LICOS Centre for Institutions and Economic Performance
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LICOS Discussion Paper Series

Discussion Paper 263/2010

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Food Standards and Welfare:
A General Equilibrium Model with Market Imperfections

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Version: 11 June, 2010

Abstract

We analyze the effects of high standards food chains on household welfare taking into account general equilibrium effects and market imperfections. To measure structural production changes and welfare effects on rural and urban households, our model has two types of agents, five kinds of products and four types of factors. We calibrate the model using dataset from China. The simulation results show that how poor rural households are affected depends on a variety of factors, including the nature of the shocks leading to the expansion of high standards sector, production technologies, trade effects, spillover effects on low standards markets, market imperfections, and labor market effects.

Acknowledgements:

The authors thank Pavel Ciaian and participants in conferences and seminars in Beijing (IAAE and CCAP), Budapest (IAMA), Leuven (LICOS and RSA), Brussels (BAAE) for their comments and suggestions. This research was financially support by the KU Leuven Research Fund (Excellence Finance Programme) and the KULeuven-China Scholarship Council (CSC) Scholarships for Excellence Program.

1. Introduction

A series of recent studies have identified the spread of 'high standards' as having a fundamental impact on the process of development (Farina and Reardon, 2000; Fulponi, 2007; Henson et al., 2000; McCluskey, 2007; Swinnen, 2007). The growing demand of wealthy consumers for high quality, safety, health, and ethical standards put pressure on governments to increase public regulatory standards and on private processing and retailing companies to introduce or tighten private corporate standards (Swinnen and Vandemoortele, 2008). Generally, growing demand for high standards is a natural consequence of income growth. In recent years it has been reinforced by several additional events. For example, international campaigns against child labor and genetically modified food, NGO activities for the environment and several food safety crises, such as the food dioxin crisis and the appearance of BSE in Europe, have all contributed to a rising demand for high quality, safe and traceable products in the production chains of many nations.[1]

Although high standards emerged initially in rich countries, they now affect poorer countries through several channels. First, standards in richer countries are also imposed on imports and consequently have an impact on producers and traders in exporting nations (Jaffee and Henson, 2004; Unnevehr, 2000). Second, global supply chains are playing an increasingly important role in world food markets and the growth of these vertically coordinated marketing channels is facilitated by increasing standards (Swinnen, 2007). For example, modern retailing companies increasingly dominate international and local markets in fruits and meats, including those in poorer countries, and have begun to set standards for

[1] This paper focuses on the development implications of changes in the demand for product standards. There are several related areas of the literature on standards, including a.) analyzes of asymmetric information problems which may be reasons for companies or public regulators to introduce standards (Fulton and Giannakas, 2004; Gardner, 2003); b.) studies on the role of standards in reducing consumption externalities (Copeland and Taylor, 1995; Besley and Ghatak, 2007); c.) the role of standards in providing non-tariff trade protection (Anderson et al. 2004; Fischer and Serra 2000), and (d) the political economy of standards (Swinnen and Vandemoortele, 2008).

food quality and safety in this sector wherever they are doing business (Dolan and Humphrey, 2000; Henson et al., 2000). Third, rising investment in processing and retailing in developing countries is translated into higher standards, as buyers are making new demands on local producers in order to serve the high-end income consumers or to minimize transaction costs in supply chains (Reardon et al., 2003).

Early studies argued that the penetration of international marketing chains was much more widespread than people originally thought (e.g., Gulati et al., 2007; World Bank, 2005) and predicted that the implications of these developments would be vast: a new development paradigm was emerging (Reardon and Timmer, 2005).

Importantly, the early literature also posited that the rise of standards could have sharp negative influences on equity and poverty. Several of the studies argued that modern supply chains in developing countries systematically exclude the poor and negatively affect the incomes of small farmers; unlike other waves of rising economic activity, the poor would suffer from this process (Farina and Reardon, 2000). For example, studies in Latin America and Africa argued that small farmers were being left behind in the supermarket-driven horticultural marketing and trade (Dolan and Humphrey; 2001; Humphrey et al., 2004; Key and Runsten, 1999; Reardon et al., 2003; Weatherspoon et al., 2001). In a study on Kenya, Minot and Ngigi (2004) demonstrated that modern marketing chains put intense pressure on smallholders (although smallholders were still participating). Even more extreme, in the case of Côte d’Ivoire, almost all of the fruit and vegetables being produced for exports were being cultivated on large industrial estates owned by wealthy capitalists. Likewise, Weatherspoon and Reardon (2003) reported that the rise of supermarkets in Southern Africa failed to help small producers who were almost completely excluded from dynamic urban markets due to quality and safety standards.

In contrast, recent research suggests a more nuanced picture of the effect of the international marketing chains on poverty and development. For example, Dries and Swinnen (2004) and Dries, et al. (2009) find that high standards lead to increased vertical coordination in supply chains which improves access to credit, technology and quality inputs for poor farmers in Eastern Europe. Minten et al. (2007) and Maertens and Swinnen (2009) also find increased vertical coordination in newly emerging supply chains between buyers and farms in African countries, such as Madagascar and Senegal. According to their results, poor rural households experienced measurable gains from supplying high standards horticulture commodities to global retail chains. In China, researchers find that while rising urban incomes and the emergence of a relatively wealthy middle class are associated with an enormous rise in the demand for fruits and vegetables and sharp shifts in the downstream segment of the food chain towards 'modern retailing', almost all of the increased supply is being produced by small, relatively poor farmers that sell to small, relatively poor traders. (Wang et al., 2007; Huang et al., 2008)

An important shortcoming of this literature – in addition to empirical problems – is the absence of a consistent and comprehensive conceptual framework for interpreting the empirical findings. Related to this, very few of the empirical studies actually measure welfare or poverty effects. The vast majority of these studies analyze which farmers are supplying to the high standards market and/or the impacts on productivity or investments of supplying farms. The only studies that actually examine poverty effect are Maertens and Swinnen (2009) and Maertens et al. (2008). They find strong poverty reducing effects of high standards exports in Senegal. In addition, they show that much of the welfare benefits for the poor come through the labor market, which is ignored by most other studies.

Moreover, no studies analyze other general equilibrium effects such as demand and supply spillover effects on other markets, such as staple foods, which may have very important impacts in developing countries. Measuring these effects econometrically is very difficult because annually collected datasets usually do not contain the necessary data on high standards market and datasets from surveys targeted to measure impacts of the growth of high standards typically do not have sufficient information (either spacially or dynamically) to measure spillover effects on other markets. Hence for all these reasons a CGE approach can make a very important contribution to this literature.

The objective of this paper is therefore to model the process through which high standards production and consumption affects development while explicitly taking into account general equilibrium effects and market imperfections. The model has both a low standard and high standard supply chain and we explicitly integrate key characteristics of many developing and emerging economies, such as capital constrains and labor market imperfections. We use the model to analyze how and through which channels welfare of rural and urban households is affected.

Because of many general equilibrium interactions the model is too complex to solve analytically. Therefore we use simulations to show the effects. For this, we calibrate the model with data from China. The development of high standards food sector in China is particularly relevant for three reasons. First, even though China has sustained high growth rates for nearly thirty years and the continuously increasing income per capita leads to structural change of Chinese diet (Gale and Huang, 2007), the food distribution system remained laggard until very recently. However, recent years are characterized by the fast rising supermarkets and some food safety scandals (Hu et al., 2004; Wang et al., 2007). Yet the transition from a system occupied mainly by low standards food produced by millions of small farms (Rozelle and Swinnen, 2004) to one mainly by high standards food is only now starting and will undoubtedly have huge impact on both producers and consumers. Second, despite high growth rates, an increasing inequality between wealthy and poor households becomes a more and more acute issue (Ravallion, 2001). After the initially fast decrease of poverty rate, in the last decade China faces more difficulties in reducing the rural poverty (Chen and Ravallion, 2007; Riskin, 2004). 90% of poverty is still rural in China (World Bank, 2009). The welfare and poverty effects associated with the expansion of high standards food sector are therefore potentially very important. Third, both the agricultural commodity and factor markets are under transition. Whereas the commodity market is becoming more and more efficient (Huang and Rozelle, 2006), factor markets imperfections remain important. Therefore, China provides a very interesting case for research on the interaction between the food system transition and the acute equity and poverty problem under conditions of market imperfections.

2. Theoretical Framework

As discussed in the introduction, the findings of the previous literature suggest that the expansion of the high standards food affects the GDP growth and income distribution through various channels. Although, by focusing on a particular channel provides detailed insights of that particular channel, the partial equilibrium approach, which dominates the previous literature on food standards, has important drawbacks for interpreting the results and for drawing policy conclusions. In particular, it is essential to measure and integrate the impact on other commodity markets and on factor markets in order to fully capture the welfare effects.

In order to address the limitations associated with the partial equilibrium framework, the present paper adopts a general equilibrium setting for studying the impacts of the expansion of the high standards food on household welfare. Our model follows the tradition of applied general equilibrium models pioneered by Shoven and Whalley (1984), although its precise specification is more closely allied to the CGE models described in de Janvry and Sadoulet (2002), and Stifel and Thorbecke (2003).

2.1. A canonical model

The structure of this type of models is as follows. The economy consists of N households indexed by c, M commodities indexed by i and J factors indexed by j. Let P be a vector of prices. The commodity demands can be derived from the first order conditions of household utility-maximization:

$$\max U^c \text{ s.t. } \sum p_i X^c = \sum p_j V^c \qquad (1)$$

where U^c is household utility, X^c and V^c denote commodity demand and factor endowment for the *c*th household; p_i and p_j are the corresponding commodity and factor prices.

Households' demand for consumption goods is a function of their disposable income and the vector of consumer prices. Household incomes are determined by their ownership of production factors and returns to the production factors.

As usual, consumer preferences and production technologies are specified in nested constant elasticity of substitution (*CES*). The intermediate sectors are specified to produce goods with a *CES* function of rural labor, land and capital. Final food production combines intermediate inputs and the bundle of primary factors (other than intermediate inputs), aggregated through a *CES* function with a sub-nest of a Cobb-Douglas (*CD*) function for the two types of labor. The gross output of the other commodities sector is a *CES* function with a sub-nest of a *CD* function for labor.

Profit maximization yields factor demands:

$$V_j^i = V_j^i(p_j, Q^i) \qquad (2)$$

where V_j^i and Q^i are factor demand and output of industry *i* respectively.

The total demand and supply of factors, goods and intermediate products must be equal in equilibrium. The general equilibrium solution can be described by a set of prices p^* and activity levels X^* such that demands equal supplies and no production activity makes positive profits:

$$Q^i = \sum X_i^c \quad (3)$$

$$\Pi^i(Q^i, p_i, p_j) = 0 \quad (4)$$

The aggregate consumer price index (CPI) and the aggregate producer price index (PPI) are defined as a sum of composite prices (PQ_m) weighted by the value shares of final goods (ν_m) and the sum of producer prices (PI_m) weighted by the value shares of output (μ_m), respectively.

$$CPI = \sum_m \nu_m * PQ_m \quad (5a)$$

$$PPI = \sum_m \mu_m * PI_m \quad (5b)$$

The market for foreign exchange equilibrates via adjustments of the net export, with fixed foreign exchange rates. Pressures to adjust export or import quantities (and hence, demand and supply of foreign currency) are therefore equilibrated by adjustments in the trade surplus.[2] The economy is connected to the rest of the world through trade. The substitutability between the imported and the domestic goods is determined on the consumption side through a CES aggregation function (Armington 1969), and on the production side through a constant elasticity of transformation (CET) function. The relative prices of foreign goods are determined by world market prices and the exchange rate.

