Coping with Food Price Volatility: Trade Insulation as Social Protection*

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Abstract

In a world with volatile food prices, countries have an incentive to shelter their populations from the induced real income shocks. When some agents are net food producers while others are net consumers, there is scope for insurance between the two groups. A domestic social protection scheme would therefore transfer resources away from the former group to the latter in times of high food prices, and do the reverse otherwise. We show that in the presence of consumer preference heterogeneity, implementing the optimal social protection policy can potentially induce higher food price volatility. Such policy indeed generates a counter-cyclical demand shock that amplifies the effects of the underlying food shortage. Our results call for a reassessment of food stabilization policies. In particular, we urge caution against the systematic condemnation of trade insulation practices.

Keywords: food prices, trade insulation, social protection, beggar thy neighbor

JEL Codes: Q17, O24

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1 Introduction

Between 2007 and 2011 an estimated 33 countries resorted to restrictions on exports of grains and other food commodities (Sharma, 2011). The international policy community mobilized itself against these practices. Then World Bank president Robert Zoellick, at the 2008 High-Level Conference on World Food Security, advocated for "an international call to remove export bans and restrictions. These controls encourage hoarding, drive up prices, and hurt the poorest people around the world who are struggling to feed themselves."[1] U.S. Secretary of State Hillary Clinton echoes the same concerns in a 2011 speech on global food security: "We also saw how unwise policy also had an impact. Some policies that countries enacted with the hope of mitigating the crisis, such as export bans on rice, only made matters worse. (...) And that sounder approach includes (...) abstaining from export bans no matter how attractive they may appear to be, using export quotas and taxes sparingly if at all (...)."[2]

This paper revisits these claims and argues that trade policies are not necessarily the fundamental source of the macroeconomic amplification decried above. Rather, we show that an optimal *domestic* social protection scheme would also take the shape of a "beggar-thy-neighbor" policy when beneficiaries of social transfers have a higher propensity to spend on food. Trade insulation policies are then mere second-best instruments available to policy makers that ought to be evaluated against policy alternatives. We therefore encourage a reassessment of food price policy responses that would not single out trade-based instruments but rather consider these together with the wide range of "second-best" options available to policy makers and evaluate the distortions specific to each of them (as suggested earlier by Meade, 1955).

To develop our argument, we analyze a two-country two-sector endowment economy in which food price volatility is generated by endowment shocks. The endowment profile is such that some agents are net food sellers while others are net food buyers. Thus, there is some scope for insurance between the two types of agents: when food prices are high, net food sellers have a positive income shock, while it is negative for net food buyers, vice and versa. In an optimal social protection policy, the former would therefore transfer resources to the latter in times of food crisis, while the opposite would hold otherwise. Such domestic policy does not necessarily have any international implication unless agents also have heterogeneous preferences over items in their consumption baskets. In particular, when social protection payments during a crisis are being made to agents with a higher propensity to consume food, this will result in an increase in aggregate domestic consumption of food, with the associated implications for world food supply and therefore prices. Domestic social protection policies when agents have

[1] http://go.worldbank.org/BUEP7C3NC0
[2] http://www.state.gov/secretary/rm/2011/05/162795.htm

heterogeneous preferences therefore result in an amplification of supply shocks. Indeed, the insurance motive constitutes a counter-cyclical demand shock that exacerbates the effect of the output shock, thereby increasing overall food price volatility. When several countries engage in similar practices, policies are strategic complements, increasing the demand for insurance and resulting in even larger price increases.

It is in this context that we analyze trade insulation policies. In a world with limited commitment, the aforementioned social protection contract may not be feasible if one party can renege on her commitment and either sell to (resp. buy from) the international consumer (resp. producer). Trade insulation is then a government intervention to enforce an implicit social protection contract in times of high food prices. Agricultural subsidies on the other hand could then be viewed as compensations when food prices are low. While we have argued that trade-based instruments are not necessarily at the root of the amplification phenomenon described above, they admittedly distort consumption patterns across countries and result in additional upward pressure on food prices. Such distortion nevertheless decreases with the extent of preference heterogeneity among agents and eventually vanishes in the degenerate case.

