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**P**olitiques **E**conomiques et **P**auvreté  
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## **MPIA Working Paper**

**2006-07**

### **Trade Liberalization and the Dynamics of Poverty in Tunisia: A Layered CGE Microsimulation Analysis**

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**April 2006**

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## Abstract

The effects of trade liberalization on poverty in Tunisia are examined, using a layered dynamic CGE-microsimulation approach. A dynamic CGE model endogenously generates the evolution of prices, as well as income paths under protection and freer trade assumptions for each household group. These results are then used to assess the change in real income of each household, using a sample from the 1995 household survey, and thus the effects of the simulated changes on poverty. Dominance tests are also used to avoid the arbitrariness of choosing a poverty line and a poverty measure. Simulation results show that trade openness slows down the poverty reduction in the short run, but enhances it in the long-run.

## Résumé

Une analyse dynamique des effets de la libéralisation commerciale montre que celle-ci n'entraînera pas, contrairement aux cas précédents, une augmentation de la pauvreté en Tunisie. Néanmoins, l'ouverture commerciale freinera probablement la dynamique de la réduction de la pauvreté à court terme mais, l'accélèrera à long terme. La baisse de la pauvreté touchera aussi bien les ménages urbains que ruraux, avec une plus faible réduction de la pauvreté rurale à court et à long terme. Pour comprendre ce résultat, il faut d'abord noter que la Tunisie, comme dans la plupart des autres pays, impose des taux de protection plus élevés sur les produits agricoles que sur les produits industriels; pendant que les branches industrielles, notamment celle des services, contribuent davantage aux recettes d'exportation. Par conséquent, la libéralisation commerciale entraîne une expansion plus rapide du secteur des services par rapport aux autres branches industrielles et au secteur agricole. Cela engendre un taux de croissance du revenu nominal des ouvriers et des exploitants agricoles plus faible que celui des autres ménages urbains. Les prix à la consommation croient plus faiblement pour les ménages urbains, qui consomment davantage de produits industriels et des services, que pour les ménages ruraux, qui consomment plus de produits alimentaires. Tous ces résultats font que l'amélioration du revenu réel, qui touche toutes les catégories des ménages, est légèrement plus importante pour les ménages urbains.

**Keywords:** Trade liberalization; poverty; dynamic CGE models; sequential microsimulation; Tunisia.

**JEL Classification:** C68; I32; O24.

This work was carried out with the aid of grants from the International Development Research Centre (IDRC)-funded Poverty and Economic Policy (PEP) research network [[www.pep-net.org](http://www.pep-net.org)], the FEMISE network, the Arab Planning Institute (API), and International Food Policy and Research Institute (IFPRI). We are grateful to Ali Abdel Gadir Ali, Shenggen Fan, Jean-Yves Duclos, Mongi Boughzala and Rachid Barouni for their useful comments. The usual disclaimer applies.

## 1. Introduction

The links between trade reform and poverty are diverse and complex. In the developing countries, the poor, i.e., households with income falling below the poverty line, share common broad features: (i) they are generally concentrated in rural (subsistence) agriculture and in urban informal sector activities; (ii) they have limited assets, the most abundant of which is low-skilled labor; and (iii) food is by far the most important item of their expenditure. This paper intends to identify both the direct and indirect effects of trade liberalization on the poor, given this poverty profile<sup>1</sup>.

Trade reform works directly through the transmission of price signals. To illustrate, if a trade policy allows for an increase in the price of something the poor households sell (unskilled labor, goods, services), and/or forces downward the price of something the poor households consume (goods, services), it will increase the real income (purchasing power) of the poor households and move more poor people above the poverty line, and vice versa.

Economic growth is the indirect channel through which freer trade can contribute to poverty alleviation. There is now substantial empirical evidence supporting a positive association between open trade regimes and growth and development<sup>2</sup>. Indeed, trade openness reduces the anti-export bias of protection, allows efficient allocation of scarce resources and provides incentives to investment and innovation. In addition, trade reform is usually associated with higher flows of foreign direct investment (FDI) with attendant spillovers of improved technologies, new business practices, and other positive effects on domestic firms, thus increasing the overall level of productivity and growth. In turn, economic growth becomes a powerful force for permanent and sustained poverty reduction. The extent to which growth affects poverty, however, depends on how the additional income generated by growth is distributed across the population. The more the income of the bottom segment of the population rises, the more the growth pattern is deemed pro-poor. Dollar and Kraay (2002) find that the incomes of the poorest fifth of the population grew one-for-one with GDP per head in a sample of 80 countries over four decades.

Trade liberalization is therefore expected to help the poor, given the positive relationship between openness and growth, and growth and poverty reduction. However, trade reform alone is not a panacea and relying solely on the growth effect of a liberal

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<sup>1</sup> A detailed synthesis of the different mechanisms through which changes in trade policy can affect the poor could be found among others in Bannister and Thugge (2001), Hoekman et al. (2001) and Winters et al. (2002).

<sup>2</sup> Support comes from several studies including Coe et al. (1997) and Feenstra et al. (1999).

trade policy is not sufficient to address any country's poverty problem. Trade liberalization should be supported by a stable macroeconomic environment and a competitive real exchange rate. Furthermore, it should be supplemented by a menu of other pro-poor growth policies targeted directly towards the vulnerable segments of society. In this regard, government has an important role to play in fostering (rural) development, encouraging diffusion and absorption of new technologies, expanding access to education, providing basic social services to poor people, and investing in infrastructure.

This paper also aims to trace the dynamic impact of trade liberalization on the Tunisian poor, while accounting for many of the above structural features that the Tunisian poverty profile shares with those of other developing countries. Indeed, trade liberalization was an integral part of the structural adjustment program that has been adopted by Tunisia since 1986. The trade policy reform has been pursued and consolidated by the country's joining the World Trade Organization (WTO) in 1990 and by concluding a free trade agreement with the European Union (EU) in 1995. The agreement called for a gradual removal of all tariff and non tariff barriers on industrial goods and the creation of a non-agricultural free-trade zone over a twelve-year transition period. It has been progressively implemented since 1996 and came into force on 1998. A complete dismantling of these barriers on EU imports will thus be achieved by 2008.

In Tunisia, a large share of the work force is unskilled, given that they were not able to attain proper educational qualifications. In 1999 for example, employment distribution data revealed that 92.2 percent of the labor force was unskilled. Among this number, 20.5 percent were working in rural agriculture while 30.7 percent were in the urban informal sector. Poverty has remained a mainly rural phenomenon and - to a lesser extent - urban informal. Since 1990, about 65 percent of the poor have lived in the rural area and about 10 percent of the poor were working in the urban informal sector.<sup>3</sup>

The extreme complexity of the links between trade reform and poverty motivates the use of a dynamic computable general equilibrium (DCGE) model, accounting for many of the above-mentioned channels of transmission, in order to check whether the Tunisian economy's greater openness to the world market hurts the marginalized of its society.

To address issues related to poverty within the framework of economy-wide models, one can identify in the literature three broad varieties of CGE methodologies. The most common method, pioneered by Adelman and Robinson (1978), consists of stratifying as much as possible the representative household into a small number of homogenous groups according to occupation, location, or income criteria. Using a

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<sup>3</sup> See the World Bank (1995). Note that this poverty profile would not have changed since 1990.

household income and expenditures survey, the authors assume that incomes within each group follow a lognormal distribution and then proceed to the estimation of the mean and variance of each distribution. In this approach, the CGE model provides the counterfactual change in the average income level of each of the groups, while the variance of this income (and thereby the within-group inequality) is assumed fixed and unaltered by the CGE experiments. Hence, changes in overall inequality can only result from a redistribution between groups, whereas analyses of household surveys indicate that changes in intra-group inequality contribute at least as much as changes in inter-group inequality to the overall disparity.

Recent studies attempt to come to grips with the issue of fixed intra-group inequality by complementing CGE models with microsimulation. The latter can be classified into two broad categories: layered and integrated CGE-microsimulations<sup>4</sup>.

The layered CGE-microsimulation or top-down technique is conducted in two separate and sequential steps. In the first step, the CGE model is simulated to generate a full vector of commodity and factor prices, owing to a policy experiment. These are then fed into a microsimulation framework which utilizes the CGE model results on prices to conduct a detailed analysis of income distribution and poverty at the household level.

This approach has two limitations. First, there is no consistency imposed between the data in the micro-simulation and the CGE models. Second, the reactions of households to commodity and factor prices changes are not (fully) transmitted back to the microsimulation model, so that only a fraction of the intra-group inequality is captured.