In order to model savings and investment, we make the following three widely used assumptions: (1) savings are determined by exogenous constant rates for households; (2)

[2] This is compatible with Chinese situation even though this assumption has no important impact on results. In fact, if savings do not enter households' utility function, then fixing either the exchange rate or the trade balance is the same right approach for welfare analysis, since it prevents an arbitrary shift away from savings towards current consumption from being confused with a welfare improvement.

private investment is savings driven; and (3) investment spending is allocated to commodities in fixed proportions.[3] For simplicity and data paucity, we further assume that only the final commodities are used as investment goods. Total savings equal total investments.

Following de Janvry and Sadoulet (2002), the nominal exchange rate is used as a numeraire. This ensures that only relative prices matter.[4] Households' welfare (W^c) is measured by real income, which is nominal income (Y^c) normalized by a households-specific price index (P^c):

$$W^c = \frac{Y^c}{P^c} \tag{6}$$

To measure inequality, we calculate a Gini coefficient using the trapezium rule[5]:

$$G = 1 - \sum_{c=1}^{4} (N^c - N^{c-1}) * (Y^c - Y^{c-1}), c \in C \tag{7}$$

where N^c and Y^c are the cumulated proportions of population and income respectively.

2.2. Integrating Standards and Market Imperfections

In order to incorporate the key features of food standards and their linkages to the rest of the economy, we extend the canonical CGE model along several dimensions. First, given that differentiated goods are important for studying the impact of standard expansion, we follow Banerjia and Jain (2007) and extend the canonical CGE model by introducing two types of vertically differentiated goods in the food sector:[6] low standards food and high standards food. Second, to allow for differential effects among rural households, we explicitly model

[3] Following Dewatripont and Michel (1987), this neoclassical closure is the most common one in comparative static CGE models and widely used in the literature (e.g., de Janvry and Sadoulet, 2002).
[4] As stated by de Janvry and Sadoulet (2002), the choice of numeraire has no impact on real income effects, but has impact on decomposition of real income effects, which should be born in mind to explain the simulation results.
[5] For this we make use of the trapezium rule which is an approximate technique for calculating the definite integral of Gini coefficient. In our case, the trapezium rule is applicable since the income distribution of representative households are not continuous. (Cruz-Uribe and Neugebauer, 2002)
[6] The same extensions can be straightforwardly implemented also to other sectors. However, for the sake of simplicity, these extensions are not presented here.

the heterogeneity of farms. Third, in order to study the impact of rural credit market imperfections, which are very important in many developing countries, we follow Harris (1984) and introduce credit constraint for rural households. Finally, in order to trace rural-urban effects of the high standards food expansion, an inter-regional CGE approach of Kilkenny (1993), Ando and Takanori (1997), and Kancs (2001) is adopted with labor market imperfections. Figure 1 and Table 1 summarize the model structure.

Accounting for the dual farm structure characteristic to many developing countries, there are two types of rural producers in the model: households (C) (which will be further separated in sub-groups) and corporate farms (CF).[7] On the consumer side, in order to study the distributional consequences of standards, we distinguish between urban and rural households, and rural households are further disaggregated into several income groups. There are four types of factor inputs: rural labor (LR), urban labor (LU), capital (K) and land (A), with rural households (*CR*) owning three types of them: rural labor, land and capital, while urban households (*CU*) owning urban labor and capital. Net wages of workers in rural region are assumed to be lower than wages of workers in urban region, even though rural workers migrate to urban areas. The wage differences can be explained by different skills of different labor types and by migration costs (Stifel and Thorbecke, 2003).

The detailed modeling of different types of rural producers and consumers allows us to decompose the aggregate income effects of the high standards food expansion, which are crucial for policy recommendations. This disaggregation allows us to isolate the effects on urban and rural households, and rural households are further disaggregated into two groups by their income level: the "poorest" and the "other" rural households. We define 'the poorest' and 'the other' rural households according to the stratification of the national statistics

[7] To avoid confusion between notations for households and high standards, we use capital '*C*' and '*H*' to indicate households and high standards respectively. Later, to differentiate with activity set, noted as '*I*', we use '*O'* as the notation for the industrial sector. We use '*LF*'/'*HF*' and '*L*'/'*H*' for low/high standards final food and low/high standards intermediate products respectively.

bureau.[8]

Five commodities are produced in the economy, three of which are final goods: low standards food (LF) and high standards food (HF) and other commodities (O).[9] There are two types of agricultural intermediate products: low standards (L) and high standards (H), which are exclusively used by their respective food processing sectors to produce the respective final food.

We assume that high standards food is a luxury good compared to low standards food products. Accordingly, household consumption is modeled by the following system:[10]

$$X_{HF}{}^{c} = \frac{a_{HF}^{c}(1-mps^{c})Y^{c}}{PQ_{LF}} - a_{LF}^{c}\zeta^{c}, c \in C \tag{8a}$$

$$X_{LF}{}^{c} = \frac{a_{LF}^{c}(1-mps^{c})Y^{c}}{PQ_{LF}} + \frac{PQ_{HF}}{PQ_{LF}} a_{LF}^{c}\zeta^{c}, c \in C \tag{8b}$$

$$X_{O}{}^{c} = \frac{(1-a_{LF}^{c}-a_{HF}^{c})}{PQ_{O}}(1-mps^{c})Y^{c}, c \in C \tag{8c}$$

subject to the households budget constraint:

$$\sum_{m} P_m X_m^c = (1-mps^c)Y^c, c \in C$$

where a_m^c is the commodity share parameter in the households consumption function, mps^c the saving rate for households and ζ^c a parameter determining the degree of preference for low standards food. A smaller ζ^c means a larger preference for high standards food.

Factor use in the production of these commodities will be affected by specific investment

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8 The households' quintile with lowest income in the national statistical data is regarded as the "poorest" rural households. The other four quintiles with higher income are grouped together to represent the other rural households. Hence, the share of the poorest rural households in the whole population is 11.4%. In the base year the poorest rural households had an average income per capita of 2090.02 Yuan while the other rural households 5677.81 Yuan.

9 The underlying model is not limited to the selected four sectors, it can be straightforwardly expanded to *n* sectors. However, given that they would add little insights to our question, while unnecessary complicating the analysis, the rest of the economic activities are aggregated into one sector 'other commodities'.

10 This is a modified Linear Expenditure System derived from Stone-Geary utility function (Stone, 1954). 'This demand system has the advantage of specifying non-discretionary and discretionary expenditure.' (Savard, 2005)

requirements and market imperfections. In order to produce high standards intermediate product, farms face fixed investment cost to satisfy the standards requirement (Farina and Reardon, 2000; Maertens and Swinnen, 2009). Following Harris (1984) and without loss of generality, we assume that these fixed investment costs are a mixture of rural labor (φ) and capital (ψ). In the simulations later, we analyze the effects of alternative assumptions on fixed costs.

Rural households are often credit constrained (see e.g., Barham et al., 1996; Swinnen and Gow, 1999). We assume that, because of rural credit market imperfections, rural households and corporate farms face credit constraints in their production for the high standards intermediate product market. To model this we assume that the supply of capital to farms for high standards production (K_H^c) is constrained as follows:[11]

$$K_H^c = \kappa^c r^{\varepsilon^c}, c \in CR \cup CF \tag{9}$$

where κ^c is the collateral, r the price of capital, and ε^c the capital supply elasticity.

In order to decompose the aggregate labor market effect into rural and urban impacts, we model the labor market as two separate sub-markets (rural and urban labor) with different skill composition. Migration between rural and urban regions is subject to iceberg migration costs, τ, with $0 < \tau < 1$. Thus, $wr_U = wr_R / \tau$, where wr_U and wr_R are wages for rural workers working in urban and rural regions respectively.

All sectors have zero profit as in the canonical CGE model except the high standards intermediate sector, where rural households and corporate farms may earn positive profits if credit constraints limit their production capacity to satisfy the market. This reflects the investment costs of high standards production, which may be prohibitive for poor rural households (Hallward-Driemeier et al., 2003).

[11] We only cite the most critical equations in our model while keep the set of all equations in Table 1.

More specifically, rural households and corporate farms' profits ($\prod^c$) in high standards intermediate sector are given by the value-added net of factors payments:

$$\prod^c = PX_H f_H(LR_H^c, A_H^c, K_H^c) - wr_R(LR_H^c + \varphi^c) - tA_H^c - r(K_H^c + \psi^c), c \in CR \bigcup CF \qquad (10)$$

Profits of corporate farms are transferred to employed factors proportionally to their value shares in production.[12] Rural households' net income (Y^c) is therefore the sum of its profit in high standards farming, factor incomes and profits from corporate farms, while the urban households' income is only composed of factor incomes and profits:

$$Y^c = \begin{cases} wr_R LR^c + tA^c + rK^c + \prod^c + \gamma^c \prod^{CF}, & c \in CR \\ wuLU^c + rK^c + \gamma^c \prod^{CF}, & c \in CU \end{cases} \qquad (11)$$

where γ^c is the endogenous share parameter of transferred profit from corporate farms.

3. Empirical Implementation

Two types of parameterization techniques are adopted in the present study. All key parameters are estimated econometrically or taken from the literature. The remaining parameters are calibrated within the model.

Empirically, one of the most crucial issues is to identify the "high standards" commodities in the baseline, because there are no reliable data for China. For example, Hu, et al (2004) estimated that roughly 30% of food was sold through supermarkets. Large wholesale and retail companies, as defined by the Chinese Economic Yearbook (CEYC, 2006), have sold 8.7% of total food. However, according to Wang et al. (2009), nearly all of these products came through semi-traditional supply channels and production systems. For this reason, in the present study we follow expert judgments and assume that high standards production is still minimal and not particularly linked with specific commodities. We make

[12] The actual distribution of profits among factors depends on the bargaining power of factor owners. In fact, because the profit is not a big amount comparing with the overall factor incomes, our assumption will have no significant impact on the empirical results except in simulation 3C, where profit of corporate farms increase sharply.

the working assumption that 5% of all commodities are "high standards". This assumption is used consistently across production systems, investment activities, etc. for the baseline model. Using a rather small share (5%) assumption implies that the size of the effects will be small. However, this is not a problem since in this exercise we are primarily interested in the direction and the relative size of different sub-effects. Furthermore, in simulations and sensitivity analyzes, we analyze how variation in investment costs, production technologies, elasticities etc. in the high standards sector affect the growth scenario effects.

Second, all key elasticities are drawn from the literature,[13] and they are subject to extensive sensitivity analysis (Appendix B). Table 3 summarizes the elasticities assumed in our analyzes. The income elasticities of low standards products are 0.9, 0.4 and 0.1 for the poorest and the other rural households, and urban households respectively. Such a structure is compatible with the literature and the stylized facts that poor households consume a relatively larger share of staple (low standards) food compared to wealthy households (Lipton, 2001). On the import side, a relatively low aggregation elasticity between imports and domestically produced goods is assumed (0.5) for the other commodities sector. For the food sectors, including both low and high standards food, we assume a rather high elasticity of substitution (3.0). In addition, on the export side, the level of elasticities of transformation depends on the homogeneity of the aggregated sectors (Shoven and Whalley, 1992). Given the large sectoral aggregation in our study, we assume intermediate values (1.2) for both low and high standards food sectors, and a lower value (0.8) for the other commodities sector.

Finally, all *CES* production functions in the top nests have a medium value of substitutability among these factors equal to 0.7, 0.15 and 0.9 for intermediate, processing and the other commodities sectors, respectively. The choice of relatively small elasticities of substitution between intermediate input and other factors is standard in the CGE literature

[13] For a review of literature on elasticities, see Ciaian et al., 2002.

and caters to the reality (e.g., Wang and Schuh, 2002). The elasticity of substitution among primary factors in the CES sub-nest of the processing sectors is equal to 0.8. The price elasticities of variable capital supply for the high standards intermediate activities of rural households and corporate farms are set at rather moderate levels (0.7, 1.3 and 1.9 for the poorest and the other rural households, and corporate farms respectively).