This paper builds on the literature that analyzes the interactions of international trade and domestic risk-sharing. In a pioneering contribution, Newbery and Stiglitz (1984) showed that trade opening can reduce the de facto domestic risk sharing by making goods prices (and hence real incomes) less sensitive to supply shocks. Our paper is closest to Eaton and Grossman (1985), who argue that when domestic insurance markets are incomplete, trade restrictions may improve welfare.[3] Unlike these contributions, we analyze the global implications of trade restrictions on the volatility of food prices. Our main argument is not so much that some trade restrictions are preferable to none. Rather, our point is that the optimal domestic policy would result in similar international outcomes as would export restrictions. Our paper therefore relates to the literature on (ex-post) food price stabilization policies (von Braun et al., 2008; Wright, 2009; Gouel and Jean, 2012) and departs from Martin and Anderson (2012) and Anderson (2012) in that we view trade restrictions as second-best implementation tools of a domestic social protection scheme. We therefore argue that international efforts to restrict trade-based instruments would make vulnerable populations at risk without necessarily mitigating food price volatility. More broadly, our paper relates to the literature on the interplay between domestic and international risk-sharing in the presence of domestic asset market frictions (Levchenko, 2005; Leblebicioglu, 2009; Broner and Ventura, 2011). A repeated finding in this literature is that an increase in international risk-sharing can lead domestic risk-

[3] Dixit (1987, 1989) challenges the view that trade may reduce welfare, or that trade restrictions may increase welfare when domestic asset markets are incomplete, by modeling explicitly the sources of domestic market incompleteness through moral hazard and adverse selection.

sharing to break down. In our model, it is greater domestic risk-sharing that leads to increased volatility internationally.

The rest of the paper is organized as follows. Section 2 lays out the foundation of the model and section 3 studies the optimal social protection policy. In section 4, we analyze trade insulation policies as government interventions to enforce an implicit social protection contract. Section 5 concludes. All the proofs are gathered in the Appendix.

2 Setting the Stage

Let's consider a two-country two-sector endowment economy. The two countries are labeled D and F for *Domestic* and *Foreign*, respectively. Agents have endowments of food and gold. There are are two types of domestic agents: a representative net food seller s with an endowment $(\Phi_s, 0)$ of food and gold, respectively, and a representative net food buyers b with endowment vector $(0, \Gamma_b)$. On the other hand, the foreign country F is populated with one representative agent i with stochastic endowment $\left(\tilde{\Phi}_i, \tilde{\Gamma}_i\right) = (\Phi_i \tilde{\varepsilon}, \Gamma_i)$, such that $\tilde{\varepsilon} = \varepsilon^h$ with probability π and $\tilde{\varepsilon} = \varepsilon^l$ with probability $1 - \pi$, where $\pi \varepsilon^h + (1 - \pi) \varepsilon^l = 1$. For the purpose of the illustration, one can assume that π is large and ε^h is not much greater than 1, while ε^l is small and implies a large negative aggregate shock on food availability, hence triggering a food price crisis.

Timing and Uncertainty The economy consists of one single time period. At the beginning of the period, consumers and producers have the ability to sign contracts. Uncertainty about *Foreign* endowments is realized, and at the end of the period, payments – if any – are made, consumption takes place and agents die.

Preferences For a given consumption bundle (f_k, g_k) of food and gold, respectively, agent $k \in \{s, b, i\}$ derives utility

$$V_k (f_k, g_k) = \alpha_k \ln f_k + (1 - \alpha_k) \ln g_k,$$

i.e. agent k has log-linear preferences over composite good $f_k^{\alpha_k} g_k^{1-\alpha_k}$; preferences for food relative to gold are therefore allowed to vary from one individual to the other. Composite good $f^{\alpha_i} g^{1-\alpha_i}$ will henceforth be the numeraire. In the rest of the paper, we will assume that $\alpha_b \geq \alpha_s$ to capture the idea that net food buyers are also putting a higher weight on food in their consumption basket.