In contrast to the layered CGE-microsimulations models, the integrated ones enable to directly incorporate into a single CGE model the behavior of as many households as is found in an income and expenditure household survey<sup>5</sup>. Although appealing, this technique needs to reconcile household data with the national data, to secure full consistency between the micro-analysis and the CGE model prediction. This is done at the cost of restructuring households' income or expenditures.

In the present paper, we extend the layered CGE-microsimulation approach, so that a larger fraction of the intra-group inequality could be captured. We apply then this layered approach to study the effect of trade liberalization on the dynamic of poverty in Tunisia. In a first layer, we build a recursive DCGE model, accounting for many of the structural features of the Tunisian economy, which are described in the

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<sup>4</sup> Davies (2004), and Hertel and Reimer (2004) offer a survey of recent studies relying on these new approaches.

<sup>5</sup> This approach has found application in Cogneau (1999), Cogneau and Robillard (2000), Cockburn (2001), Boccanfuso et al. (2003) and Rutherford et al. (2004).

following section. The DCGE provides the resulting price and income changes from any reform over the period 1998 – 2015, which in turn will be used to communicate with the second layer microsimulation model. The paper then discusses and concludes the consequential impact of the projected reforms on the dynamics of poverty.

## **2. DCGE model general features**

The DCGE we use is largely influenced by the (MINI)-IMMPA framework developed by Agénor (2003) and Agénor et al. (2003). The model is calibrated to data from a Tunisian social accounting matrix for 1998, the latest year for which definitive information was available at sectoral level. The Tunisian economy in the reference year is disaggregated into 14 production sectors, one rural agriculture and 13 urban industries and services. Except for the urban government public services, the composite output of each of the remaining 12 urban sectors results at least from one of three types of firms: private, informal, and public. They are assumed to produce imperfect substitutes for local demand.<sup>6</sup> The national accounts data reveal that the three types of firms do not exist in all sectors. Some sectors are only informal like construction, while others are only public like water and electricity. There are also sectors with both private and public, or private and informal firms.

Since our focus in this study is about poverty and income distribution, the household bloc is disaggregated in the reference year into six household groups, identified by their source of income: two rural and four urban.

### **2.1 Production structure**

Production functions in the model are of the nested form and exhibit constant returns to scale over private inputs. Gross output of all categories of firms is produced by combining, in fixed proportions, intermediates goods and primary factors composite. The primary factors composite is either Cobb-Douglas or CES aggregate of the various factors used in production. We distinguish in the model four broad categories of factors: skilled and unskilled labor, land, and specific physical capital.

Land is specific to the production of agriculture. In addition, physical capital is specific to the firms to which it belongs, whereas skilled and unskilled labor are treated as predetermined policy variables in the government public services sector.

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<sup>6</sup> The informal sector can be defined in various ways. In Tunisia, the official institute of statistics (see INS (1998)) consider as informal small sized non-agricultural firms with less than 6 employees.

In addition to private inputs, it is assumed along the lines of Rioja (1999) and Kato (2002) that private and public firms as well as farmers use the economy-wide composite public stock of infrastructure and health, which is provided by the government, as a given external input.<sup>7</sup> This assumption signifies that the total output of the latter firms is distributed entirely to the private inputs, and the consideration of the return to the government from the public capital stock is ignored<sup>8</sup>.

All informal firms, as well as almost all public firms, produce non tradable goods. Two exceptions for the latter categories of firms are represented by the transport and telecommunications services, and mining and petroleum, since public firms are the only ones involved in export activity. The private formal firms are the main exporters in all the tradable sectors. Finally, exporting firms allocate their output to the local and international markets according to the constant elasticity of transformation aggregation.

## **2.2 Labor market segmentation**

The model accounts for various sources of labor market segmentation. Unskilled workers are employed both in rural agriculture and the urban economy. Skilled workers however are employed only in the urban formal economy.

There is no unemployment in the rural region; nominal wage is flexible and adjusts to clear the rural unskilled labor market. The supply of labor in the rural area is predetermined at any point in time, but grows over time at the exogenous rural population growth rate, net of workers' migration to urban areas. Following Harris and Todaro (1970), the incentive to migrate is taken to depend negatively on the ratio of the expected real wage in rural areas to that prevailing in urban areas.

Unskilled workers in the urban economy may be employed either in the informal, private, or public enterprises. However, skilled workers who are unable to find a job in the formal economy opt to remain openly unemployed, instead of entering the informal economy.

In the formal activities, it is assumed along the lines of Kheo et al. (1995), that unions fix the uniform (skilled and unskilled) labor real wage while the firms determine the employment level accordingly. In the skilled labor market, although the bargaining power of the unions depends negatively on the skilled labor unemployment, the resulted real wage is higher than that would have been cleared this labor market. For the unskilled real

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<sup>7</sup> We rely then on Morrison and Schwartz (1996) and Kamps (2004) who give evidence that public capital is productive and pays off in terms of increases in sectoral value-added and private investment.

<sup>8</sup> In this, we depart from the (MINI)-IMMPA framework, which considers public capital as an internal input of production.

wage in the formal sector, it is greater than that paid in the informal sector. This gives an incentive to unskilled workers to seek a job in the private and public firms first.

The total supply of unskilled workers in the formal sector is allowed to adjust over time according to the expected wage differential between the informal and formal sectors. The total supply of unskilled workers in the informal labor market is instead determined residually and it always equals the induced demand for unskilled labor by all informal enterprises. The wage in the informal market is therefore uniform and flexible.

The supply of unskilled labor in the urban sector evolves as a result of (exogenous) natural urban population growth and migration of unskilled labor from the rural economy. Moreover, given the skilled and unskilled wage differential and the public capital stock of education per capita, some urban unskilled workers become skilled and leave the unskilled workforce to increase the supply of skilled labor. Thus, the progress of the skilled labor force supply depends on the rate at which unskilled workers acquire skills.

The distribution of unskilled employment in the reference year reveals that the rural agriculture and the urban informal sector together provide 51.2 percent of unskilled labor employment, whereas each of the public and private sectors offers around 16 percent of unskilled jobs. As a consequence of this unskilled job distribution, 16.8 percent of the unskilled workforce is unemployed in the reference year.

Job provision for skilled workers in 1999 was such that the public sector was the main sector creating jobs for the more-educated workers, as it employed 82 percent of the skilled workforce in the base year.<sup>9</sup> Government administration accounted for 91 percent of total public sector skilled labor employment, whilst public enterprises accounted for the remaining 9 percent. Compared to the public sector, the private sector absorbed only 8.7 percent of the skilled workforce.

Since the agriculture and informal sectors do not rely on skilled work in their production process, the remaining 8.6 percent of skilled workers found themselves without a job.<sup>10</sup> This figure shows that the public sector plays an important role in skilled labor policy for the economy as a whole. More details about the distribution of labor between the different sectors and firms can be found in Table 1.

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<sup>9</sup> Although we use a 1998 SAM, we rely on information from the 1999 population census to allocate all the labor force between sectors and firms.

<sup>10</sup> In reality, the agriculture and the informal sector employ very small shares of the skilled workforce, 0.1 percent in agriculture (see INS (2002b)) and 0.4 percent in the informal sector (see INS (1998)). Since the distribution of wages between skilled and unskilled was not available, we have considered that these two sectors are not relying on skilled work.

**Table 1: Sectoral features of the Tunisian sectors in 1998 (in percentage)**

Sector	Status	VA/GDP	uld/tot_uld	sld/tot_sld	USAL/tot_USAL	SSAL/tot_SSAL
Agriculture	Rural	14.6	24.7	—	3.5	—
Food processing	Public	0.5	0.9	0.3	1.0	0.3
	Private	1.4	1.2	0.3	1.3	0.3
	Informal	1.7	1.6	—	0.9	—
Quarrying products	Public	0.7	0.7	0.3	0.8	0.3
	Private	0.8	0.6	0.3	0.7	0.3
	Informal	0.4	0.5	—	0.3	—
Mechanical	Public	0.5	0.8	0.4	0.9	0.4
	Private	1.9	1.9	0.8	2.1	0.8
	Informal	0.4	0.2	—	0.1	—
Chemicals	Public	1.4	0.7	0.4	0.8	0.4
	Private	1.0	0.7	0.3	0.8	0.3
	Informal	0.1	0.1	—	—	—
Textile, apparel and leather	Public	—	—	—	—	—
	Private	6.6	6.5	1.5	6.9	1.5
	Informal	1.0	1.8	—	1.1	—
Miscellaneous manufacture	Public	0.2	0.2	0.1	0.3	0.1
	Private	1.2	1.0	0.5	1.2	0.5
	Informal	1.3	0.7	—	0.4	—
Mining and petroleum	Public	2.5	1.2	1.2	1.7	1.2
	Private	1.3	0.1	0.1	0.1	0.1
	Informal	—	—	—	—	—
Electricity	Public	1.8	0.6	1.2	1.1	1.2
	Private	—	—	—	—	—
	Informal	—	—	—	—	—
Water	Public	0.5	0.5	0.4	0.7	0.4
	Private	—	—	—	—	—
	Informal	—	—	—	—	—
Construction	Public	—	—	—	—	—
	Private	—	—	—	—	—
	Informal	5.3	16.9	—	9.9	—
Transport and telecom.	Public	6.7	5.8	3.9	7.1	3.9
	Private	1.2	0.9	0.6	1.1	0.6
	Informal	1.0	1.7	—	1.0	—
Other services	Public	—	—	—	—	—
	Private	8.9	6.4	5.0	8.2	5.0
	Informal	18.9	13.4	—	7.9	—
Public services	Public	15.9	7.6	82.3	38.2	82.3
Total		100.0	100.0	100.0	100.0	100.0