The remaining parameters are calibrated to the China data for 2005 (see appendix A for details). As usual in CGE models, the data base is organized in the form of a Social Accounting Matrix (SAM), which is shown in Table 2. The CGE model is operationalized using the General Algebraic Modeling System (GAMS) software (Brooke et al., 1988).[14] The model is calibrated so as to reproduce the macroeconomic benchmark data from national accounts.

4. Simulations

4.1 General Approach

A consistent modeling of the high standards food expansion implies that the size of the high standards food sector cannot be changed exogenously, because in the underlying CGE model the supply and demand of all commodities, including the high standards intermediary and final products are determined endogenously. Therefore we have to "induce" the expansion of the high standards food sector differently. First, we simulate an increase in the world price of high standards products (which is exogenous) – a scenario which we refer to as "export-led growth" of high standards food. An important factor is the elasticity of transformation of the high standards food, i.e., the elasticity of substitution between domestic and exported product. Therefore, we simulate an export-led expansion both when the

[14] The source code is available from the authors upon request.

elasticity of transformation is "normal" (i.e., as in other models) and when it is high (scenarios 1A and 1B). Second, we simulate an increase in (domestic) consumer preferences for high standards food. This scenario we refer to as "domestic demand growth". As will become clear from the simulations, growth in consumer demand induces import growth of high standards food with open trade. Again trade responsiveness plays an important role. Therefore we analyze the domestic demand growth scenario with elastic imports (scenario 2A) and inelastic imports (scenario 2B).

A crucial issue in the simulations is the assumption on the technology used by the high standards sector in China. As explained above, there are no precise data on the emerging high standards sector, because it is just emerging in China, and there is no consensus whether high standards farming is relatively labor- or capital-intensive compared to other activities (Bijman, 2008; Miyata, et al., 2007; Weinberger and Lumpkin, 2007). Therefore we construct a baseline SAM and perform simulations by assuming the same production technology, i.e. factor intensities, in high standards and low standards farming.[15] Later, we simulate how different production technologies in high standards farming affects the results.[16] The actual production structures for each scenario (sets of assumptions) can be found in Table 2.

Finally, we study the effect of market imperfections. In particular we simulate how the results change when credit market constraints are binding.

In addition to these simulations, we assess the robustness of our results by performing sensitivity analysis of the key assumptions on income elasticities of low standards products, the elasticities of transformation and substitution in the Armington equations and the substitution elasticities in production. The results, which are presented in Appendix B, show that our key conclusions are robust to variations in the key parameters.

[15] In the initial simulations with the same factor intensities for low and high standards, we use the weighted average of the factor shares for all agricultural commodities in China.
[16] When constructing the SAM under assumption that high standards farming is relatively labor (capital) intensive, we change labor and capital use in the other commodities sector, so that the SAM keeps its balance.

4.2 Scenario 1: Export-led growth in high standards

China has continuously increased its exports of agricultural products and the ratio of agricultural trade to agricultural GDP has risen steadily (Huang et al., 2000). According to Gulati et al. (2007), an outward-looking trade policy can induce the growth of high quality products. The main reason for the rise of high standard products in trade is that exporters are forced to meet international standards and safety regulations. These standards are typically considerably higher than in developing countries, such as China.

To study the potential impact of this export-led emergence of high standard farming, we exogenously increase the world market price for high standard products, pwe_{HF}, by 25%. The simulation results for the effect of rising international prices of high standard commodities are reported in the first column of Table 4. As a consequence of the increase in the world market price of HS products, the domestic consumption of HS declines (-59%) strongly and that of LS products increases (+0.62%). There is a decline in imports (-77%) and growth of exports (+31%) of HS products. There is a rise in the domestic price of HS products (+9.31%) and a corresponding increase in production of both HS products (+9.31%) and LS products (+0.48%) because growth in the international demand for HS products and growth in the domestic demand for LS products leads to increased production of both. Labor use increases substantially on all farms (around 15%) and returns to all rural production factors increase: between 0.44% (capital) and 1.52% (land). As a consequence, rural household incomes increase by 0.14% (for both poor and other households). Urban households lose (-0.15%) as their increased wages from increased employment in HS food processing are more than offset by increased consumer prices. Notice that the income effects are small. The main reason is that the HS sector is small and changes there have relatively limited effects on aggregate. Therefore, what is most important here – if one assume that the sector will grow in the future and thus that the size of the effects will become larger – is the relative size of the effects.

However, another reason is relatively limited "pass-through" of world market effects on the domestic market. A comparison with simulation 1B shows that these effects are strongly depending on the elasticity of transformation between domestic and exported products. With a higher elasticity, the increase in prices is much larger: the price of domestic HS food is higher (+21%) instead of +7% as in the increase in the (farmgate) price of HS intermediate goods (+30% instead of +10%). The output response is stronger both for HS food (+26% instead of +9%) and HS farm products (more than 20% compared to less than 10% on all farms). Labor use on farms increase much more (by more than 40%) and the income effects for rural households are more than double: +0.31% compared to +0.14%.

4.3 Scenario 2: Domestic demand growth in high standards

Simulation 2A models the effect of a growth in domestic preferences for HS food. These effects are quite different. Now the substitution between LS and HS food lead to an increase in HS food consumption (+178%) but a decline in LS food consumption (-2%). However these changes have important implications because most of this increased consumption comes from increased imports of HS food (+274%). Domestic production of HS food (+24%) and HS intermediate products (+21% to +23%) increase less, while LS production falls. Because of the importance of LS production, this leads to a decline for all rural factor returns: labor (-1.22%), land (-3.63%) and capital (-1.14%). All rural households lose because of this, but the poorest lose less because they own less land and because they consume more LS food. Since LS food prices go down, they benefit as consumers. Notice that the household income numbers in table 4 reflect real income effects and that we use household-specific CPIs to measure these. For example, while the factor price of rural labor declines by 1.22% in simulation 2A, the factor income from labor for the poorest household increases by 0.01% because their CPI decrease by more than the labor price, as LS food prices (which make up a large share of their expenditures) decline by 1.61%. This is less the case for richer households which spend more on HS food whose price increases by more than 10%.

Again these results are strongly influenced by the trade effects. In simulations 2B we consider the same exogenous change in preferences but with less elastic imports. In this case domestic producers benefit more from the increased demand for HS food by domestic consumers. In fact, the increased profits from the production of intermediate products for HS food more than offset losses from declining prices for LS products. Now rural households benefit: their incomes increase slightly: by 0.05% to 0.08%. However in this case urban households benefit less from imported HS food. The increase in domestic HS food prices is higher (+15% compared to +10%) and the reduction of LS food price lower (-0.32% compared to -1.60%). Their net income effects are zero (compared to +0.31%).

4.4 Aggregate effects

Before turning to sensitivity analyses, let us consider the aggregate effects. In the export-led scenario both real GDP (by -0.05% to -0.07%) and inequality decline (Gini declines by -0.28% to -0.57%). Hence, the growth in rural incomes with increase international HS prices is more than offset by urban consumers losses in terms of total growth, but it does lead to a reduction in inequality. The aggregated effects of the domestic growth scenario depend on the trade effects. With elastic trade responses, the growth in urban household incomes more than offset declines of rural incomes. Hence there is aggregate growth (+0.16%) but inequality increases (Gini +0.51%). With inelastic imports, there is still growth but now the Gini coefficient goes up (+0.02%) indicating reduced inequality. At first sight, this is surprising since (poorest) rural household incomes increase and (richer) urban income do not change. The reason is that the Gini coefficient is calculated in nominal terms or, equivalently, using the same CPI for all households. We have therefore also calculated a "real Gini" coefficient which uses household specific CPIs, to capture different consumer effect. As Table 4 shows, the real Gini is negative (-0.04%), showing a reduction in inequality, which reflects the real income changes more correctly.

4.5 Sensitivity analyses

Figures 2-5 summarize a series of sensitivity analyses (and figures A1 – A4 in appendix show the results of further robustness tests). Figures 2 and 3 show the effect of differences in technology use in HS farming. Figure 2 shows under the export-led scenario how rural households will benefit more (less) if the technology used in HS farming is more (less) labor intensive (see also table A1 in Appendix for more details). This effect is strongest for the poorest as is reflected in the different curves for poorer and other rural households. Similarly, Figure 3 shows (under the domestic growth scenario) how the rural households (and especially the poorest) will lose less with more labor intensive HS farming.

Figure 4 illustrates the impact of credit constraints. A lower (higher) capital supply elasticity represents more (less) credit constraints. The figure shows that income effects for rural households are lower with stronger credit constraints. Capital market imperfections thus limit the potential benefits of HS expansion for farmers. Figure 5 illustrates the effects of investment requirements for HS farmers. The simulations show that in particular poor farmers are negatively affected by higher investment costs.

In summary, these sensitivity analysese are consistent with intuition: poor farms whose main assets are labor are most likely to gain if the high standards products can be produced with labor intensive technologies and less likely if the cost of capital is higher – e.g.

because of capital market constraints in particular when investment costs are higher.

5. Conclusion and Discussion

In this paper we analyze how the expansion of high standards food production affect the structural production changes, the incomes of different types of rural and urban households, and the rural poverty and equity by using a CGE model with market imperfections. We explicitly model credit constraints and its consequences for poverty and equity. In addition, we explicitly model households' preferences for high standards food. We use 2005 data from China to calibrate the model and perform three simulations: the effect of an increase in the world price of high standards food, an increase urban households' preference for high standards food, and a reduction in credit constraints.

This paper is the first to show the complex set of factors that will determine growth and equity effects of HS growth. First, the simulation results show that poor rural households will expand their production of high standards product with the increase of world price for high standards food. In this way an expansion in the high standards food sector leads to a reduction of poverty and of inequality. Second, expansion of high standards sector resulting from domestic preference changes may increase or decrease real incomes of poor rural households, and hence increases or decreases inequality (depending on whether HS production can compete with HS imports.). Third, the effects are influenced by technology, the required investment costs and factor market imperfections. A reduction in credit constraints induces an increase in high standards farming and rural households will gain more. If the technology used in high standards farming is more labor intensive it will benefit the poor more, and vice versa. Fourth, the spillover effects of HS demand growth on other product markets (in this in particular LS markets) is important. Since poor rural households depend importantly on HS production they may benefit or lose from spillover effects. As we have shown, the effects depend, among others, on where HS demand comes from and from substitution between imports and domestic products.

In summary, our paper shows the importance of analyzing all the relevant effects together. The simulation results have shown that the general equilibrium effects can be very different from partial equilibrium effects. The overall welfare effects of standards on poor rural households are determined by many tradeoffs and hence cannot be analyzed separately. Overlooking some effects may lead to biased, and sometimes wrong, policy conclusions.

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APPENDIX.

A. Data

The structure and characteristics of China's economy are shown in Table 2. The System of National Accounts and its related data sets for China provide the starting point for our dataset of 2005, which is also the latest available dataset. Most data are collected from China Statistics Yearbook (CNBS, 2006). For those that can't be found from the yearbook, we complement from other sources, like China Agriculture Yearbook (CMA, 2006) and the Input/output Table 2002.[17]

Essentially the procedure required to produce our data set involves extensions, modifications and redefinitions of concepts for portions of the national accounts data; the addition of further detail to this system; and final adjustments between blocks of data in order to restore mutual consistency. As we have stated that the concept of standards includes so many aspects that we cannot differentiate exactly which food belongs to high standards or not. Hence, we only make some approximation to describe a rough figure.

A.1 Production

GDP is 18.67 trillion Yuan and divided into the final commodity sectors: low and high standards food, and the other commodity sector. The shares of rural households and corporate farms in the high standards farming are estimated according to their farming areas.

