses only on selected key variables, the choice of which relies on the mechanisms through which agricultural trade liberalization affects economic performance, poverty and inequality. The simulation results are reported using the percentage deviation from the model's base-line, and in the interest of space limitation, most of the results refer to agriculture.[16]

[16] Results on more variables and with different scenarios can be obtained from the authors upon request.

We begin by comparing the global impact of the four simulation scenarios on some macro aggregates. The results are reported in Table 2. As expected agricultural trade openness exerts a significant positive effect on agricultural imports and exports. An increase in trade of non agricultural products with the rest of the world will be observed only with a complete elimination of tariff barriers. In terms of real GDP it's important to note that real GDP is positive only when we take into account the productivity gain create by an increase in trade. Real GDP is negative in scenarios 1 and 3 and positive for scenarios 2 and 4 (we will come back to this issue later in the discussion). Regarding the production side, a more open trade policy does not seem to exert any appreciable positive effect. Total production of agricultural and non agricultural commodities seems to vary negatively or weakly positively under the first three scenarios. The increased competition on agricultural markets appears to have a negative impact on total production in the whole economy and particularly in agriculture. However when the productivity gain is taken into account the negative impact is substantially reduced. This effect is however reversed when trade is liberalized in the whole economy and productivity gains are taken into account, as shown by the simulation results of the last scenario. In this case agricultural production as well as other productions is positively affected.

In Table 3 we present the productivity gains as well as the imports and exports variations induced by the elimination of tariff on agricultural commodities (scenario 2) and on all products (scenario 4). The findings show important productivity gains in all agricultural productions. The sectors "Other fruits", (+3.92%) "Leguminous" (+2.93%) and "Industrial cultures" (+2.92%) seem to enjoy the most important productivity gains. These sectors are among the most protected (the initial tariff rates are between 55 to 65 % for these three sectors) and the elimination of tariff barriers on these commodities appear to induce a substantial increase in the import and export in these sectors enhancing the transfer of new technologies and contributing to achieve gains in productivity.

The removal of trade barriers and the transfer of new technologies will induce changes in the labor demand and might affect its skill structure. As sketched earlier, the labor force in the agriculture sector is assumed to be composed of three categories of workers: family labor and skilled and unskilled wage workers. We assume also that the nominal wage rates for all categories of workers are rigid downward in such a way that the farmers, and in general the firms, that confront a reduction in their output prices have no other choice than reducing employment. With the real depreciation of the exchange rate needed to keep the current account balance in equilibrium we observe a reduction of domestic prices with respect to the foreign prices. Consequently the real wage rate will go up and, in the absence of productivity gains, labor demand will decrease. However if the productivity gains inferred by the trade openness are sufficiently important these would eventually compensate the increase in the real wage rate. Depending on the magnitude of this sectoral productivity gain, the farmers and in general the firms in the non-agricultural sectors will be affected differently by the increase in the real wage rate.

Furthermore, the transfer of modern technologies induced by increased openness to trade would lead to skill biased productivity change affecting mostly wage workers. Increased sectoral trade would enhance the productivity of skilled workers more than that of the unskilled ones. For a given level of production, the shifting of the production function for skilled workers will be more pronounced that the shifting of the production function for the unskilled ones. Ceteris paribus this will lead to a greater reduction of the demand for skilled workers than for unskilled one.

This mechanism is at work as shown by the evidence in Table 4.

In the three sectors mostly affected by an elimination of tariff we have a huge reduction in family labor of – 55.5 % in " Industrial culture", of -51.1% in "Leguminous" and of -17.2 % in "Other fruits". However we observe an important substitution in these sectors in favor of unskilled workers. The skill biased productivity gain due to a more open trade policy appears to play a significant role in the heavily protected sectors. All together this shifting of labor demand has a positive impact on the wage rate for unskilled agriculture workers + 8.37% and a negative impact on unemployment level for the two other categories. The unemployment rate of family workers increased from 7% to 11.1%. An even stronger increase in unemployment is observed for skilled agricultural workers as the unemployment rate rises from 7% to 23.6%. Mutatis mutandis the same results applied for the Scenario 4.

We are now in position to summarize the mechanisms at work in the Tunisian economy. With unemployment and a downward rigidity of nominal wages, a complete removal of tariff either on agricultural goods or for the whole economy will create an increase in unemployment that could lead to a reduction of real GDP. (See the results presented in table 2). The positive impact of an optimal reallocation of resources will eventually not be sufficient to compensate the rigidity on the labor market. However if an increase in the degree of openness of the economy induces productivity gains, the real GDP could go up even with an increase in the level of unemployment. The magnitude of the sectoral impacts are linked to the initial level of protection, the initial technological gap with respect to the best practice frontier and of the nature of the technological bias affecting the productivity of different types of workers.