**Notes:** VA/GDP represents the contribution of each type of firm in each sector to GDP; uld/tot\_uld is the share of each type of firm in each sector in total unskilled labor demand; sld/tot\_sld is the share of each type of firm in each sector in total skilled labor demand; usal/tot\_usal is the contribution of each type of firm in each sector to total unskilled labor wage bill; ssal/tot\_ssals is the contribution of each type of firm in each sector to the total skilled labor wage bill.

### 2.3 Demand structure

Producers demand composite goods, imported and local, for intermediate use, according to a Leontief input-output technology; that is, the coefficients of intermediate

goods in production are fixed. Furthermore, the model explicitly features the expenditures flows arising from government behavior and the activities of private investors.

It is assumed that both government expenditures and savings, and transfers to households are in fixed proportion of public sector revenue. Government expenditures consist of current unproductive expenditures as well as productive public investment. The model also distinguishes among the investments in infrastructure, education and health. In 1998, public investment in infrastructure accounted for 1.7 percent of current GDP, whereas public investments in health and education represented respectively 0.3 percent and 1 percent of GDP.

Each distinguished type of public investment allows the endogenous accumulation of the corresponding public capital stock. The accumulation process is modeled in a conventional way, where the next period stock of each public capital stock is equal to the amount invested in the current period plus the surviving stock. We further assume geometric depreciation, that is, the capital stock depreciates at a constant rate.

The public stock in education positively affects the skills formation, whereas the public stock of infrastructure has, in one hand, a positive effect on private investment and, on the other hand, combines with the public stock of health to increase the total factor productivity in agriculture, and public and private firms, as previously explained.

Following the World Bank (1996) estimations for Tunisia, an increase in public investment or government spending on education as a share of GDP by 1 percentage point would enhance the per capita GDP growth by 0.2 percent. Furthermore, a rise in the ratio of government consumption net of education spending to GDP by 1 percentage point would reduce the per capita GDP growth by 0.12 percent. Finally, an expansion of the share of exports in GDP by 1 percentage point would contribute to the augmentation of the per capita GDP by 0.06 percent. Adding the population growth rate to these estimates, we can approximate the impact of these changes on total factor productivity. Thus, we have taken the latter estimates of the determinants of productivity explicitly into consideration in addition to the productive contribution of the public stock in infrastructure and health. It is assumed that they simultaneously affect the shift parameter in the production function of agriculture, and public and private firms. It is also assumed that the contribution of the change in the ratios of infrastructure and health expenditures to GDP is equal to that of education spending.

The government revenue derives from the transferred returns on capital of public firms, the collection of direct taxes (set on households' income and firms' return on capital), indirect taxes (on households' consumption), and tariffs.

In the base year, 30 percent of the government fiscal revenue was driven from tariffs on imports and 34.2 percent from consumption taxes, whereas the contribution of households' income and corporate taxation to total fiscal revenue were equal to 21.8 and 14.1 percent, respectively. This fiscal structure allowed the government to reap 25 percent of 1998 GDP.

The investment demand for the different composite goods by sector of origin are also assumed to be in fixed shares of total investment demand, which is equal to total saving. Capital accumulation is assumed to occur only in the urban private firms, according to the same conventional process as the public capital stock accumulation. The decision to invest hinges positively on the after tax rate of return to capital relative to cost of funds, on the public capital stock in infrastructure, and the real GDP growth.

As already mentioned, the model identifies six household types grouped by socio-economic status and labeled by  $h$ ,  $h=1,6$ . The landholders in agriculture and the agricultural workers represent two distinct households living in the rural area. The remaining four urban households are the unskilled households working in the informal enterprises, the unskilled employees working both in the formal private and public sectors, the skilled households working in the formal private and public sectors, and the capitalists. Classifying household groups in this way allows the model to identify the impact of economic reforms on income distribution and poverty. Household income is based on salaries and/or distributed profits, in addition to government and the rest of world (ROW) transfers. Table 2 sets out the characteristics of each group, including shares of population, per capita income, and the incidence of poverty.

**Table 2: Characteristics of household groups**

Household type	Population Share (%)	Incidence of Poverty <sup>a</sup> (%)	Per capita income (TND)
HH_Land: Landholders	13.7	10.6	670
HH_AGR: Agriculture laborer	9.9	19.7	498
HH_INF: Unskilled households in the informal sector	29.3	4.1	747
HH_ULF: Unskilled households in the formal (private and public) sector	33.8	4.8	764
HH_SLF: Skilled households in the formal (private and public) sector	9.9	0	1937
HH_CAP: Capitalists in the private and informal sectors	3.4	0	2957

<sup>a</sup> Percentage of households in the group below the poverty line, based on 1995 household survey and lower poverty line (The World Bank (1999)).

Households' preferences are represented by Cobb-Douglas utility functions defined over saving and the 14 composite goods. Saving and demands are thus a constant fraction of households' disposable income.

Each composite consumption good is then represented as a sum of households groups, government and investors' final consumption demands and all producers' intermediate composite goods demands. It is also assumed to be a CES aggregation of imported and composite domestic goods. The latter are deemed imperfect substitutes by the local demanders. Furthermore, it is assumed that the composite domestic good is a CES aggregation of informal, private and public domestic goods.

The above DCGE model, the formal description of which is given in the annex, is designed in such a way that it captures the relevant structural features of the Tunisian economy. Hence the price and income changes it generates embody both the effective direct and indirect effects of the policy reform. In this way, any change of poverty obtained from the microsimulation model, which we describe in the subsequent section, will be as close as possible to what would be expected.

### **3. An Overview of the Microsimulation Approach**

Directly incorporating into a DCGE model as many households as there are in a household survey would certainly be the ideal approach to address the question of the dynamics of poverty following any economic change. This is indeed the best way to keep all the information about the households' heterogeneity with regard to their pattern of endowment and consumption. Unfortunately, the Tunisian household expenditure survey is notable for its under-reporting of the source and level of each household member's income and its composition. The relevant information it records for our purpose is the households' expenditures for various items, the household's head level of education, and occupation. The latter information is used to roughly decompose the available sample of 2500 households from the 1995 household survey into the closest six groups in the DCGE model.<sup>11</sup> The aim is to proceed to a layered CGE-microsimulation analysis.

As pointed out by Ganuza et al. (2004), in the top-down methodology, microsimulations range from pure accounting approaches to models with behavioral equations based on econometric estimates. The seminal work by Bourguignon et al. (2003) falls in the latter category. The authors estimate the microsimulation model which is based on a set of equations representing a detailed description of the real income generation mechanism at the household level. The estimated model captures the heterogeneity of households in terms of income sources, area of residence, endowment in human capital, and consumption preferences.

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<sup>11</sup> The 1995 household survey is multipurpose and provides reliable information on consumption expenditures on many commodities and extensive socio-demographic information on about 10000 households. However, the survey does not include information on incomes leading to the use of total household expenditure *per capita* for characterizing the dynamics of poverty.

The accounting approach however, consists in simply calculating a welfare indicator (change) at the household level using the transmitted commodity and factor prices (change) from the CGE model. For example, knowing the source of income of each household, Ganuza et al. (2004) calculate the nominal income level resulting from the new set of factor prices, and then infer the poverty level. In doing this, they place strong emphasis on the earning-side effects as a channel for transmission to poverty, over consumption side effects of any reform. Chen and Ravallion (2004) as well as Hertel et al. (2004) however, focus both on the contribution of the labor and commodity markets to the poverty change and calculate a linear first-order approximation to the welfare change in a neighborhood of the household's optimum. In these two studies, there is no need to specify a utility function, yet the methodology is only robust for small (or marginal) changes in prices.