Individual Consumption, Market Clearing and Prices As a benchmark case, agents are not allowed to contract at the beginning of the period; procurement of gold and food takes place on the international spot market at the end of the period. Prices for food and gold are denoted $(\bar{p}^\sigma, \bar{q}^\sigma)$ when $\tilde{\varepsilon} = \varepsilon^\sigma$ with $\sigma \in \{l, h\}$. Agent k dedicates a fraction α_k of her income to food consumption and the remaining to gold consumption. Since food consumption and food production equalize in equilibrium, the relative price of food to gold is therefore

$$\frac{\bar{q}^\sigma}{\bar{p}^\sigma} = \frac{(1-\alpha_s)\,\Phi_s + (1-\alpha_i)\,\Phi_i \varepsilon^\sigma}{\alpha_b \Gamma_b + \alpha_i \Gamma_i}. \tag{1}$$

Trade and Welfare Net food producing households therefore have welfare

$$\bar{V}_s^\sigma = (1-\alpha_s) \ln \frac{\bar{p}^\sigma}{\bar{q}^\sigma} + \ln \Phi_s,$$

while consumers' is equal to

$$\bar{V}_b^\sigma \quad = \quad \alpha_b \ln \frac{\bar{q}^\sigma}{\bar{p}^\sigma} + \ln \Gamma_b.$$

Turning to the foreign representative agent, his utility is simply $\bar{V}_i^\sigma = \ln(\bar{p}^\sigma \Phi_i \varepsilon^\sigma + \bar{q}^\sigma \Gamma_i)$. Subtracting total domestic consumption from total domestic food endowment (i.e. Φ_s) gives a net export level equal to:

$$\bar{X}^\sigma = \frac{\alpha_b \Gamma_b \alpha_i \Gamma_i}{\alpha_b \Gamma_b + \alpha_i \Gamma_i} \left(\frac{1-\alpha_s}{\alpha_b} \frac{\Phi_s}{\Gamma_b} - \frac{1-\alpha_i}{\alpha_i} \frac{\Phi_i}{\Gamma_i} \varepsilon^\sigma \right). \tag{2}$$

3 Social Protection

Focusing on domestic agents, we note that net food sellers and buyers face income uncertainty and since a positive shock for one is a negative shock for the other, there is scope for mutual insurance. We will refer to the domestic insurance scheme as social protection. Although social protection programs often have a redistribution component built-in so that payments are not necessarily state-dependent, we restrict to the insurance part of these policies. Food voucher programs that are being implemented in times of crisis or the equivalent cash transfer programs, workfare programs in that they are being taken up when market wages drop below the program's proposed wage, would therefore fall into the category of schemes being considered in this analysis.

3.1 Arrow-Debreu Securities

We view a social protection program as the implementation of the allocation of resources that domestic agents would achieve if they were given the opportunity to purchase Arrow-Debreu securities at the beginning of the period. The price of an Arrow-Debreu security that pays out one unit of food in state of the world h (resp. l) is denoted πp^h (resp. $(1-\pi)\, p^l$). Similarly the price of an Arrow-Debreu security that pays out one unit of gold is denoted πq_h and $(1-\pi)\, q^l$ in states h and l, respectively.