We finally assessed the main inequality and poverty implications of trade liberalization. Household poverty is measured using the poverty headcount index (or the "incidence of poverty"), which gives the proportion of the population with income below the poverty line, and the poverty gap index (or the "intensity of poverty"), which indicates how far below the poverty line the poor are. The inequality is estimated by the Gini and Theil indexes. The poverty and inequality indicators are applied for the per capita household equivalent income.

The simulation results of the previous four scenarios are reported in Tables 5 and 6.

As we can see it's nearly impossible to detect any change neither with the Gini coefficient nor the Theil inequality index. However for the poverty index we can see that taking into account the productivity gain created by an opening of the economy leads to a substantial reduction in the headcount ratio as well as the poverty gap and confirms our expectation regarding the contribution of farming productivity improvement to alleviating poverty. Trade liberalization and agricultural productivity gains appear to be particularly beneficial to the rural poor.

6. Conclusions

The issue of what effects trade liberalization has on inequality and poverty has been accorded an important attention in the recent studies. There is a widespread acceptance that relatively open policies contribute to improve the well being of the poor, however much remains to be learned about the mechanisms by which trade liberalization translates into poverty impacts. Access to new technology and productivity gains are identified among the most critical pathways through which trade openness may alleviate poverty. The analysis of this paper examines the effects of trade openness on agricultural productivity, and assesses how trade reforms and farming performance impinges on poverty and inequality in Tunisia using a general equilibrium model.

The study incorporates econometric evidence of the trade productivity linkage into a general equilibrium model to estimate the poverty outcomes of agricultural liberalization in Tunisia. The econometric methodology follows the latent class stochastic frontier models to account for producers' heterogeneity.

The results show that trade openness exerts a significant ameliorating influence on the incidence of poverty in Tunisia. Opening up to foreign trade seems to facilitate catching up with the best practice technology, providing substantial support for the view that openness promotes productivity growth through technology transfers. The different simulation analyses of trade liberalization scenarios show that the direction and magnitude of sectoral labor demand effects are variable and depend on the initial level of protection in these sectors, the initial technological gap with respect to the best practice frontier and the nature of the technological bias affecting the productivity of different types of workers. The distributional implications seem negligible as shown by the little variation of the inequality indicators across the different simulation scenarios. Trade openness and agricultural productivity gains appear however to have a substantial positive influence on poverty reduction and are shown to benefit the rural poor more than proportionately.

In concluding this paper it is important to remember that the different simulation scenarios presented are probably not the best options for the Tunisian government in its negotiations with the EU and in the international arena. The scenarios are essentially representative of the maximum benefit we can expect if the Tunisian government wants to open its economy even more. Our purpose in this paper is more of a methodological nature showing the possibility of combining econometric evaluation of productivity gain induced by a trade oriented strategy and the way we can infer the global impact on the whole economy and on poverty.

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Table 1: Impact of International Trade on Agricultural TFP Growth

	TRADE VOLUMES	TRADE BARRIERS
Human capital (α_1)	0.05**	0.04***
International trade*Human capital*(1-GAP) (α_2)	0.17*	-0.13***
α_{op}	0.34***	-0.14***
α_H	0.35***	-0.14**
R&D	0.024**	0.029**
Average holdings	0.0038*	0.0022*
Control of corruption	0.0003*	0.0002
Government effectiveness	0.0004*	0.0003*
Political stability	0.0003*	0.0002*
N. of observations	1260	1260
R^2 adjusted	0.62	0.53

Notes: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels respectively.

Table 2: Macroeconomic Results

VARIABLE	INITIAL	SCENARIO 1 % variation	SCENARIO 2 % variation	SCENARIO 3 % variation	SCENARIO 4 % variation
Real GDP	28735	-0,06	0,07	-0,84	0,78
Agricultural Production	2647	-1,44	-0,16	-1,38	1,02
Non-agricultural Production	50174	0,12	0,13	-1,22	0,81
Agricultural exports	155	1,03	1,76	2,36	2,11
Non agricultural exports	13578	0,12	0,13	3,07	4,18
Agricultural imports	854	11,83	9,52	5,94	10,77
Non agricultural imports	16258	-0,53	-0,43	1,10	0,76