Whilst enabling non marginal changes of prices, the alternative approach we suggest in this paper nevertheless requires explicitly specifying a utility function.<sup>12</sup> Our approach works as follows. In the first step, the DCGE model provides an estimation of the consumption goods prices,  $p_t$ , resulting from the economic change. For each household group, it also yields the growth rate in its average nominal income,  $g_{th}$ .<sup>13</sup> Secondly, we then apply these results to assess the real income of each household in the sample. Since households within the same group  $h$  do not have the same budgetary share for each good, the real income resulting from a policy change varies from one household to another even within the same group.

More precisely, we assume that each household  $m$  within a group  $h$  has an original income per capita  $Y_{0h,m}$  and faces the price system  $p_0$  in the baseline year. From one year to the other, each household in the sample faces a new vector of prices and income  $(p_t, Y_{th,m})$ . Since we aim to characterize the dynamic of households' and social welfare over time under different scenarios, we consider the baseline price vector  $(p_0)$  as the reference price system.<sup>14</sup> Then, we define as King (1983) the concept of equivalent income: for a given budget constraint  $(p_t, Y_t)$ , the equivalent income is

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<sup>12</sup> This is not a major limit whenever the goods consumed by households are, to a large extent, additively separable, so that utility functions like the Cobb Douglas or Stone Geary characterizes well the households' preferences.

<sup>13</sup> The assumption of a common nominal income shift for all households within the same representative group represents a limitation of this approach. It can be easily relaxed if we have more information about the different sources of income for each household.

<sup>14</sup> Following King (1983), the choice of the reference price system is to some extent arbitrary, although for the analysis based on computable general equilibrium models, the baseline price vector,  $p_0$ , is a natural choice. The reason for this is that any comparison must use a common reference price system.

defined as that income level which allows, at  $p_0$ , the same utility level as can be reached under the given budget constraint. Formally, we have:

$$v(\mathbf{p}_0, Y_e(\mathbf{p}_0, \mathbf{p}_t, Y_t)) = v(\mathbf{p}_t, Y_t) \quad (1)$$

where  $v(\cdot)$  is the indirect utility function,  $\mathbf{p}_t$  is a vector of price system at  $t$ , and  $Y_t$  is the per capita household's nominal income. Notice that since  $\mathbf{p}_0$  is fixed across all households,  $Y_e(\cdot)$  is an exact monetary metric of actual utility  $v(\mathbf{p}_t, Y_t)$  because  $Y_e(\cdot)$  is an increasing monotonic transformation of  $v(\cdot)$ . Thus, inverting the indirect utility function, we obtain the *equivalent income*,  $Y_e(\mathbf{p}_0, \mathbf{p}_t, Y_t)$ .

We take the predicted price and income changes from the DCGE model as given in the micro-simulation model. Since we assume that the nominal income growth rate is invariant within each household group (but variant within groups) and equal to  $g_t^h$ , we have in the sample:

$$Y_t^{h,m} = (1 + g_t^h) Y_0^{h,m} \quad (2)$$

By (2), and assuming a Cobb-Douglas utility function, we can compute the indirect utility function,  $v(\cdot)$ , for each household in the sample using this formula:

$$v(\mathbf{p}_t, Y_t^{h,m}) = \frac{1}{(1 + g_t^h) Y_0^{h,m}} \prod_{i=1}^I (p_{i,t})^{w_i^{h,m}} \quad (3)$$

where  $p_{i,t}$  is the price of good  $i$  at the period  $t$  and  $w_i^{h,m}$  is the budget share devoted to the good  $i$  by the household  $m$  within the group  $h$ . Using (1) and (3), the equivalent income function of each household in the sample at each period  $t$  is then given by:

$$Y_e(\mathbf{p}_0, \mathbf{p}_t, Y_t^{h,m}) = \prod_{i=1}^I \left( \frac{p_{i,0}}{p_{i,t}} \right)^{w_i^{h,m}} (1 + g_t^h) Y_0^{h,m} \quad (4)$$

Further to obtaining information about the distribution of equivalent income among households, it is worthy to assess the social impact of the change. A natural measure could be given by the variation of a pre-specified poverty yardstick. An important class of poverty measures is the FGT class of additively decomposable indices suggested by Foster et al. (1984), which can be written in terms of equivalent income as:<sup>15</sup>

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<sup>15</sup> Writing poverty measures in terms of equivalent income make them sensitive to both income and price variations.

$$\begin{aligned}
P_{\alpha}^t(z_0, y_e^t) &= \frac{1}{N} \sum_{m=1}^M n^{h,m} \left( 1 - \frac{Y_e(\mathbf{p}_0, \mathbf{p}_t, (1+g_t^h)Y_0^{h,m})}{z_0} \right)_+^{\alpha} \\
&= \frac{1}{N} \sum_{m=1}^M n^{h,m} \left( 1 - y_e(\mathbf{p}_0, \mathbf{p}_t, (1+g_t^h)y_0^{h,m}) \right)_+^{\alpha}
\end{aligned} \tag{5}$$

where  $N$  is the population size,  $M$  is the number of households,  $n^{h,m}$  is the household size,  $z_0$  is the poverty line at the baseline year and which is fixed in real terms over time,<sup>16</sup> and  $\alpha$  may be considered as a measure of poverty aversion: a larger  $\alpha$  gives greater emphasis to the poorest of the poor. The incidence of poverty or the headcount ratio (the proportion of the population living with less than the poverty line) is obtained for  $\alpha = 0$ . When  $\alpha = 1$ , the resulting index yields the average poverty gap (or the deficit of poverty); and when  $\alpha > 1$  poverty measures additionally take account of distribution among the poor. When  $\alpha$  becomes very large,  $P_{\alpha}(\cdot)$  approaches a Rawlsian measure, which considers only the poorest individuals' welfare.

#### 4. Simulation results

We consider four alternative scenarios. The first one, labeled ref, illustrates the Tunisian economy path of growth between 1998 and 2015, in the absence of any technical progress or trade reform. The dynamics of the economy involve rural and urban labor force growth and both private and public capital accumulation.<sup>17</sup>

This first simulation provides a benchmark against which the contribution of trade reform and public spending structuring to poverty alleviation in the remaining alternative scenarios is judged. In this regard, we simulate in the second and third scenarios, labeled respectively opn and tpf, an annual 10 percent decrease of all tariffs on non agricultural imports during the first decade, compensated by an annual 9 percent increase of all consumption taxes until 2008, the year of the complete achievement of the agreement with the EU.<sup>18</sup> From the latter date, consumption taxes become fixed to the level they have reached. This trade reform is not sustained by total factor productivity change in opn, in order to isolate the contribution of openness to poverty alleviation, while there is an additional technical progress in tpf.

<sup>16</sup> Note that  $Y_e(\mathbf{p}_0, \mathbf{p}_t, z_t) = Y_e(\mathbf{p}_0, \mathbf{p}_0, z_0) = z_0$ .  $z_0$  appears as the equivalent poverty line, i.e. the minimum expenditure level required at  $\mathbf{p}_0$  to reach the indifference curve corresponding to the minimum standard of living. Fixing the poverty line in real terms over time underlines an absolute approach to poverty analysis. The relative poverty, which is beyond the scope of this paper, is based on the setting of a real poverty line which rises with the average income.

<sup>17</sup> For the active labor natural population growth, we have used the trend projected by the Tunisian statistics agency for the period of interest (see INS (1996b)), in addition assuming that it is the same for rural and urban unskilled labor. As to the skilled labor growth, it is endogenously determined by the model, starting with a rate of 2.5 percent between 1997 and 1998 (the World Bank (2004a)).

<sup>18</sup> The growth rate in all consumption taxes until 2008 is calibrated so as to maintain approximately constant the government fiscal revenue as a share of GDP.

In all previous scenarios, subsidies on agricultural goods and food processing have been unchanged. In the fourth scenario, we thus progressively and uniformly eliminate the subsidies on these goods over the transition period 1998 – 2015.<sup>19</sup> Each year, the saved amount of subsidies is allocated to increase both investments in education, health and infrastructure according to the share of each one in total public investment. This simulation is labeled edu and it aims to check whether investment in infrastructure and human capital is a better tool to combat poverty than food subsidies.