The parameters in production functions are determined by using either cost/revenue table or the input/output table according to the availability of data. The cost/revenue tables for the agriculture are used to calculate the contribution rates of low and high standards farming under our following assumption: Since the profit rate of contract farming is larger than that of non-contract farming from the sample data of Miyata et al. (2007), the difference (11.2%) is treated as the positive profit for high standards farming in our case. And we proxy the

[17] The input/output tables of China are edited once per five years. The Input/output Table 2002 is, hence, the latest available table.

input/output of both high standards and low standards intermediate product by the weighted average of agricultural products including wheat, maize, rice tobacco, tea, peanut, sugar cane, beet and apple, etc.The contribution rates of factors in the processing sector are calculated from the Input/output Table 2002 (CNBS, 2006). The labor wages, amortization and intermediate input of construction sector are proxies of contributions of labor, capital and land. The wages in processing and industrial sectors are divided into rural and urban labor according to the aggregate ratio of rural to urban labor revenues.

A.2 Households income, savings/investment and consumption

From the expenditure side, GDP is divided into consumption, investment and net export. All the aggregate amounts can be found in the GDP structure from the yearbook. The disaggregate data of households are collected from the income and expenditure structures of individual households.

The investment and net export are added up to the amount of savings. The individual households savings are calculated as income less consumption. However, the calculated saving rates seem too low, probably because of lack of treatment of government and corporate savings, and are enlarged to suit the aggregate saving amount according to their relative shares. The investments are sorted into the final commodity sectors according to their shares in input/output table.

The division of income between rural[18] and urban households is based on the income per capita and ratio of population. The consumption structures are calculated from the expenditure of households. Engel indices are used to divide food and non-food consumptions.

[18] Rural Households, according to the explanation of the yearbook, refer to usual resident households in rural areas. 'Usual resident households in rural areas are households residing on a long term basis(for more than one year) in the areas under the administration of township governments (not including county towns), and in the areas under the administration of villages in county towns. Households residing in the current addresses for over one year with their household registration in other places are still considered as resident households of the locality. For households with their household registration in one place but all members of the households having moved away to make a living in another place for over one year, they will not be included in the rural households of the area where they are registered, irrespective of whether they still keep their contracted land.' (CNBS, 2006)

The expenditure on food is divided into consumptions of low and high standards food. The poorest rural households and urban households are assumed to consume the largest shares of low standards food (99.9%) and high standards food (6.7%) respectively. The consumption ratios of the other rural households are calculated by inserting numbers proportionally so that the overall consumption is equal to production minus investment.

As far as the households income structures are concerned, the yearbook only divides income data into four parts: Income from wages and salaries, from households operations, from properties, and from transfers. The divisions among these items of income are not very clear and can't be easily sorted into factor income and profit. We deal with them as follows: Income from wages and salaries is treated as wages and income from properties as capital income straightforwardly. Income from transfers is excluded since there is no government in our model. The most important income for rural households is the income from households operations. It is sorted into profit and factor incomes, including those from labor, from land and from capital, which are added into other factor incomes to get the final income structures of rural households. Even though the statistical income from operations includes other activities, like transportation, we use its total amount as proxy to farming operations since we cannot differentiate them. As for urban households, its income from wages and salaries is treated as income from labor. And the incomes from households operations and from properties are added up to income from capital.[19]

Because of transportation cost of migration between rural and urban regions, the wages earned in the two regions are different. The gap between wage of rural labor working in urban region (8520 Yuan according to PBC, (2006)) and average income[20] per labor in rural region (6948 Yuan) is treated as the iceberg costs. The implicit assumption under the use of

[19] Even though the migrants from rural to urban may keep their rights in the rural land, we don't count it in because of the unavailability of data.
[20] Because all the incomes earned by rural households are attached to their operations in rural activities, they are the best alternative choice to wages earned in urban area.

income per labor in rural as the comparison base is that rural labor make the decision of migration by comparing it with wage in urban region.

A.3 External sector

All final commodities are tradable and have both export and import.

A.4 'RAS' adjustments[21]

After the adjustments, modifications and additions listed above are completed, the remaining inconsistencies in our data set involve major data blocks which need to be realigned so as to satisfy (or restore in certain cases) equilibrium conditions.

In the 'RAS' procedure a non-negative matrix which does not initially meet prescribed non-negative row and column sum constraints is restored to a situation of consistency through a sequence of alternating operations on rows and columns of the matrix. First row constraints are satisfied, then column constraints, then row constraints, and so on until a consistent matrix is achieved. The sums of prespecified row and column constraints must be the same since they both provide the matrix sum. If the matrix is everywhere dense, convergence is assured.

After the 'RAS' procedure, the GDP as a whole only increases 0.7%. The largest modification is to decrease the consumption of high standards food for urban households by 57.8%. This may be a signal that we have no precise data on high standards food consumption and that high standards food consists of a very small part of the whole economy and is more vulnerable to change. Considering the limited data availability against intensive use of data, such scale of data modification is thought to be acceptable.

[21] This method is referred to St-Hilaire and Whalley (1983).

B. Sensitivity analysis

In order to assess the robustness of our results we perform sensitivity analysis of the key assumptions.[22] First, our results are robust to alternative assumptions on income elasticities of low standards products ($\sigma_{LF}{}^{RP} \in (1.35,\ 0.9,\ 0.45)$ for the poorest rural households, and structural modification of elasticities for the other households).

Second, alternative choices of the elasiticities of transformation ($\sigma_{LF}{}^{t} \in (0.6,\ 1.2, 1.8)$, $\sigma_{HF}{}^{t} \in (0.6,\ 1.2, 1.8)$ and $\sigma_{O}{}^{t} \in (0.4,\ 0.8,\ 1.2)$) and the elasticities of substitution ($\sigma_{LF}{}^{q} \in (1.5,\ 3.0, 4.5)$, $\sigma_{HF}{}^{q} \in (1.5,\ 3.0, 4.5)$ and $\sigma_{O}{}^{q} \in (0.25,\ 0.5,\ 0.75)$) yield only marginal changes to our comparative static results in the simulations of trade and credit constraints, while they have some impacts on the simulations of preference changes. The reason why the simulation results of preference change are sensitive to different assumptions of elasticities in trade lies in the fact that higher values of elastisities of substitution between domestic and foreign markets will benefit those consumers and producers who are highly involved in the outward-oriented sector.

Third, alternative choices of the substitution elasticities between factors ($\sigma_{R}{}^{s} \in (0.35,\ 0.7,\ 1.05)$, $\sigma_{po}{}^{s} \in (0.075,\ 0.15,\ 0.225)$, $\sigma_{PS}{}^{s} \in (0.4,\ 0.8,\ 1.2)$ and $\sigma_{O}{}^{s} \in (0.45,\ 0.9,\ 1.35)$) yield only small changes in the results for the simulations of trade and credit constraints. They do have some significant impacts on the simulations of preference changes. But the signs of the effects do not change. For example, increasing these substitution elasticities will decrease the income of the poorest rural households more (from -0.09% to -0.13%), decrease the income of the other rural households less (from -0.16% to -0.15%) and increase the income of urban households less (from +0.31% to +0.29%).

In summary, our results are robust to variations in all these parameters.

[22] A full set of sensitivity analyzes results is available from the authors upon request.

Figure 1. Model structure

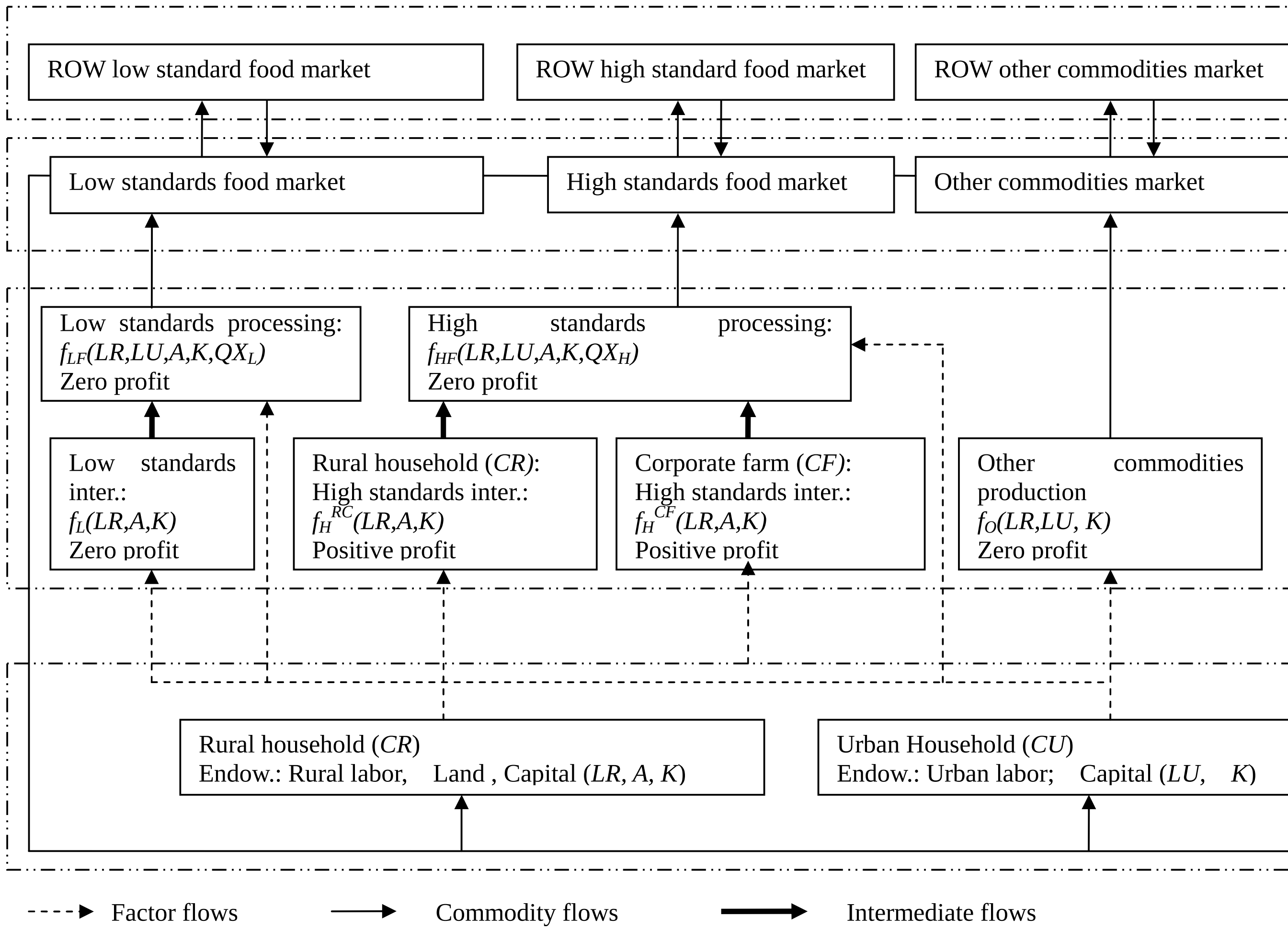

Figure 2. Export-led expansion under different technologies in high standards farming

(Baseline = Simulation 1A)