Domestic agents Domestic agent $k = s, b$ chooses her consumption bundle $(f_k^\sigma, g_k^\sigma)_{\sigma=h,l}$ to maximizes her welfare

$$W_k\left(f_k^h, g_k^h, f_k^l, g_k^l\right) = \pi V_k\left(f_k^h, g_k^h\right) + (1-\pi)\, V_k\left(f_k^l, g_k^l\right)$$

subject to budget constraint

$$\pi\left(p^h f_s^h + q^h g_s^h\right) + (1-\pi)\left(p^l f_s^l + q^l g_s^l\right) \leq \left[\pi p^h + (1-\pi)\, p^l\right] \Phi_s \tag{3}$$

for net food sellers, and similarly

$$\pi\left(p^h f_b^h + q^h g_b^h\right) + (1-\pi)\left(p^l f_b^l + q^l g_b^l\right) \leq \left[\pi q^h + (1-\pi)\, q^l\right] \Gamma_b \tag{4}$$

for net food buyers.

Finally, at the heart of this paper is the inability of aggregate risk to be smoothed, so that we require an additional trade balance condition, i.e. for $\sigma = l, h$

$$p^\sigma\left(f_s^\sigma + f_b^\sigma\right) + q^\sigma\left(g_s^\sigma + g_b^\sigma\right) \leq p^\sigma \Phi_s + q^\sigma \Gamma_b. \tag{5}$$

Foreign agents Foreign agents do not have access to the insurance market, and therefore maximize their welfare

$$W_i\left(f_i^h, g_i^h, f_i^l, g_i^l\right) = \pi V_i\left(f_i^h, g_i^h\right) + (1-\pi)\, V_i\left(f_i^l, g_i^l\right)$$

subject to budget constraint

$$p^\sigma f_i^\sigma + q^\sigma g_i^\sigma \leq p^\sigma \Phi_i + q^\sigma \Gamma_i \tag{6}$$

for $\sigma = h, l$.

3.2 Optimal social protection policy

Equilibrium definition An equilibrium is a price vector $\{(p^\sigma, q^\sigma)\}_{\sigma\in\{h,l\}}$ such that consumption choices are the solutions to the maximization of agents' utilities subject to their respective budget constraints (3), (4) and (6). Furthermore, trade balance condition (5) holds and food and gold markets clear.

We now turn to the characterization of the equilibrium of the economy. For expositional simplicity, we can rewrite food sellers' budget constraint as a within-state-of-the-world budget constraint

$$p^\sigma f_s^\sigma + q^\sigma g_s^\sigma \leq p^\sigma \left(\Phi_s + \phi_s^\sigma\right) \tag{7}$$

with a between-state-of-the-world budget constraint that ϕ_s^σ must satisfy, i.e.

$$\pi p^h \phi_s^h + (1-\pi)\, p^l \phi_s^l \leq 0. \tag{8}$$

Similarly for net food buyers, their budget constraint can be rewritten as

$$p^\sigma f_b^\sigma + q^\sigma g_b^\sigma \leq q^\sigma \left(\Gamma_b + \gamma_b^\sigma\right) \tag{9}$$

where γ_b^σ verifies

$$\pi q^h \gamma_b^h + (1-\pi)\, q^l \gamma_b^l \leq 0. \tag{10}$$

Transfers ϕ_s^σ and γ_b^σ could be interpreted as insurance payments made to or from agents in state of the world σ. For simplicity and without loss of generality, we henceforth assume that food sellers have insurance payments made in food, while food buyers have insurance payments made in gold. When conditions (8) and (10) are binding, insurance policies are actuarially fair.

The budget constraints then pin down to

$$p^\sigma \phi_s^\sigma + q^\sigma \gamma_b^\sigma \leq 0 \tag{11}$$

for $\sigma = h, l$.