Figure 1 displays the incidence of poverty trend in the reference scenario (referred to as  $P_{\alpha\_ref}$ ), the trade reform scenario (referred to as  $P_{\alpha\_opn}$ ), the trade reform with total productivity progress scenario (referred to as  $P_{\alpha\_tpf}$ ), and in the final scenario when the savings from food subsidies removal is used to enhance investment in education, health and infrastructure (referred to as  $P_{\alpha\_edu}$ ). The left-hand side of this figure displays the headcount ratio trend under these different scenarios. Interestingly enough, trade liberalisation and food subsidy removal appear to be not pro-poor in the short run but really pro-poor in the long run. Indeed, the left-hand side of Figure 1 shows that until 2005 (and even until 2008, the year of when tariffs shall have been completely dismantled), the simulated reforms and mainly the one which involves subsidies removal, would slow down the decline of poverty. Yet, from 2008 onwards, the substitution of public investment to food subsidies would contribute most to the achievement of the Millennium Development Goal of halving poverty, as measured by the headcount ratio, by 2015. Indeed, while more than 5 percent of the population is in extreme poverty in 1998, by 2015 less than 2 percent of the population would remain in extreme poverty under the last scenario.

The headcount ratio could fail to accurately capture the impact of any change in the country's poverty situation, since it only records those who escape or reach the segment of the poor. Thus, it could under-estimate the effectiveness of the other reforms, since most poor people could find their welfare improved but not enough to lift them out of poverty. To curb this likely drawback, the right-hand side of Figure 1 displays the estimates of the poverty deficit,  $P_1(\cdot)$ , during the period under consideration resulting from the different changes. These curves show similar decreasing trend as the poverty incidence, meaning that the average income of those staying below the poverty line has increased. Further, from 2008 to 2015, the poverty deficit curve resulting from the elimination of subsidies will lie always below the others.

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<sup>19</sup> This reform route departs from that of Bibi and Duclos (2006a) who have checked the likely effects on poverty of the restructuring of the subsidy system in Tunisia, not its elimination.

The above analysis could depend critically on the choice of the poverty line and poverty measures. Since both of these choices are somewhat arbitrary, so could the dynamics of poverty characterised using these be arbitrary as well. Drawing on the recent study of Ravallion and Chen (2003), it is possible to curb such degrees of arbitrariness by computing first the growth rate in the mean of each income quantile:

$$g(q) = \frac{y_e^t(q)}{y_e^{t-1}(q)} - 1 \quad (6)$$

where  $g(q)$  is the growth rate in the King's (1983) equivalent income of the  $q$ th quantile between  $t$  and  $t-1$  and  $y_e^t(q)$  is the mean of  $y_e(p_0, p_t, y_t)$  within the quantile  $q$  at the pertinent period.<sup>20</sup> Considering the full range of possible  $q$ ,  $g(q)$  traces the growth incidence curve (henceforth *GIC* curve), showing how the growth rate is distributed across different quantiles, ranked by equivalent income.

Figure 2 splits the period of transition in two: one going from 1998 to 2000 and the other from 2000 to 2015. For each period, we give the average income rate of growth of the 25 percent least-endowed individuals and the remaining segments of the society, under the different reforms.

Figure 2 shows that all the *GIC* curves lie nowhere below 0, meaning that poverty will certainly fall within the period under consideration, regardless of the chosen poverty line and the poverty measure. In the stochastic dominance literature, this finding is known as "first-order dominance" (*FOD*).<sup>21</sup> As lower order dominance entails higher orders, there is no need to test higher order dominance to study less robustly the dynamics of poverty.<sup>22</sup>

The right-hand side of Figure 2 shows that from 2000 to 2015, the trade reform improves the equivalent income of all the individuals. However, the total productivity progress (referred to as  $g_{2015\_tpf}$ ) considered in addition to openness reform (referred to as  $g_{2015\_opn}$ ) adds roughly nothing to the gains achieved through better allocation of scarce resources, since the two *GIC* curves are very close.

Figure 2 also shows that in the first period, the income growth pattern of the poorest is the lowest under food subsidies removal reform (referred to as  $g_{2000\_edu}$ ), while it becomes the highest within the same scenario in the second period, once the

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<sup>20</sup> Alternatively,  $y_e(q)$  could be expressed as  $y_e(\mathbf{p}_0, \mathbf{p}_t, y_t(q))$ .

<sup>21</sup> See, among many others, Atkinson (1987) for a detailed description on stochastic dominance tests.

<sup>22</sup> On the higher dominance tests about the link between economic growth and poverty, see for instance Son (2004) and Bibi (2005).

indirect effect of investment in infrastructure and human capital begins to bear fruit for the poor.

Testing solely *FOD* conditions does not yet inform us about the distributional pattern of economic growth. For instance, the *GIC* curves displayed in the left-hand side of Figure 2 are approximately horizontal. This means that the Lorenz curve does not really shift at the beginning period under consideration, and the economic growth is, to some extent, distribution-neutral. Nevertheless, the right-hand side of Figure 2 shows that  $g(q)$  exhibits an upward sloping across different income quantiles. Thus, while curbing absolute poverty, this growth pattern will worsen all inequality measures, and then worsen relative poverty, since the richest quantiles profit more from economic growth than the poorest ones. This means that these pro-poor policies are compatible with a fair amount of “vertical and horizontal” inequality.<sup>23</sup>

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<sup>23</sup> For a discussion of this, see for instance Bibi and Duclos (2006b).