Note : values in the base year are in Million TD

Table 3: Trade Induced TFP Gains and External Trade

	SCENARIO 2			SCENARIO 4		
	TFP GAIN	IMPORTS	EXPORTS	TFP GAIN	IMPORTS	EXPORTS
Agricultural	0,99	9,52	1,76	1,43	10,77	2,11
Non Agricultural	0,02	-0,43	0,13	0,63	0,76	4,18
TWHEAT	1,29	8,42	0,00	1,64	9,05	0,00
HWHEAT	0,98	15,33	0,00	1,40	15,48	0,00
BARLEY	0,23	2,24	1,40	0,63	-2,26	0,22
OCER	0,27	3,07	1,64	0,85	7,77	1,90
LEGUM	2,93	59,09	22,51	3,42	61,85	22,96
OLIV	0,05	0,00	0,73	0,36	0,00	0,59
CITR	0,08	-2,27	1,44	0,53	-2,11	2,01
DAT	0,07	-2,68	1,67	0,52	-2,15	1,93
OFRUITS	3,92	136,19	5,45	4,40	139,67	5,72
VEG	0,07	1,42	1,79	0,53	3,09	2,25
LVST	0,01	-0,51	0,44	1,39	33,79	6,18
INDCUL	2,92	6,43	-4,42	3,43	10,85	-2,95
OCROPS	1,04	20,75	0,04	1,33	17,36	2,02

Table 4: Agricultural Labor Demand by Type

	FAMILY WORKERS		UNSKILLED WORKERS		SKILLED WORKERS	
	Initial	%	Initial	%	Initial	%
TWHEAT	14,37	-19,48	2,353	-1,45	1,23	-43,98
HWHEAT	50,17	-9,86	7,708	12,57	3,95	-38,54
BARLEY	12,44	-2,90	2,042	-11,33	1,06	-9,46
OCER	29,93	-2,86	4,589	-10,13	2,56	-10,59
LEGUM	11,71	-51,10	1,918	129,40	1,00	-91,12
OLIV	88,23	0,69	11,38	-14,04	7,21	0,42
CITR	23,25	0,04	4,371	-13,35	2,07	-1,65
DAT	56,76	0,24	10,68	-13,38	5,04	-1,22
OFRUITS	166,44	-17,20	31,27	57,83	14,83	-63,01
VEG	233,79	-0,58	21,81	-14,16	12,25	-1,97
LVST	180,67	3,17	25,24	-13,52	16,63	4,79
INDCUL	4,698	-55,53	0,489	107,53	0,37	-91,88
OCROPS	91,519	-2,56	14,46	-5,58	9,58	-14,38

Table 5: Poverty Effects

	Incidence of Poverty P0					Poverty Gap P1				
	Initial	Scen.1	Scen.2	Scen.3	Scen.4	Initial	Scen.1	Scen.2	Scen.3	Scen.4
Rural households	1.78	1.51	1.18	1.28	0.38	0.37	0.28	0.17	0.19	0.08
Urban households	4.75	4.96	4.62	4.73	3.00	0.7	0.92	0.84	0.86	0.49
Total	3.5	3.03	2.82	2.93	1.81	0.63	0.55	0.5	0.51	0.3

Table 6: Inequality Effects

	GINI					Theil				
	Initial	Scen.1	Scen.2	Scen.3	Scen.4	Initial	Scen.1	Scen.2	Scen.3	Scen.4
Rural households	0.285	0.287	0.287	0.287	0.286	0.134	0.136	0.136	0.136	0.135
Urban households	0.307	0.313	0.312	0.314	0.311	0.165	0.172	0.17	0.173	0.17
Total	0.316	0.319	0.319	0.32	0.317	0.176	0.177	0.177	0.178	0.175

Appendix

Table A1: Latent Class Model Parameter Estimates

	Class 1	Class 2	Class 3	Class4
Production Frontier				
Land	0.309***	0.261***	0.444***	0.216***
Water	0.275***	0.289***	0.276***	0.333***
Labor	0.236***	0.26***	0.141*	0.144**
Fertilizers	0.107*	0.092*	0.127*	0.111*
Machines	0.097*	0.16*	0.136**	0.327***
Time	0.017***	0.06**	0.009**	0.008*
Intercept	0.55**	0.76**	0.022	0.12
Efficiency term				
Land Gini	0.212***	0.169***	0.175***	0.123***
Land fragmentation	0.038**	0.002*	0.058**	0.02*
Land quality	-0.04**	-0.04*	-0.05***	-0.011*
Trade openness[1]	-0.157***	-0.135***	-0.268***	-0.165***
Human capital	-0.095***	-0.098**	-0.156**	-0.149**
R&D	-0.004*	-0.002*	-0.002**	0.001*
Government effectiveness	-0.026	-0.0034*	-0.01**	0.003***
$\Gamma = \sigma_e^2/\sigma_s^2$	0.72***	0.829***	0.784***	0.891***
Probabilities				
Fertilizers consumption		-0.073	0.144**	-0.99**
Agricultural machinery		0.079*	-0.03	0.472***
Agricultural land		0.0367***	0.045**	0.408***
Average holdings		-0.026**	0.35*	0.093**
Rain		-0.006*	0.01**	0.262**
Intercept		-1.36	-1.359*	-3.29**
Log-likelihood		-274.33		
Number of Obs.		1344		

Notes: the variables in the production frontier and efficiency function are in natural logarithm. The significance at the 10%, 5% and 1% levels is indicated by *, ** and *** respectively. A negative sign in the inefficiency model means that the associated variable has a positive effect on technical efficiency.