Consumer optimization and the demand for insurance $\{(\hat{p}^\sigma, \hat{q}^\sigma)\}_{\sigma\in\{h,l\}}$ refers to the equilibrium price vector. Consumer k spends a share α_k of her state-contingent post-transfer income on food, and the remaining $1-\alpha_k$ on gold, so that her budget constraint is binding. Furthermore, since insurance contracts are actuarially fair in equilibrium, for every equilibrium insurance policy schedule $\left(\hat{\phi}_s^\sigma, \hat{\gamma}_b^\sigma\right)$, we denote $\hat{\phi} = -\hat{\phi}_s^l$ the premium paid by food sellers in times of a food crisis, and $\hat{\gamma} = -\hat{\gamma}_b^h$, the premium paid by food buyers in "normal" times, so that $\hat{\phi}_s^h = \frac{1-\pi}{\pi} \frac{\hat{p}^l}{\hat{p}^h} \hat{\phi}$, and $\hat{\gamma}_b^l = \frac{\pi}{1-\pi} \frac{\hat{q}^h}{\hat{q}^l} \hat{\gamma}$. Domestic agents' indirect utilities are therefore given by $\hat{W}_s\left(\hat{\phi}\right)$ and $\hat{W}_b\left(\hat{\gamma}\right)$, respectively, with

$$\hat{W}_s(\phi) = (1-\alpha_s)\left[\pi \ln \frac{\hat{p}^h}{\hat{q}^h} + (1-\pi) \ln \frac{\hat{p}^l}{\hat{q}^l}\right] + \pi \ln\left(\Phi_s + \frac{1-\pi}{\pi} \frac{\hat{p}^l}{\hat{p}^h} \phi\right) + (1-\pi) \ln(\Phi_s - \phi),$$

for net food sellers, and for net food buyers, we have

$$\hat{W}_b(\gamma) = -\alpha_b\left[\pi \ln \frac{\hat{p}^h}{\hat{q}^h} + (1-\pi) \ln \frac{\hat{p}^l}{\hat{q}^l}\right] + \pi \ln(\Gamma_b - \gamma) + (1-\pi) \ln\left(\Gamma_b + \frac{\pi}{1-\pi} \frac{\hat{q}^h}{\hat{q}^l} \gamma\right).$$

Domestic agents choose their insurance policies to equalize their marginal utilities of consumption across states of the world, defining "demand for insurance" curves:

$$\begin{cases} \hat{\phi} = \pi\left(1 - \frac{\hat{p}^h}{\hat{p}^l}\right)\Phi_s \\ \hat{\gamma} = (1-\pi)\left(1 - \frac{\hat{q}^l}{\hat{q}^h}\right)\Gamma_b \end{cases}. \tag{12}$$

As expected, the demand for insurance increases with the price difference between the two states of the world.

Market clearing, trade balance and equilibrium insurance and price levels Food market clearing implies that world food consumption and world food endowment equalize, i.e.

$$\alpha_s \hat{\phi}_s^\sigma + \frac{\hat{q}^\sigma}{\hat{p}^\sigma}\left(\alpha_b \Gamma_b + \alpha_i \Gamma_i + \alpha_b \hat{\gamma}_b^\sigma\right) = (1-\alpha_s)\Phi_s + (1-\alpha_i)\Phi_i \varepsilon^\sigma,$$

and given the trade balance condition, $\frac{\hat{q}^\sigma}{\hat{p}^\sigma} \hat{\gamma}_b^\sigma = -\hat{\phi}_s^\sigma$, relative prices are thus

$$\frac{\hat{q}^\sigma}{\hat{p}^\sigma} = \frac{\bar{q}^\sigma}{\bar{p}^\sigma} + \frac{1}{\alpha_b \Gamma_b + \alpha_i \Gamma_i}(\alpha_b - \alpha_s)\hat{\phi}_s^\sigma. \tag{13}$$

When $\sigma = l$, the world economy experiences an aggregate food shortage pushing food prices up. By shifting wealth from individuals who value food less to individuals who value food more, domestic insurance policies induce aggregate demand for food to increase, inducing an additional upward pressure on food prices as captured in (13). The general equilibrium effect is all the stronger than preference heterogeneity is more pronounced. For the rest of the paper, we assume that $\alpha_b > \alpha_s$, so that net food buyers are also those who put a higher weight on food in their consumption basket.