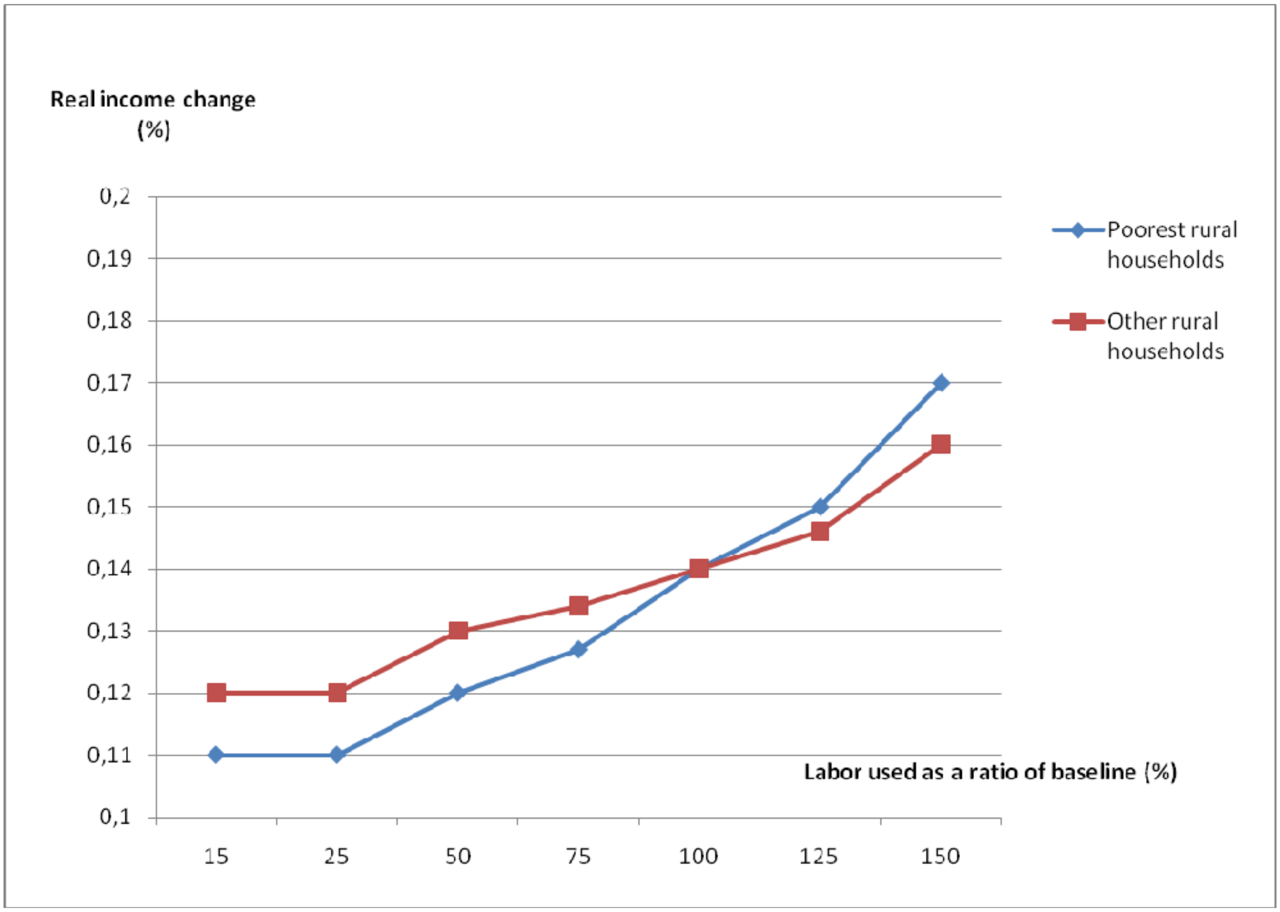
Real income change (%)
0,2
0,19
0,18
0,17
0,16
0,15
0,14
0,13
0,12
0,11
0,1
15
25
50
75
100
125
150
Labor used as a ratio of baseline (%)
Poorest rural households
Other rural households

Figure 3. Domestic demand growth with elastic import under different technologies (Baseline = Simulation 2A)

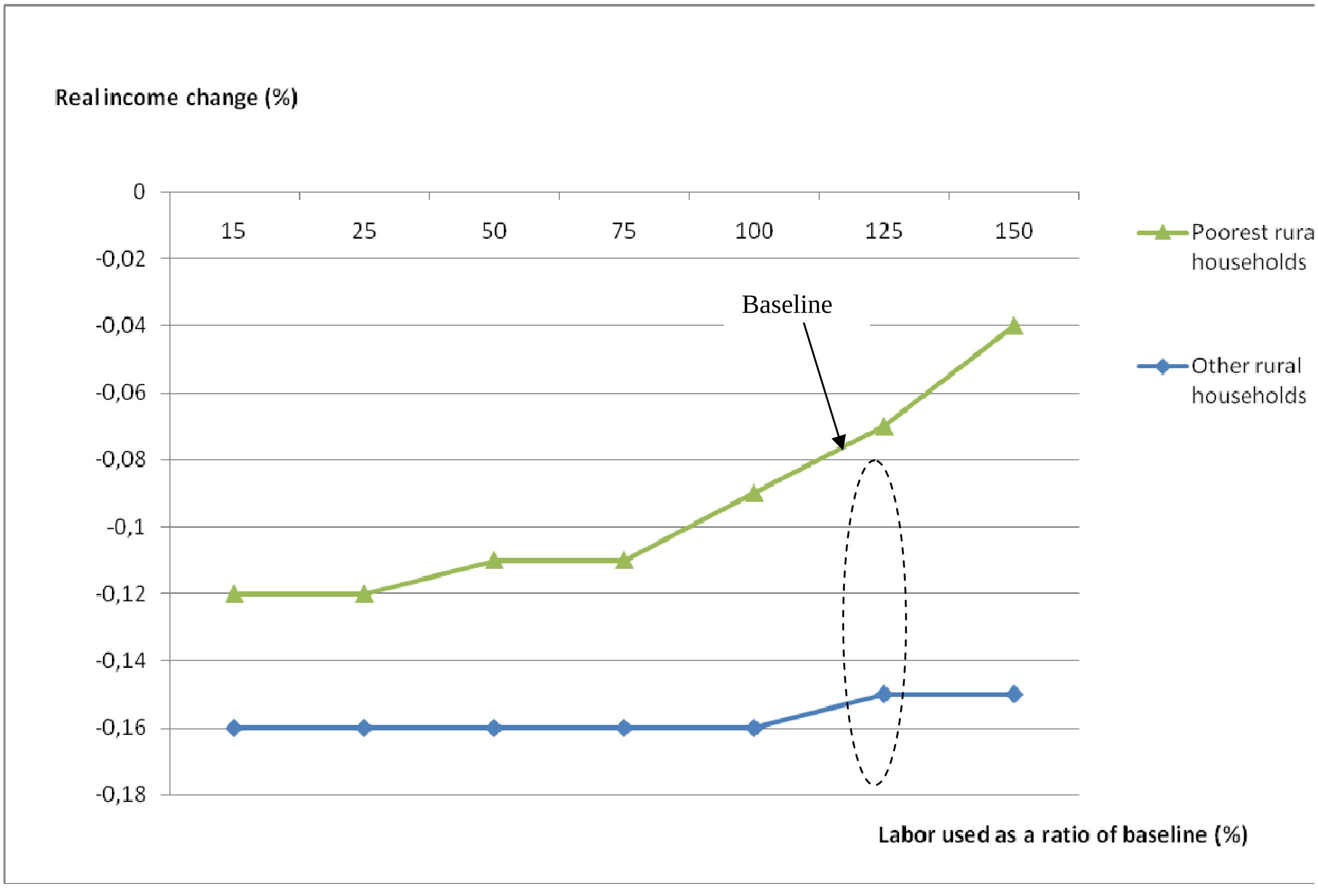

Figure 4. Export-led expansion with different credit constraints (Baseline = Simulation 1A)

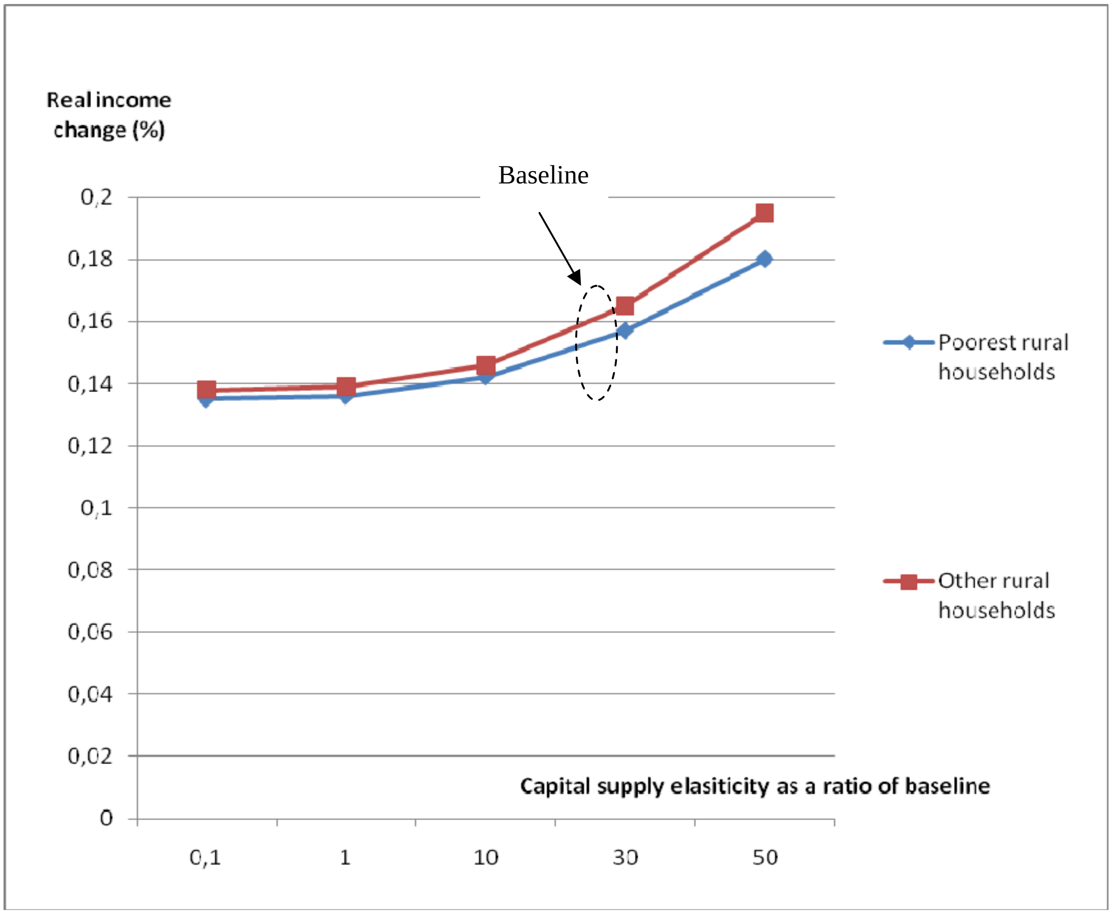

Figure 5. Export-led expansion with different fixed investment costs (Baseline = Simulation 1A)