Figure 1: Poverty trend over 1998 – 2015

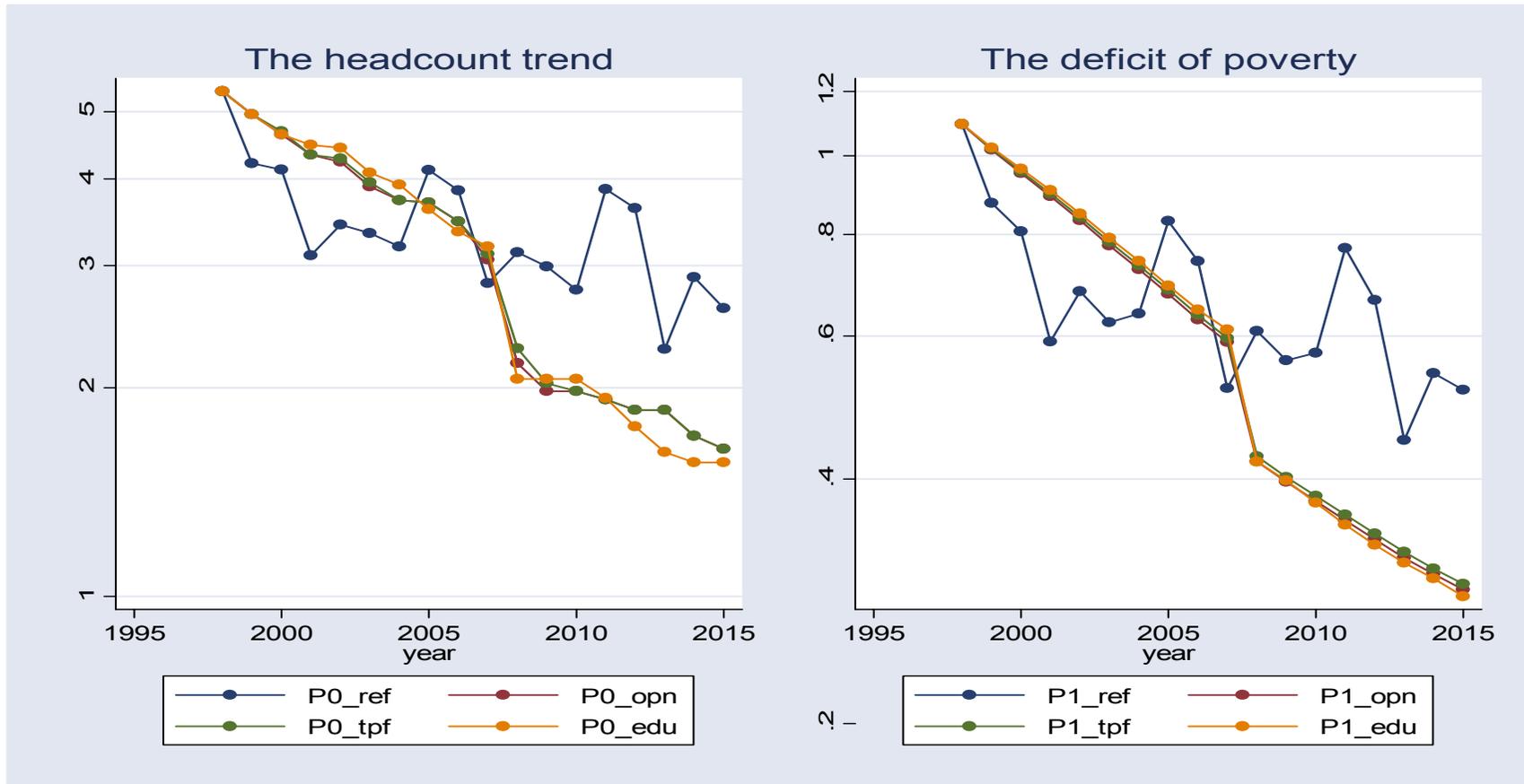
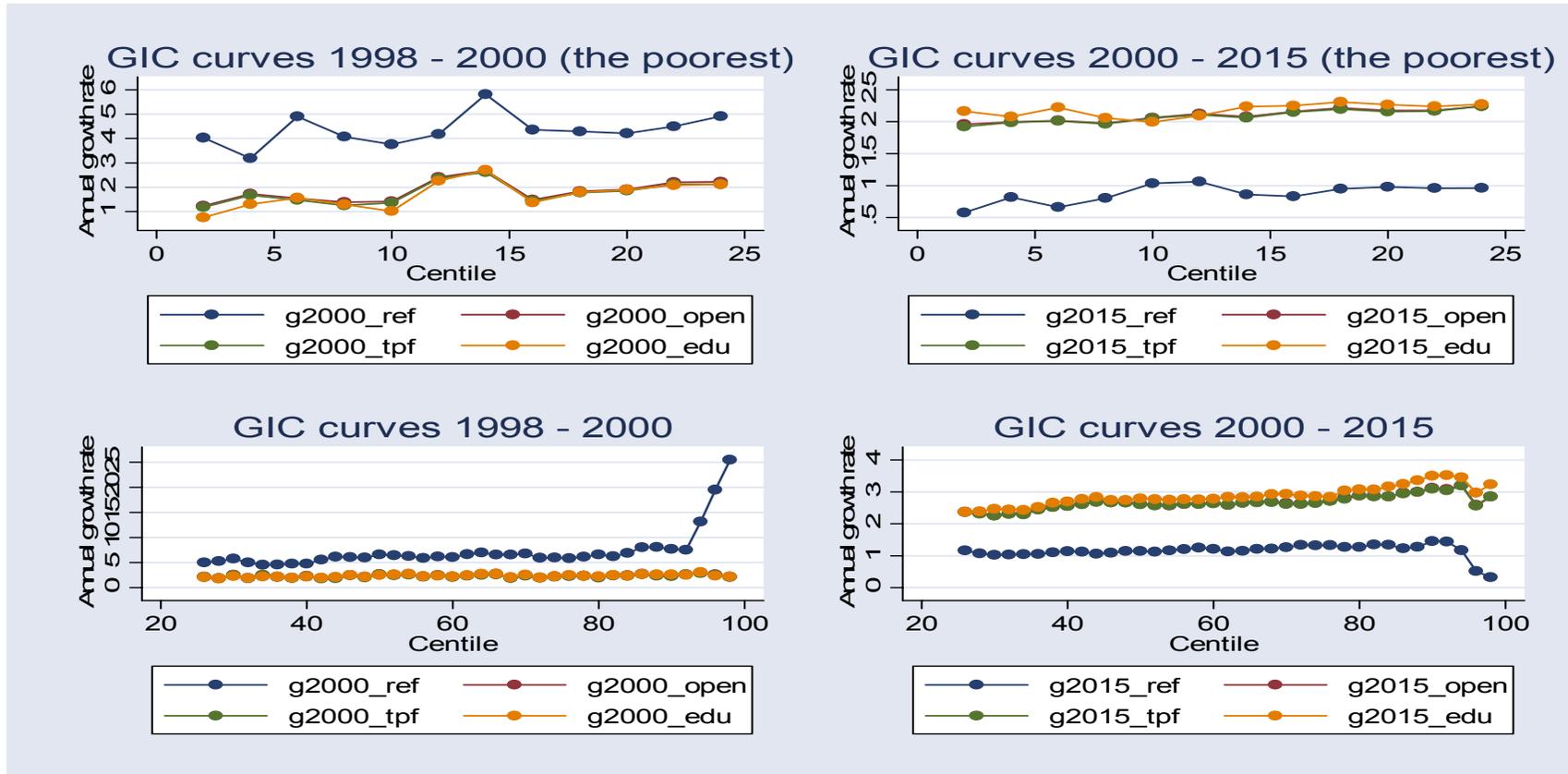


Figure 2: GIC Curves under different scenarios



## 5. Conclusion

In this paper, a DCGE model is used to assess the impact of trade liberalization with EU on poverty in Tunisia. To achieve this goal, it was common in the literature to classify foremost households according to some socio-economic grouping. Then, a distribution function (usually a log-normal distribution) for each household group is constructed in order to describe the variation of income distribution and poverty following a policy change. The main drawback of such an approach is that the intra-group variances are specified exogenously. Therefore, this type of model will not capture the within-group variation of inequality (following a policy change) which represents generally a large share of the overall change of inequality. This would provide a biased estimation of poverty change, essentially when the poverty indices used are sensitive to the distribution of well-being within the poor. The alternative route is to include all households from a survey directly into the CGE model. However, the lack of relevant information on the (sources of) income in the Tunisian household survey impedes us to proceed to an integrated microsimulation. We instead limit ourselves to layered microsimulation, which captures a (good) fraction of the within-group variation of inequality, in addition to the between-group variation of inequality.

In this regard, we infer the price change and the variation rate of each household income group provided by the DCGE simulation change into the households of the survey, previously classified by groups, to assess the equivalent income of each one. Since households do not have the same budgetary share for each good, the equivalent gain (or loss) varies from a household to another even within the same group. This enables a better characterization of poverty change within each group and has several policy implications in terms of the choice of groups that should benefit from an anti-poverty program, and the cost of such program.

The empirical illustration of this methodology computes the likely effects of trade liberalization and more public investment on infrastructure and human capital financed by food subsidy removal. The main results are outstanding, showing that such changes could slow down the poverty reduction in the short run, but enhance it in the long run.

The present study is mainly illustrative. The analysis of the effects of trade liberalization on income distribution and poverty requires more detailed information. For instance, earnings and occupational choice of households' head should be modeled as a function of their specific characteristics. Thus, whenever there is a

change in the aggregate demand for wage labor, which workers move from the formal to the informal sector (and reciprocally) depends on their specific characteristics. Such a shift can be at the root of a significant change in income distribution and poverty. However, capturing these effects requires that our methodology should be supplemented by an econometric model which characterizes the households' labor market responses to external shocks. Although such characterization is needed to improve the predictive power of any layered microsimulation framework, it is precluded by data availability for the present study. Yet, the outcome of this analysis highlights the potential return from a more refined research that could provide guidelines for policymakers on the optimal level of any change as well as its expected effects.

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## Appendix

### Model Equations

$i, j = A(\text{agriculture}), 2-14$ ;  $k = R(\text{rural}), I(\text{informal}), P(\text{private}), G(\text{public})$ ;  $f = I, P, G$ ;  $gk = INF(\text{infrastructure}), EDU(\text{education}), HEL(\text{health})$ ;  $H = H1-H6$

Intermediate goods demand  $i\alpha_{ijk}X_{jk} = CI_{ijk}$  (A1)

Total intermediate goods cost  $TIC_{ik} = \sum_j i\alpha_{jik} PQ_j X_{ik}$  (A2)

Total costs  $TC_{ik} = PFC_{ik} + TIC_{ik}$  (A3)

Price cost margin  $PX_{ik} X_{ik} = TC_{ik}$  (A4)

Unskilled labor demand in agriculture  $ULD_{AR} = \frac{X_{AR}}{AT_{AR}} \left( \frac{\alpha_{X_{AR}} PL}{(1 - \alpha_{X_{AR}}) WR} \right)^{1 - \alpha_{X_{AR}}}$  (A5)

Land demand in agriculture  $LAND_{AR} = \frac{X_{AR}}{AT_{AR}} \left( \frac{(1 - \alpha_{X_{AR}}) WR}{\alpha_{X_{AR}} PL} \right)^{\alpha_{X_{AR}}}$  (A6)

Primary factors cost in agriculture  $PFC_{AR} = WR ULD_{AR} + PL LAND_{AR}$  (A7)

Land market equilibrium condition  $\overline{LAND}^S = \sum_A \sum_R LAND_{AR}$  (A8)

Rural labor market equilibrium condition  $RUR\_ULS = \sum_A \sum_R ULD_{AR}$  (A9)

Unskilled labor demand by informal urban firms  $ULD_{il} = \frac{X_{il}}{AT_{il}} \left( \frac{\alpha_{X_{il}} R_{il}}{(1 - \alpha_{X_{il}}) WI} \right)^{1 - \alpha_{X_{il}}}$  (A10)