To fully characterize the equilibrium of the economy, we need to solve for prices and insurance policies. To do so, we have the demand functions defined in (12), the market clearing and trade balance conditions. The following proposition characterizes the equilibrium of the economy.

Proposition 1: Optimal Social Protection The unique equilibrium of the economy is characterized by the following social protection policy:

In times of food crises (i.e. $\tilde{\varepsilon} = \varepsilon^l$), net food producers transfer an amount

$$\hat{\phi}_s^l = -\pi \frac{\left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)\Phi_s}{\left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right) - (\alpha_b - \alpha_s)\frac{\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}, \tag{14}$$

of food to net food consumers, and in "normal" times (i.e. $\tilde{\varepsilon} = \varepsilon^h$), therefore receive

$$\hat{\phi}_s^h = (1-\pi)\frac{\left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)\Phi_s}{\left(\frac{\bar{q}^l}{\bar{p}^l} + \frac{\Phi_s}{\Gamma_b}\right) - (\alpha_b - \alpha_s)\frac{\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}$$

in return, where relative prices $\left(\frac{\bar{q}^\sigma}{\bar{p}^\sigma}\right)_{\sigma\in\{h,l\}}$ are defined in (1). Equilibrium prices adjust according to (13).■

The optimal social protection scheme is the intersection of a "demand for insurance" curve and a "food supply curve". The higher the price difference between the two states of the world, the larger the insurance motive. On the other hand, as agents insure themselves against food price shocks, the supply shock is exacerbated since *Domestic* demand is higher subsequently to a wealth redistribution from food producers who value food relatively less to food consumers who value food relatively more. Such additional effect further increases the optimal level of social protection as indicated in (14).

3.3 The n country case

We extend the analysis to the case of n identical exporting countries to a large foreign market, the size of which is also assumed to grow linearly with n. Among these n countries, we denote by $m \leq n$, the number of countries that actually implement a social protection policy as described above and we denote $\theta = \frac{m}{n}$ the fraction of countries that implement a social protection scheme. Since agents are price takers, the demand for insurance remains identical and determined by (12). Relative prices are however changed and for expositional simplicity, we focus on prices in times of food crisis, i.e. $\sigma = l$, and denote by $\hat{\phi}_\theta$ the optimal insurance policy when θn countries decide to implement a social protection scheme. Recall that $\hat{\phi}_\theta$ is the transfer made from net food producers in a given country to net food consumers of that same country and that transfers in other states of the world are defined by conditions (7) to (11) being binding. Prices are now equal to

$$\frac{\hat{q}^l}{\hat{p}^l} = \frac{\bar{q}^l}{\bar{p}^l} - \frac{\theta}{\alpha_b \Gamma_b + \alpha_i \Gamma_i} \left(\alpha_b - \alpha_s\right) \hat{\phi}_\theta. \tag{15}$$

How will agents in each country choose their social protection levels? As pointed out in Proposition 1, optimal insurance schemes depend on price levels that in turn depend on equilibrium levels of contingent transfers.

Proposition 2: Optimal Social Protection with Multiple Countries The optimal social protection policy $\hat{\phi}_\theta$ is given by

$$\hat{\phi}_\theta = \frac{\pi \left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{\theta(\alpha_b - \alpha_s)}{\alpha_b \Gamma_b + \alpha_i \Gamma_i}}$$

■

As the number of countries implementing social protection policies increases, the upward pressure applied on prices further increases the scope for insuring food consumers more. This pecuniary externality exacerbates the effect of social protection on food prices that increase more than linearly as the number of "participating" countries increases. To look at the welfare implications for domestic consumers of a given country as θ grows closer to 1, we assume that shocks are small enough so that second order effects are negligible. Formally, we notice that $\hat{\phi}_\theta$ converges to zero as the magnitude of the output shock goes to zero (i.e. ε^l gets arbitrarily close to 1), uniformly with respect to θ. Net food consumers' welfare levels