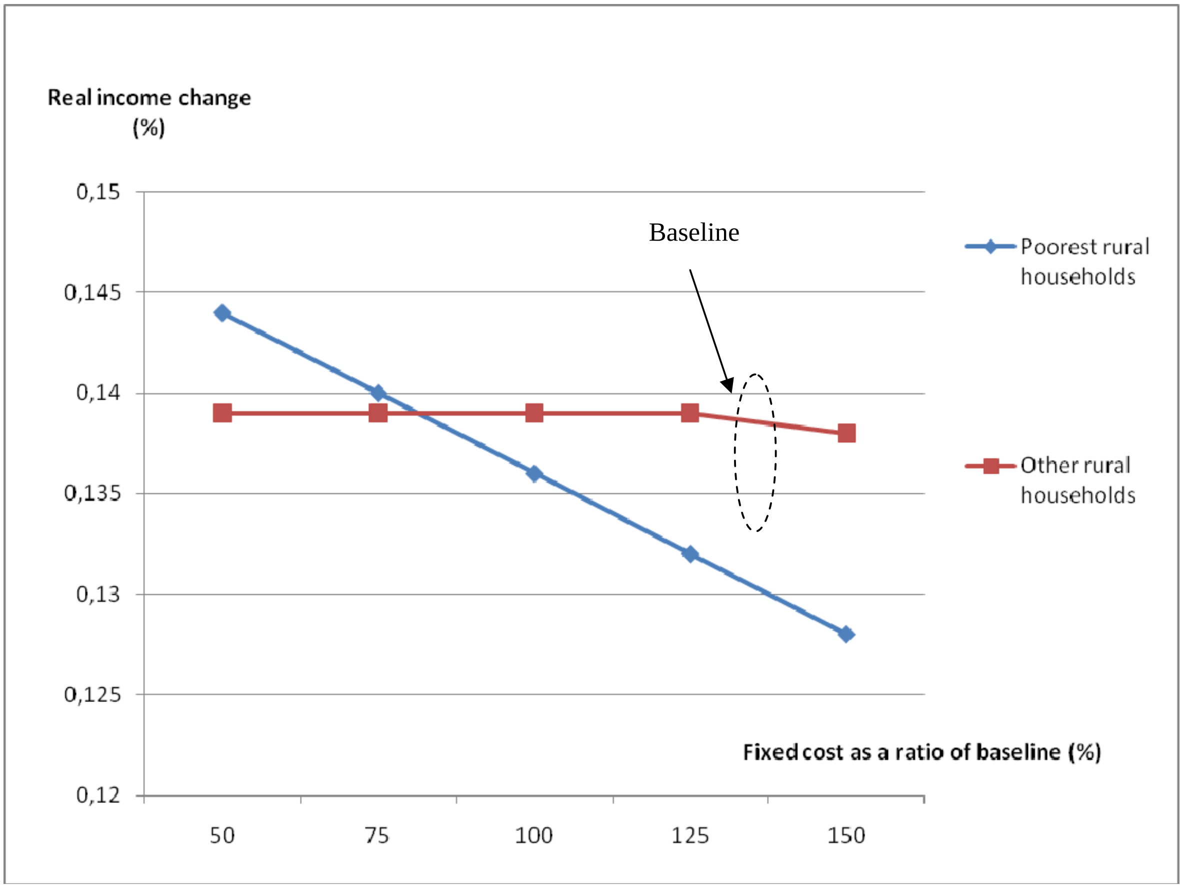

Figure A1. Export-led expansion with different income elasticities

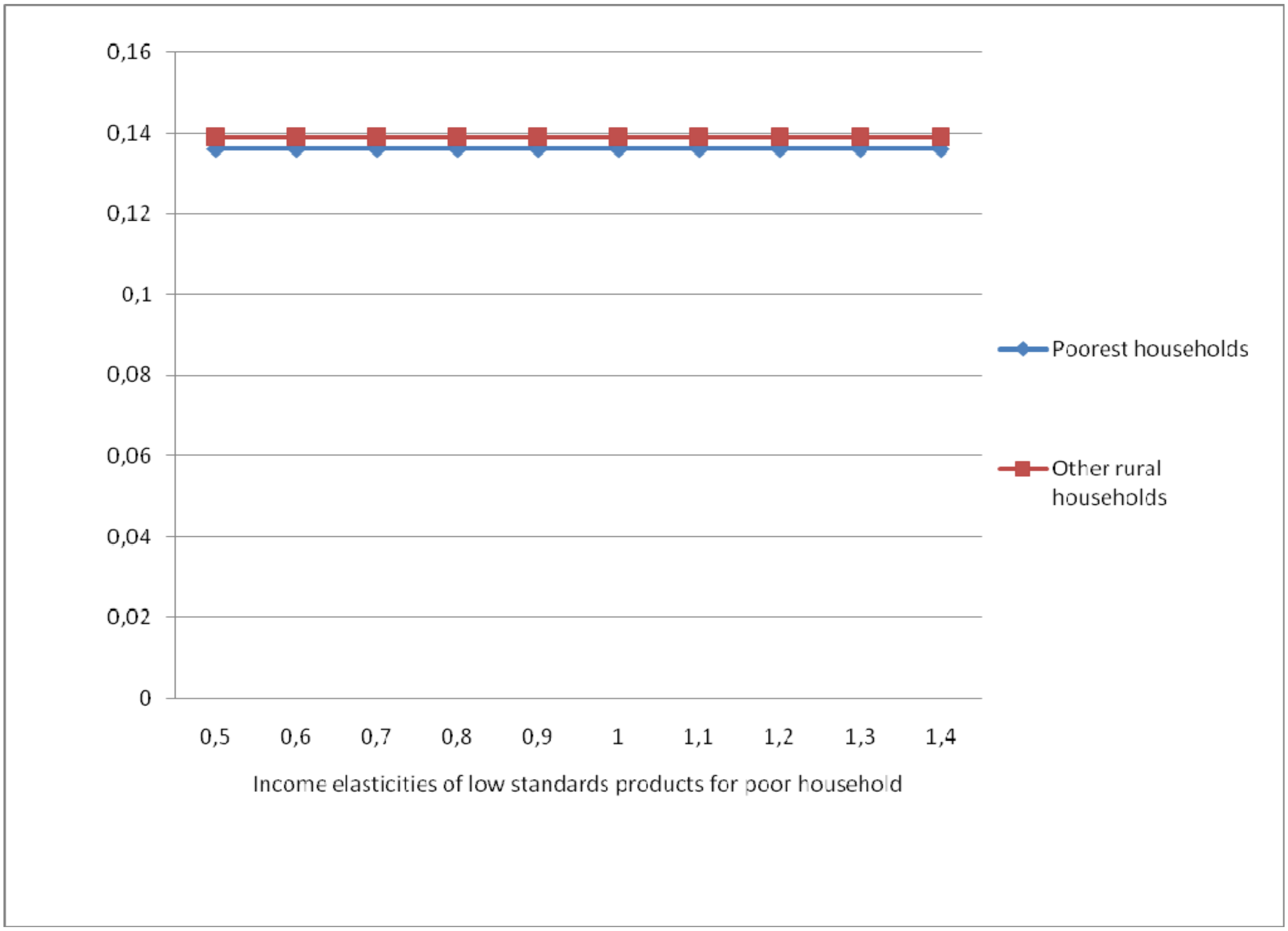

Figure A2. Export-led expansion with different Amington elasticities

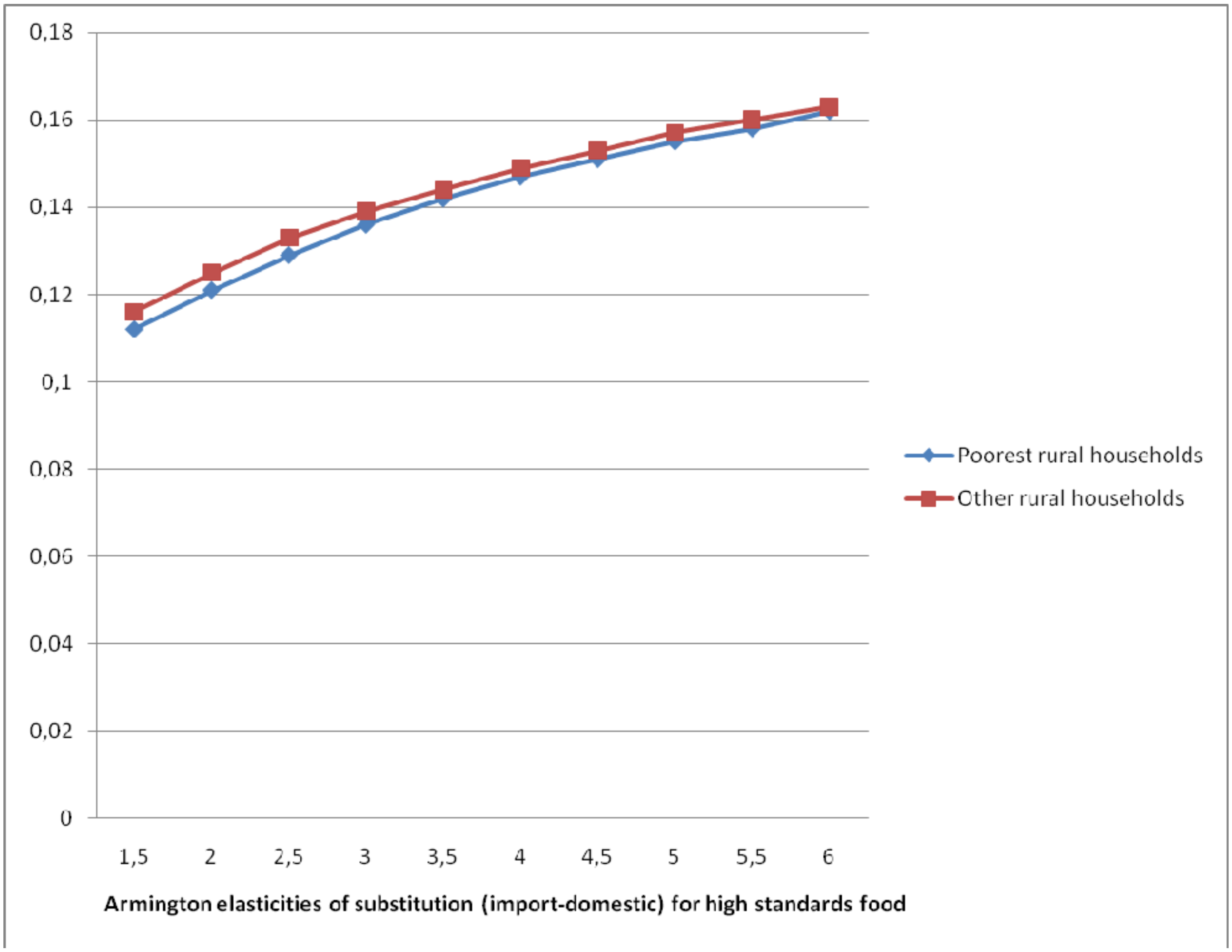

Figure A3. Domestic demand growth with different substitution elasticities

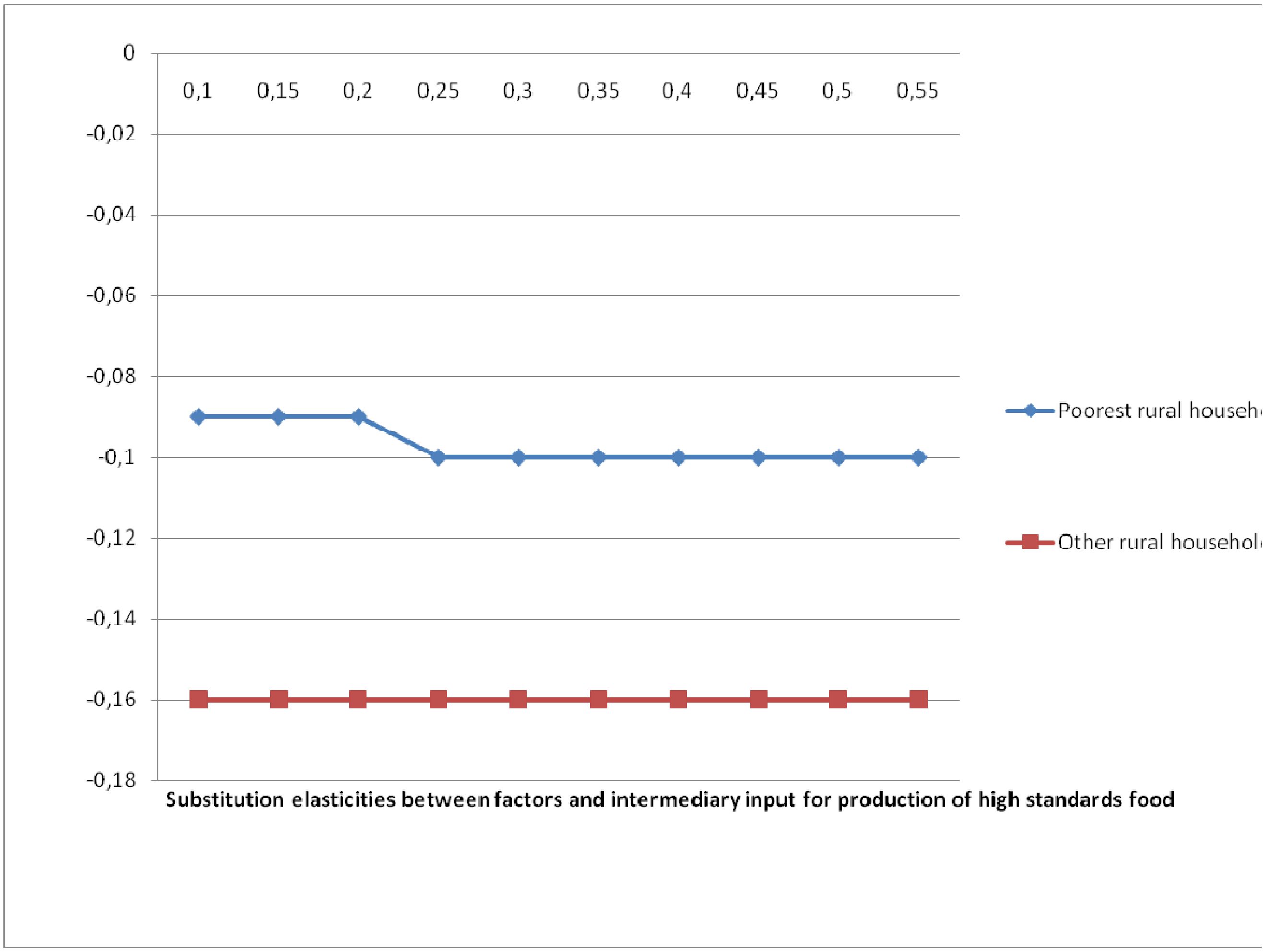

Figure A4. Domestic demand growth with different elasticities of transformation

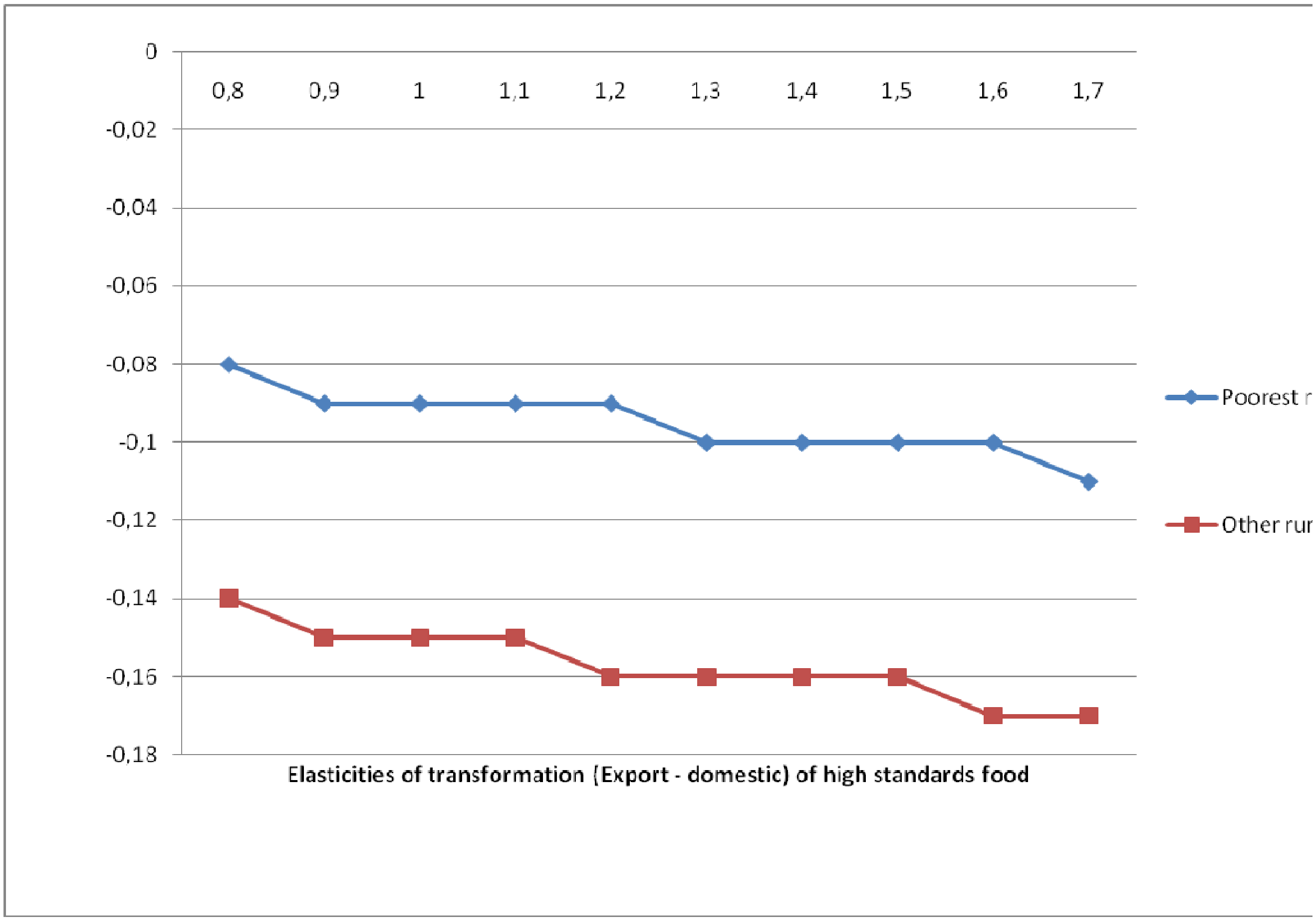
0
-0,02
-0,04
-0,06
-0,08
-0,1
-0,12
-0,14
-0,16
-0,18
0,8
0,9
1
1,1
1,2
1,3
1,4
1,5
1,6
1,7
Elasticities of transformation (Export - domestic) of high standards food
Poorest r
Other rur

Table 1 The Model

Production and factor demand

$$QX_b = \phi_b CES(LR_b, A_b, K_b) \quad \text{(A1)}$$

$$QX_O = \phi_O CES(\phi_{OL} CD(LR_O, LU_O), K_O) \quad \text{(A 2)}$$

$$QX_{po} = \phi_{po} CES(\phi_{poS} CES(\phi_{poL} CD(LR_{po}, LU_{po}), A_{po}, K_{po}), QXI_{po}) \quad \text{(A 3)}$$

$$K_H^c = \kappa^c r^{\varepsilon^c}, c \in CR \cup CF \quad \text{(A 4)}$$

$$LR_L = LR_L^*(PX_L, wr_R, t, r) \quad \text{(A 5)}$$

$$LR_H^c = LR_H^{c\,*}(PX_H, wr_R, t; K_H^c), c \in CR \cup CF \quad \text{(A 6)}$$

$$Ll_{po} = Ll_{po}^*(wr_R, wu, t, r, PXI_{po}) \quad \text{(A 7)}$$

$$Ll_O = Ll_O^*(PX_O, wr_U, wu, r) \quad \text{(A 8)}$$

$$A_L = A_L^*(PX_L, wr_R, t, r) \quad \text{(A 9)}$$

$$A_H^c = A_H^{c\,*}(PX_H, wr_R, t, r; K_H^c), c \in CR \cup CF \quad \text{(A 10)}$$

$$A_{po} = A_{po}^*(wr_R, wu, t, r, PXI_{po}) \quad \text{(A 11)}$$

$$K_L = K_L^*(PX_L, wr_R, t, r) \quad \text{(A 12)}$$

$$K_{po} = K_{po}^*(wr_R, wu, t, r, PXI_{po}) \quad \text{(A 13)}$$

$$K_O = K_O^*(PX_O, wr_U, wu, r) \quad \text{(A 14)}$$

$$X_{po} = X_{po}^*(wr_R, wu, t, r, PXI_{po}) \quad \text{(A 15)}$$

Income and demand

$$\prod^c = PX_H f_H(LR_H^c, A_H^c, K_H^c) - wr_R(LR_H^c + \varphi^c) - tA_H^c - r(K_H^c + \psi^c), c \in CR \cup CF \quad \text{(A 16)}$$