Specific capital demand by informal urban firms  $\overline{KD}_{il} = \frac{X_{il}}{AT_{il}} \left( \frac{(1 - \alpha_{X_{il}}) WI}{\alpha_{X_{il}} R_{il}} \right)^{\alpha_{X_{il}}}$  (A11)

Primary factors cost of informal urban firms  $PFC_{il} = WI ULD_{il} + R_{il} \overline{KD}_{il}$  (A12)

Unskilled labor demand by SOEs  $ULD_{iG} = \frac{X_{iG}}{AT_{iG}} \frac{\left( \frac{\alpha_{X_{iG}} R_{iG}}{(1 - \alpha_{X_{iG}} - \beta_{X_{iG}}) WM} \right)^{1 - \alpha_{X_{iG}}}}{\left( \frac{\beta_{X_{iG}} R_{iG}}{(1 - \alpha_{X_{iG}} - \beta_{X_{iG}}) WS} \right)^{\beta_{X_{iG}}}}$  (A13)

Skilled labor demand by SOEs  $SLD_{iG} = \frac{X_{iG}}{AT_{iG}} \frac{\left( \frac{\beta_{X_{iG}} R_{iG}}{(1 - \alpha_{X_{iG}} - \beta_{X_{iG}}) WS} \right)^{1 - \beta_{X_{iG}}}}{\left( \frac{\alpha_{X_{iG}} R_{iG}}{(1 - \alpha_{X_{iG}} - \beta_{X_{iG}}) WM} \right)^{\alpha_{X_{iG}}}}$  (A14)

Specific capital demand by SOEs  $\overline{KD}_{iG} = \frac{X_{iG}}{AT_{iG}} \frac{\left( \frac{\alpha_{X_{iG}} R_{iG}}{(1 - \alpha_{X_{iG}} - \beta_{X_{iG}}) WM} \right)^{-\alpha_{X_{iG}}}}{\left( \frac{\beta_{X_{iG}} R_{iG}}{(1 - \alpha_{X_{iG}} - \beta_{X_{iG}}) WS} \right)^{\beta_{X_{iG}}}}$  (A15)

Primary factors cost of SOEs  $PFC_{iG} = WM ULD_{iG} + WS SLD_{iG} + R_{iG} \overline{KD}_{iG}$  (A16)

Primary factors cost of Central Government  $PFC_{GOV} = WM \overline{ULD}_{GOV} + WS \overline{SLD}_{GOV}$  (A17)

Unskilled labor demand by formal private firms  $ULD_{iP} = \left( \frac{X_{iP}}{AT_{iP}} \right)^{1 - \Omega_{X_{iP}}} \left( \frac{\alpha_{iP} PFC_{iP}}{WM} \right)^{\Omega_{X_{iP}}}$  (A18)

Capital and skilled labor composite demand by formal private firms	$SK_{iP} = \left( \frac{X_{iP}}{AT_{iP}} \right)^{1-\Omega_{X_{iP}}} \left( \frac{(1-\alpha_{iP})PFC_{iP}}{PSK_{iP}} \right)^{\Omega_{X_{iP}}}$	(A19)
Primary factors cost of formal private firms	$PFC_{iP} = WM ULD_{iP} + PSK_{iP} SK_{iP}$	(A20)
Skilled labor demand by formal private firms	$SLD_{iP} = SK_{iP} \left( \frac{AK_{iP}(1-\gamma_{iP})PSK_{iP}}{WS} \right)^{\Psi_{X_{iP}}}$	(A21)
Specific capital demand by formal private firms	$KD_{iP} = SK_{iP} \left( \frac{AK_{iP}\gamma_{iP}PSK_{iP}}{R_{iP}} \right)^{\Psi_{X_{iP}}}$	(A22)
Capital and skilled labor composite price	$PSK_{iP} SK_{iP} = WS SLD_{iP} + R_{iP} KD_{iP}$	(A23)
Informal labor market equilibrium condition	$ILS = \sum_i ULD_{iI}$	(A24)
Urban unskilled labor unemployment	$U\_Unemp = \frac{FSUF - \sum_i (ULD_{iP} + ULD_{iG})}{FSUF}$	(A25)
Urban total labor population	$URB\_ULS = ILS + FSUF$	(A26)
Union unskilled labor wage determination	$\frac{WM}{CPI_{H4}} = A_{UNEMP} \left( \frac{1-U\_Unemp}{1-U\_Unemp_0} \right)^{\frac{1}{\sigma_{U\_Unemp}}}$	(A27)
Skilled labor unemployment	$S\_Unemp = \frac{URB\_SLS - \sum_i (SLD_{iG} + SLD_{iP})}{URB\_SLS}$	(A28)
Union skilled labor wage determination	$\frac{WS}{CPI_{H5}} = A_{S\_UNEMP} \left( \frac{1-S\_Unemp}{1-S\_Unemp_0} \right)^{\frac{1}{\sigma_{S\_Unemp}}}$	(A29)
Imports demand	$XM_i = Q_i \left( \frac{AM_i \alpha_{M_i} PQ_i}{PM_i} \right)^{\Phi_{M_i}}$	(A30)
Composite local good demand	$XD_i = Q_i \left( \frac{AM_i (1-\alpha_{M_i}) PQ_i}{PD_i} \right)^{\Phi_{M_i}}$	(A31)
Armington composite good price	$PQ_i Q_i = PD_i XD_i + PM_i XM_i$	(A32)
Import price	$PM_i = ER(1+tm_i)(1+tc_i - sc_i) \overline{WPM}_i$	(A33)
Local demand of informal, private and SOEs goods	$XDF_{if} = \frac{XD_i}{AD_i} \left( \frac{\alpha_{D_{if}} AD_i PD_i}{PDFD_{if}} \right)^{\Phi_{D_i}}$	(A34)
Local composite good unit price	$PD_i XD_i = \sum_f XDF_{if} PDFD_{if}$	(A35)
Export supply	$XE_{ik} = \frac{X_{ik}}{AE_{ik}} \left( \frac{PE_{ik}}{AE_{ik} \alpha_{E_{ik}} PX_{ik}} \right)^{\Phi_{E_{ik}}}$	(A36)
Local supply by local firm type	$XDF_{ik} = \frac{X_{ik}}{AE_{ik}} \left( \frac{PDF_{ik}}{AE_{ik} (1-\alpha_{E_{ik}}) PX_{ik}} \right)^{\Phi_{E_{ik}}}$	(A37)
Gross production unit price	$PX_{ik} X_{ik} = PDF_{ik} XDF_{ik} + PE_{ik} XE_{ik}$	(A38)
Export price	$PE_{ik} = \overline{WPE}_{ik} ER$	(A39)
	$PDFD_{ik} = (1+tc_i - sc_i) PDF_{ik}$	(A40)
Operating surplus in rural activities	$PROF_R = \sum_A PL LAND_{AR}$	(A41)
Operating surplus of urban firms	$PROF_f = \sum_i R_{iF} KD_{if}$	(A42)
Non-distributed profit	$NPROF_k = PROF_k (1-ctx_k) - ER v_k BOP$	(A43)
Firms saving	$SAVF_k = sf_k NPROF_k$	(A44)