Table A2: Efficiency Scores and TFP Index Growth

	Fruits		Citrus		Shell		Vegetables		Cereals		Pulses		Pool	
	TE[a]	GTFP[b]	TE	GTFP	TE	GTFP	TE	GTFP	TE	GTFP	TE	GTFP	TE	GTFP
Algeria	0.543	2.88	0.415	2.39	0.601	-1.19	0.683	0.62	0.546	1.78	0.639	-0.58	0.596	1.14
Egypt	0.577	1.37	0.664	1.64	0.587	-0.9	0.44	4.9	0.582	-0.14	0.593	1.61	0.598	1.16
France	0.917	1.08	0.832	-1.18	0.961	0.601	0.986	0.55	0.994	1.21	0.981	1.09	0.981	0.96
Greece	0.629	1.473	0.706	1.73	0.629	-1.65	0.646	-0.85	0.663	1.91	0.678	1.03	0.684	0.85
Israel	0.683	1.54	0.787	1.19	0.667	1.74	0.714	2.13	0.482	-0.74	0.642	2.74	0.667	1.82
Italy	0.893	1.51	0.753	1.55	0.705	0.74	0.81	1.41	0.741	1.79	0.785	1.1	0.807	1.45
Jordan	0.608	0.97	0.666	1.22	0.627	1.74	0.785	1.66	0.351	-0.89	0.645	1.72	0.659	1.34
Lebanon	0.878	1.31	0.768	1.28	0.871	1.62	0.822	1.95	0.612	1.98	0.808	-0.47	0.789	1.61
Morocco	0.617	-0.46	0.861	1.12	0.67	2.94	0.768	1.45	0.633	-0.25	0.631	1.32	0.737	1.05
Portugal	0.534	0.38	0.627	1.39	0.512	0.24	0.714	-0.41	0.638	1.92	0.558	-0.25	0.613	0.79
Spain	0.785	1.59	0.848	1.01	0.678	-2.37	0.876	1.78	0.757	1.63	0.694	0.73	0.799	0.96
Syria	0.648	1.33	0.788	0.99	0.702	3.04	0.736	2.45	0.768	2.76	0.762	1.42	0.738	2.01
Tunisia	0.638	0.74	0.641	1.03	0.685	0.31	0.734	1.62	0.684	0.93	0.654	1.58	0.657	1.07
Turkey	0.878	1.79	0.881	2.19	0.883	2.08	0.819	1.87	0.853	1.89	0.793	2.26	0.834	2.08

[a]: Technical efficiency score, [b]: TFP growth (%).

Table A3: Classification of the Accounts in the Micro SAM

SECTORS , FACTORS AND INSTITUTIONS	LABELS
Activities and commodities	
Tender wheat	TWHEAT
Hard wheat	HWHEAT
Barley	BARLEY
Other cereals	OCER
Leguminous	LEGUM
Olives	OLIV
Citrus fruits	CITR
Dates	DAT
Other fruits	OFRUITS
Vegetables	VEG
Livestock	LVST
Industrial cultures	INDCUL
Other crops	OCROPS
Fish and fishery (mollusks, crustaceans …)	FISH
Meat	MEAT
Dairy products	DAIRY
Flour	FLOUR
Olive oil	OOIL
Other oil	OGR
Canned	CANNED
Sugar and biscuits	SUGAR
Beverages	BEVER
Other agri-food products	OAGRI
Construction material, ceramic and glass industries	MCV
Mechanical and electrical industries	IME
Chemical industries	CHEM
Textiles and leathers industries	TEXT
Other manufacturing industries	OMAN
Mining industries	MINING
Urban water	WATERNA
Irrigation water	WATERA
Non manufacturing industries	NMAN
Services	SERV
Production Factors	
Family agricultural workers	FAW
Unskilled wage workers in the agricultural sector	UWA
Skilled wage workers in the agricultural sector	SWA
Unskilled wage workers in the non-agricultural sectors	UWNA
Skilled wage workers in the non-agricultural sectors	SWNA
Annual irrigated agricultural land	AIAL
Annual dry agricultural land	ADAL
Perennial irrigated agricultural land	PIAL
Perennial dry agricultural land	PDAL
Natural resources	NRES
Capital	CAP
Institutions	
Rural households	RUR
Urban households	URB
Enterprises	ENTR
Government	GOV
European Union	EU
Rest of the world	ROW
Fiscal instruments	
Indirect taxes	ITAX
Direct taxes	DTAX
Import taxes from EU	TUE
Import taxes from. ROW	TROW