$$Y^c = \begin{cases} wr_R LR^c + tA^c + rK^c + \prod^c + \gamma^c \prod^{CF}, & c \in CR \\ wuLU^c + rK^c + \gamma^c \prod^{CF}, & c \in CU \end{cases} \quad \text{(A 17)}$$

$$X_{HF}{}^c = \frac{a_{HF}^c (1 - mps^c) Y^c}{PQ_{HF}} - a_{LF}^c \zeta^c, c \in C \quad \text{(A 18a)}$$

$$X_{LF}{}^c = \frac{a_{LF}^c (1 - mps^c) Y^c}{PQ_{LF}} + \frac{PQ_{HF}}{PQ_{LF}} a_{LF}^c \zeta^c, c \in C \quad \text{(A 18b)}$$

$$X_O{}^c = \frac{(1 - a_{LF}^c - a_{HF}^c)}{PQ_O}(1 - mps^c) Y^c, c \in C \quad \text{(A 18c)}$$

Subject to the households budget constraint:

$$\sum_{m \in M} PQ_m \bullet X_m^c = (1 - mps^c) Y^c, c \in C$$

Savings and investment

$$S^c = mps^c * Y^c, c \in C \quad \text{(A 19)}$$

$$QINV_m = qinv_m * IADJ \quad \text{(A 20)}$$

$$FSAV + \sum_{m \in M} PQ_m * QINV_m = \sum_{c \in C} mps^c * Y^c \quad \text{(A 21)}$$

Foreign trade

$$QQ_m = aq_m CES(QM_m, QD_m) \quad \text{(A 22)}$$

$$QX_m = at_m CET(QE_m, QD_m) \quad \text{(A 23)}$$

$$\frac{QQ_m}{QD_m} = \left(\frac{PD_m}{QM_m} * \frac{\delta_m{}^q}{1 - \delta_m{}^q}\right)^{1/(1+\sigma_m{}^q)} \quad \text{(A 24)}$$

$$\frac{QE_m}{QD_m} = \left(\frac{PE_m}{PD_m} * \frac{1 - \delta_m{}^t}{\delta_m{}^t}\right)^{1/(\sigma_m{}^t - 1)} \quad \text{(A 25)}$$

$$PM_m = pwm_m * EXR \quad \text{(A 26)}$$

$$PE_m = pwe_m * EXR \tag{A 27}$$

$$PQ_m * QQ_m = PD_m * QD_m + PM_m * QM_m \tag{A 28}$$

$$PX_m * QX_m = PD_m * QD_m + PE_m * QE_m \tag{A 29}$$

$$CPI = \sum_m \nu_m * PQ_m \tag{A 30}$$

$$PPI = \sum_m \mu_m * PI_m \tag{A 31}$$

Equilibrium conditions

(a) *Demands equal supply for factors*

$$\sum_{i \in B} LR_i^* + \sum_{po} LR_{po}^* + LR_U^* / \tau + \sum_{c \in CR \cup CF} \varphi^c = \sum_{c \in CR} L^c \tag{A 32}$$

$$\sum_m LU_m^* = L^U \tag{A 33}$$

$$\sum_{i \in B} A_i^* + \sum_{po} A_{po}^* = \sum_{c \in C} A^c \tag{A 34}$$

$$K_L^* + \sum_{c \in CR \cup CF} K_H^c + \sum_{po} K_{po}^* + K_O^* + \sum_{c \in CR \cup CF} \psi^c = \sum_{c \in C} K^c \tag{A 35}$$