Households' non labor income	$NLYH_h = \sum_k \rho_{hk} (1 - sf_k) NPROF_k + \varepsilon_h GTH + \chi_h ER \overline{ROWTH}$	(A45)
Landholders group income	$YH_{h1} = NLYH_{h1}$	(A46)
Agricultural workers group income	$YH_{h2} = NLYH_{h2} + WR ULD_{AR}$	(A47)
Urban informal household group income	$YH_{h3} = NLYH_{h3} + WI \sum_i ULD_{iI}$	(A48)
Formal unskilled workers group income	$YH_{h4} = NLYH_{h4} + WM \sum_i (ULD_{iP} + ULD_{iG})$	(A49)
Formal skilled workers group income	$YH_{h5} = NLYH_{h5} + WS \sum_i (SLD_{iP} + SLD_{iG})$	(A50)
Urban capitalists group	$YH_{h6} = NLYH_{h6}$	(A51)
Household group disposable income	$YD_h = (1 - rtx_h) YH_h$	(A52)
Household group saving	$SAVH_h = sh_h YD_h$	(A53)
Total consumption expenditures	$HTC_h = (1 - sh_h) YD_h$	(A54)
Final consumption demand	$XAC_{ih} = con_{ih} \frac{HTC_h}{PQ_i}$	(A55)
Fiscal revenue	$TXREV = \sum_i tm_i ER \overline{WPM}_i XM_i + \sum_i \sum_k tx_{ik} PX_{ik} X_{ik} + \sum_h rtx_h YH_h + \sum_k ctx_k PROF_k - \sum_i (sc_i + sc_i tm_i) \overline{WPM}_i XM_i - \sum_i \sum_{sr} sc_i PDF_{i,sr} XDF_{i,sr}$	(A56)
Government revenue	$YG = TXREV + \sum_i R_{iG} \overline{KD}_{iG}$	(A57)
Government transfers to households	$GTH = \varphi YG$	(A58)
Government total expenditures	$CTG = \eta YG$	(A59)
Public investment	$IPub_{gk} = IPubshr_{gk} CTG$	(A60)
Government current expenditures	$GC = \left(1 - \sum_{gk} IPubshr_{gk}\right) CTG$	(A61)
Government saving	$SAVG = (1 - \varphi - \eta) YG - \nu ER BOP$	(A62)
Government consumption	$XAG_i = agov_i \frac{CTG}{PQ_i}$	(A63)
Investment demand by sector of origin	$XAI_i = ainvi_i \frac{PK ZI}{PQ_i}$	(A64)
Domestic absorption	$Q_i = \sum_h XAC_{ih} + \sum_k \sum_j CI_{ijk} + XAG_i + XAI_i$	(A65)
Equality of total saving and investment	$PK ZI = \sum_H SAVH_H + \sum_k SAVF_k + SAVG + ER BOP$	(A66)
Investment profitability	$RK_{iP} = \frac{R_{iP}}{PK}$	(A67)
Investment demand	$\frac{IND_{iPT}}{KD_{iP(T-1)}} = AI_{UPT} \left[ \frac{KPub_{INFT}}{KPub_{INF(T-1)}} \right]^{\sigma_{KI}} \left[ \frac{GDP_T}{GDP_{(T-1)}} \right]^{\sigma_{GDP}} \left[ (1 + RK_{iPT})(1 - rtx_{H6}) \right]$	(A68)
Total investment	$ZI = \sum_i IND_{iP}$	(A69)
Capital accumulation	$KD_{iPT} = (1 - \delta_{iP}) KD_{iP(T-1)} + IND_{iP(T-1)}$	(A70)
Value-added	$VA_{i,k} = ax_{i,k} X_{i,k}$	(A71)
Value-added price	$PVA_{i,k} VA_{i,k} = PX_{i,k} X_{i,k} - \sum_j PQ_j CI_{j,i,k}$	(A72)

Real GDP	$GDP = \sum_i \sum_k PVA0_{i,k} VA_{i,k}$	(A73)
Real GDP growth	$GDP_T = (1 + g_{GDP}) GDP_{(T-1)}$	(A74)
Rural population growth	$RUR\_ULS_T = (1 + \bar{g}_{RUR}) RUR\_ULS_{(T-1)} - MIG_T$	(A75)
Migration	$MIG_T = A_{MIG} RUR\_ULS_{(T-1)} \left( \frac{WUE}{WRE} \right)^{\sigma_{MIG}}$	(A76)
Expected urban wage	$WUE = \frac{\theta WM_{(T-1)} + (1 - \theta) WI_{(T-1)}}{CPI_{H4(T-1)}}$	(A77)
Expected rural wage	$WRE = \frac{WR_{(T-1)}}{CPI_{H2(T-1)}}$	(A78)
Weight in the expected urban wage	$\theta = \frac{\sum_i ULD_{iP(T-1)}}{URB\_ULS_{(T-1)} - \sum_i ULD_{iG(T-1)}}$	(A79)
Consumer price index	$CPI_H = \sum_i acon_{iH} PQ_i$	(A80)
Urban unskilled labor growth	$URB\_ULS_T = (1 + \bar{g}_U) URB\_ULS_{(T-1)} + MIG_T - SKL_T$	(A81)
Formal labor population growth	$\frac{FSUF_T}{FSUF_{(T-1)}} = B_{FSUF} \frac{\sum_i ULD_{iP(T-1)}}{FSUF_{(T-1)} - \sum_i ULD_{iG(T-1)}} \left( \frac{WM_{(T-1)}}{WI_{(T-1)}} \right)^{\sigma_{FSUF}}$	(A82)
Skilled labor population growth	$URB\_SLS_T = URB\_SLS_{(T-1)} + SKL_T$	(A83)
Skill Formation	$SKL_T = \lambda_{SKL} URB\_SLS_{(T-1)} \left( \frac{WSE}{WUE} \right)^{\sigma_W} \left( \frac{KPub_{EDU(T-1)}}{URB\_SLS_{(T-1)}} \right)^{\sigma_{KE}} + (1 - \lambda_{SKL}) SKL_{(T-1)}$	(A84)
Expected skilled labor wage	$WSE = \frac{WS_{(T-1)}}{CPI_{H5(T-1)}}$	(A85)
Public capital accumulation	$KPub_{GKT} = (1 - \delta_{GK}) KPub_{GK(T-1)} + IPub_{GK(T-1)}$	(A86)
Composite of Public capital stocks	$KGT = \left[ \varpi KPub_{INF}^\rho + (1 - \varpi) KPub_{HEL}^\rho \right]^{\frac{1}{\rho}}$	(A87)
Public capital externality	$AT_{ik} = AT_{ik0} KGT^\zeta$	(A88)
Balance of payment deficit	$walras = \sum_i \overline{WPM}_i XM_i - (1 - \nu - \nu_k) BOP - \overline{ROWTH} - \sum_i \sum_k \overline{WPE}_{ik} XE_{ik}$	(A89)
Numéraire	$\overline{PINDEX} = PQ_A$	(A90)

**List of endogenous variables**

$CI_{ijk}$	Intermediate consumption of good $i$ by firm $k$ in sector $j$
$X_{ik}, PX_{ik}$	Quantity and price of composite output
$TIC_{ik}, PFC_{ik}, TC_{ik}$	Total intermediate goods, primary factors and total costs
$ULD_{ik}, SLD_{ik}$	Unskilled and skilled labor demands
$VA_{ik}, PVA_{ik}$	Value added quantity and price
$WR, WI, WM, WS$	Rural, informal, formal unskilled and skilled wages
$WRE, WUE, WSE$	Expected rural, urban unskilled and skilled wages
$RUR\_ULS, URB\_ULS,$	Rural, urban unskilled and urban skilled labor supply
$URB\_SLS$	
$FSUF, ILS$	Formal and informal unskilled labor supply
$U\_Unemp, S\_Unemp$	Unskilled and skilled labor unemployment
$MIG, SKL$	Migration and skill formation
$\theta$	Weight in the migration function
$KPub_{gk}, IPub_{gk}$	Public capital stock and investment in infrastructure, education or health
$SK_{iP}, PSK_{iP}$	Composite of skilled and capital level and price
$KD_{ik}, R_{ik}$	Capital demand and price; demand is fixed for informal and public firms
$Land_{AR}, PL$	Land demand and price
$XM_i, PM_i$	Import level and price
$XD_i, PD_i$	Composite local good demand and price
$XDF_{ik}, PDF_{ik}, PDFD_{ik}$	Local supply by firm type and supply and demand price of firm's local good
$XE_{ik}, PE_{ik}$	Export level and price by sector and firm
$Q_i, PQ_i$	Armington composite good level and price
$GDP, g_{GDP}$	Real GDP level and growth
$KGT$	Composite public capital stock
$AT_{ik}$	Total factor productivity growth
$PROF_k, NPROF_k$	Firms' operating surplus and non-distributed operating surplus
$YH_H, YD_H$	Household groups' income and disposable income
$SAVF_k, SAVH_H, SAVG$	Firms', households' and government saving
$XAI_i, XAC_{iH}, XAG_i$	Composite demand of good $I$ for investment and households and government consumption
$RK_{iP}, IND_{iP}$	Investment profitability and investment demand
$ZI, PK$	Total investment and total investment deflator
$YG, TXREV$	Government revenue and fiscal receipts net of subsidies
$CTG, GC, GTH$	Government total and current expenditures and transfers to household groups
$NLYH_H, HTC_H$	household groups' non labor income and total consumption expenditures
$CPI_H$	Household groups' consumption price index
<i>Walras</i>	Walras law

**List of exogenous variables**

$LAND^S$	Land supply
$WPM_i, WPE_i$	World price of import and export
$tm_i, tc_i, sc_i$	Tariff rates and consumption taxes and subsidies
$BOP$	Balance of payment deficit
$PINDEX$	Price index chosen as numéraire
$io_{ijk}$	Input-output coefficient