(b) *Demands equal supply for goods*

$$\sum_c X_m^{c*} + QINV_m = QQ_m \tag{A 36}$$

$$X_{po} = QXI_{po} \tag{A 37}$$

(c) *Current account balance for ROW (in domestic currency)*

$$\sum_m PE_m * QE_m = \sum_m PM_m * QM_m + FSAV \tag{A 38}$$

Endogenous variables

wr_R , wr_U , wu , t , r	Price of factors
PX_i	Producer price of activity *i*
PXI_{po}	Producer price of intermediate product
PQ_m	Price of composite good
PD_m	Price of domestically produced good for domestic market
PE_m	Export price in domestic currency
$\prod^c$	Profit for high standards farming to agent *c*
γ^c	Endogenous share parameters of transferred profit from corporate farms
LR_i , LU_i , A_i , K_i	Demand of factor from activity *i*
X_{po}	Demand of intermediate input from processing sector *po*
$X_m{}^{c*}$	Consumption of commodity *m* by households *c*
QX_i	Domestic production
QXI_{po}	Production of intermediate input in processing sector *po*
QQ_m	Domestic demand for composite good
QD_m	Domestic demand for domestically produced good
QE_m	Export
Y^c	Income of households *c*
YF_b^c	Factor income of households *c* from factor *b*

$IADJ$	Investment adjustment factor
$QINV_m$	Quantity of investment demand for commodity *m*
$FSAV$	Foreign savings (domestic currency)
CPI	Aggregate consumer price
PPI	Aggregate producer price

Exogenous variables and coefficients

ϕ_i	Efficient parameter of activity *i* for different level of nests
$\kappa^c, c \in CR \cup CF$	Collateral of agent *c* in high standards farming
a_m^c	Share parameter of households consumption spending on commodity *m*
pwe_m	Export price for *m* (foreign currency)
pwm_m	Import price for *m* (foreign currency)
ν_m	Weight of commodity *m* in the CPI
μ_m	Weight of commodity *m* in the PINDEX
LR^c, LU^c, A^c, K^c	Households endowment
τ	Migration cost rate
mps^c	Marginal (and average) propensity to save for households *c*
$qinv_m$	Baseline quantity of fixed investment demand
$\sigma_m{}^q$	Armington elasticities of substitution
$\sigma_m{}^t$	Elasticities of transformation
φ^c	Fixed costs in the form of rural labor
ψ^c	Fixed costs in the form of capital

Numeraire

EXR	Exchange rate (dom. Currency per unit of for. Currency)

Functions

CES	Constant elasticity of substitution function
CD	Cobb-Douglas function
CET	Constant elasticity of transformation function

Indices and sets

i	Index for activities, $i \in I$
b	Index for intermediate sectors $b \in B = L \cup H$
po	Index for processing sectors $po \in PL \cup PH$
j	Index for factors, $j \in J$
l	Index for labor categories, $l = LR \cup LU$
c	Index for agents, $c \in C \cup CO$
m	Index for commodities, $m \in M$

Table 2. Archetype SAM of China when the same technology is used in high standards and low standards farming

	Low inter.	High poorest	High other	High corp.	Low proc.	High proc.	Other com.	Rural labor	Urban labor	Land	Capital	LaborRCFP	LandCFP	Capital CFP	cfpro	High inter.	Poorest rural	Other rural	Urban	S-I	ROW
Low inter.					23104.2																
High poorest																14.0					
High other																207.7					
High corp.																11.7					
Low proc.																	1933.7	14358.2	12512.8	2227.7	1416.8
High proc.																	3.0	40.4	242.5	119.3	176.0
Other com.																	2163.2	25835.2	36797.7	77173.0	42412.5
Rural labor	10514.2	5.7	83.9	4.7	1359.1	13.7	29105.5														
Urban labor					2365.2	40.9	82926.2														
Land	4362.9	2.3	34.8	2.0	1523.3	15.4															
Capital	8227.2	4.4	65.7	3.7	2876.9	29.1	40037.2														
LaborRCFP															0.6						
LandCFP															0.2						
CapitalCFP															0.5						
cfpro				1.3																	
High inter.						233.4															
Poorest rural		1.6						3727.5		370.7		0.05	0.02								
Other rural			23.3					37359.3		5570.1	18471.8	0.5	0.2	0.2							
Urban									85332.2		32772.4			0.3							
S-I																	0.0	21191.4	68551.6		
ROW					1220.8	248.9	32312.7													10223.0	
total	23104.2	14.0	207.7	11.7	32449.5	581.3	184381.6	41086.8	85332.2	5940.8	51244.2	0.6	0.2	0.5	1.3	233.4	4099.9	61425.3	118104.6	89743.0	44005.3

Source: Authors' calculation based on China's yearbooks and input/output table.

Table 3. Parameters applied in the model

	Intermediate product	Final food	Other commodities
Elasticity of factor substitution	0.7	0.15 (Agg.); 0.8 (Sub-nest)	0.9
Armington elasticity of substitution	-	3.0	0.5
Elasticities of transformation	-	1.2	0.8
	Poorest rural	Other rural	Urban
Income elasticity of low standards food	0.9	0.4	0.1
	Poorest-high	Other-high	Corporate farms
Price elasticities of capital supply	0.7	1.3	1.9

Table 4. Simulation results: The same technology in high standards and low standards farming (Percentage change comparing with baseline)

Sim 1A: World price of high standards food increase by 25% ($\Delta pwe_{PH} / pwe_{PH} = +25\%$, $\Delta pwm_{PH} / pwm_{PH} = +25\%$); Elasticity of transformation of high standards food is normal ($\sigma_{PH}^{t} = 1.2$).

Sim 1B: World price of high standards food increase by 25% ($\Delta pwe_{PH} / pwe_{PH} = +25\%$, $\Delta pwm_{PH} / pwm_{PH} = +25\%$); Elasticity of transformation of high standards food is large ($\sigma_{PH}^{t} = 20$).

Sim 2A: Urban households' preference for low standards food decrease by 25% ($\Delta\zeta^{U} / \zeta^{U} = -25\%$); Import is elastic ($\sigma_{PH}^{q} = 3$).

Sim 2B: Urban households' preference for low standards food decrease by 25% ($\Delta\zeta^{U} / \zeta^{U} = -25\%$); Import is inelastic ($\sigma_{PH}^{q} = 0.1$).

	Sim 1A	Sim 1B	Sim 2A	Sim 2B
Aggregate effects				
Real GDP	-0.05	-0.07	0.16	0.03
CPI	0.48	0.95	-1.09	-0.17
Gini coefficient	-0.28	-0.57	0.51	0.02
Real Gini coefficient	-0.25	-0.53	0.40	-0.04
Consumptions				
Low standards food	0.61	1.03	-2.19	-0.73
High standards food	-58.58	-99.95	178.22	50.38
Other commodities	0.05	0.11	-0.07	0.01
Output of final commodities				
Low standards food	0.48	0.79	-1.91	-0.68
High standards food	9.31	25.79	24.29	24.66
Other commodities	-0.12	-0.22	0.33	0.08
Individual output of high standards intermediate product				
Poorest rural households	7.58	20.93	20.75	20.59
Other rural households	8.95	24.71	23.19	23.58
Corporate farms	9.06	24.83	21.84	22.88
Trade				
Import volume				
Low standards food	2.65	5.08	-6.84	-1.68
High standards food	-77.73	-99.97	274.11	52.23
Other commodities	0.25	0.50	-0.52	-0.08
Export volume				
Low standards food	-0.32	-0.76	0.01	-0.30
High standards food	31.24	130.48	0.96	0.45
Other commodities	-0.41	-0.80	1.01	0.21
Rural labor used in high standards intermediate product				
Poorest rural households	14.74	44.23	38.89	43.83

Other rural households	16.21	48.73	45.35	47.40
Corporate farms	15.42	46.82	43.07	46.56
Domestic consumer price				
Low standards food	0.67	1.31	-1.61	-0.32
High standards food	1.64	2.97	10.37	14.55
Other commodities	0.39	0.78	-0.90	-0.17
Company food price				
Low standards food	0.67	1.31	-1.60	-0.32
High standards food	7.33	21.27	18.92	19.72
Other commodities	0.37	0.73	-0.84	-0.16
Farm gate price				
Low standards intermediate product	0.69	1.35	-1.65	-0.33
High standards intermediate product	10.23	30.00	27.67	28.35
Factor price				
Rural labor	0.54	1.07	-1.22	-0.22
Urban labor	0.27	0.55	-0.56	-0.08
Land	1.52	2.96	-3.63	-0.71
Capital	0.44	0.85	-1.14	-0.27
Poorest rural households				
Profit effect from high standards farming	0.03	0.10	0.11	0.11
Profit sharing from corporate farm	0.00	0.00	0.01	0.01
Factor income effect	0.10	0.20	-0.21	-0.03
Among it:				
Labor	0.01	0.03	0.01	0.01
Land	0.09	0.17	-0.22	-0.04
Total income effect	0.14	0.31	-0.09	0.08
Other rural households				
Profit effect from high standards farming	0.03	0.10	0.11	0.11
Profit sharing from corporate farm	0.00	0.00	0.00	0.00
Factor income effect	0.10	0.20	-0.27	-0.07
Among it:				
Labor	0.03	0.05	-0.05	-0.00
Land	0.09	0.17	-0.23	-0.05
Capital	-0.02	-0.03	0.00	-0.02
Total income effect	0.14	0.31	-0.16	0.05
Urban households				
Profit sharing from corporate farm	0.00	0.00	0.00	0.00
Factor income effect	-0.15	-0.28	0.31	-0.00
Among it:				
Labor	-0.14	-0.26	0.34	0.04
Capital	-0.01	-0.02	-0.03	-0.04
Total income effect	-0.15	-0.28	0.31	0.00

Source: Authors' simulation.

Table A1. Export-led expansion under different technologies ($\Delta pwe_{PH} / pwe_{PH} = +25\%$ and $\Delta pwm_{PH} / pwm_{PH} = +25\%$)

Sim 3A. 15% of the baseline labor is used in high standards farming.

Sim 3B. 150% of the baseline labor is used in high standards farming.

	Sim 3A.	Sim 3B.
Aggregate effects		
Real GDP	-0.04	-0.05
CPI	0.46	0.52
Gini coefficient	-0.25	-0.31
Consumptions		
Low standards food	0.64	0.53
High standards food	-60.87	-53.69
Other commodities	0.04	0.05
Output of final commodities		
Low standards food	0.52	0.39
High standards food	3.15	22.44
Other commodities	-0.11	-0.13
Individual output of high standards intermediate product		
Poorest rural households	2.07	18.04
Other rural households	2.77	22.22
Corporate farms	3.02	22.10
Trade		
Import volume		
Low standards food	2.59	2.75
High standards food	-79.09	-75.14
Other commodities	0.23	0.26
Export volume		
Low standards food	-0.23	-0.47
High standards food	22.93	47.05
Other commodities	-0.39	-0.45
Rural labor used in high standards intermediate product		
Poorest rural households	8.92	25.78
Other rural households	9.65	30.23
Corporate farms	9.92	30.11
Domestic consumer price		
Low standards food	0.64	0.73
High standards food	1.67	1.58
Other commodities	0.37	0.43
Company food price		
Low standards food	0.63	0.72
High standards food	7.34	7.30
Other commodities	0.35	0.40
Farm gate price		
Low standards intermediate product	0.65	0.75
High standards intermediate product	10.26	10.17
Factor price		
Rural labor	0.50	0.62
Urban labor	0.26	0.29

Land	1.46	1.63
Capital	0.43	0.45
Poorest rural households		
Profit effect from high standards farming	0.03	0.03
Profit sharing from corporate farm	0.00	0.00
Factor income effect	0.08	0.13
Among it:		
Labor	-0.00	0.04
Land	0.08	-0.02
Total income effect	0.11	0.17
Other rural households		
Profit effect from high standards farming	0.03	0.03
Profit sharing from corporate farm	0.00	0.00
Factor income effect	0.09	0.12
Among it:		
Labor	0.01	0.04
Land	0.08	0.09
Capital	-0.01	-0.01
Total income effect	0.12	0.16
Urban households		
Profit sharing from corporate farm	0.00	0.00
Factor income effect	-0.14	-0.16
Among it:		
Labor	-0.13	-0.15
Capital	-0.00	-0.00
Total income effect	-0.14	-0.16

Source: Authors' simulation.