$$\hat{V}_b\left(\theta\right) = \alpha_b \ln \frac{\hat{q}^l}{\hat{p}^l} + \ln\left(\Gamma_b + \frac{\hat{p}^l}{\hat{q}^l}\hat{\phi}_\theta\right)$$

can be written as

$$\hat{V}_b\left(\theta\right) = \left[\alpha_b \ln \frac{\bar{q}^l}{\bar{p}^l} + \ln \Gamma_b\right] + \frac{\bar{p}^l}{\bar{q}^l}\frac{\hat{\phi}_\theta}{\Gamma_b}\left[1 - \theta \frac{\alpha_b \Gamma_b}{\alpha_b \Gamma_b + \alpha_i \Gamma_i}\left(\alpha_b - \alpha_s\right)\right] + o\left(1 - \varepsilon^l\right), \tag{16}$$

where $o\left(1-\varepsilon^l\right)$ is a continuous function of $1-\varepsilon^l$, such that $\lim_{\varepsilon^l \to 1} \frac{o\left(1-\varepsilon^l\right)}{1-\varepsilon^l} = 0$. As θ grows, net food consumers receive an increasing social protection payment $\hat{\phi}_\theta$, the welfare benefit of which is mitigated (or offset) by higher prices. The first term in (16) is the baseline welfare level, while the second term capture the income net of substitution effect. The following proposition establishes the conditions under which one effect dominates the other:

Proposition 3: Social Protection and Welfare As the number of countries θ implementing optimal social protection schemes increases, welfare of net food consumers in state of the world $\sigma = l$ increases if and only if *Domestic* is a net food exporter, i.e.

$$\frac{1-\alpha_s}{\alpha_b}\frac{\Phi_s}{\Gamma_b} > \frac{1-\alpha_i}{\alpha_i}\frac{\Phi_i}{\Gamma_i}\varepsilon^l.$$

■

For food exporting (resp. importing) countries, as θ goes up, so does the price of food, inducing a positive (resp. negative) wealth effect. Thus, aggregate income increases in exporting countries, while it decreases in importing countries; for net food consumers in exporting countries, the welfare gain from increased social protection transfers ends up exceeding the loss due to higher food prices.

3.4 Discussion

Aggregate price volatility creates demand for insurance for domestic consumers. In the optimal social protection contract, wealth is transferred from net food producers to net food consumers in times of high food prices. However, such transfer might not be neutral in terms of aggregate consumption when agents have heterogeneous preferences over consumption goods. In particular, when resources are transferred to individuals with a higher propensity to spend on food, it results in an increase in aggregate food consumption, with the associated price implications.

The model therefore produces a counter-cyclical demand shock stemming from agents' insurance motive: the consequences of an aggregate supply shock are exacerbated by a concomitant demand shock due to the implementation of social protection policies that end up increasing the share of food in national consumption. Thus, under some parameter configurations – namely $\alpha_b > \alpha_s$ – an optimal domestic social protection policy would qualify as a "beggar-thy-neighbor" policy in that it further reduces the quantity of food available on international markets. As expected, the amplification of price shocks is further enhanced as more countries engage in similar social protection policies. Finally, such counter-cyclical demand shock further results in an overall increased food price volatility, since in "normal" times ($\sigma = h$), the aggregate demand for food also drops, driving food prices further down.

4 Trade Insulation

The previous section characterized the optimal insurance contract that domestic agents are willing to sign in a world with perfect commitment and no transaction costs. If insurance contracts cannot be enforced, then one party has an incentive to renege depending on the realization of the output shock. The insurance market therefore collapses. Trade insulation can then be considered as a government-provided alternative enforcement of a social protection in states of the world where countries face a food crisis, i.e. $\tilde{\varepsilon} = \varepsilon^l$. Admittedly, such instrument will come with distortions that are the focus of the analysis in this section. When on the other hand$\tilde{\varepsilon} = \varepsilon^h$, governments can resort to various forms of agricultural subsidies (input subsidies, credit...) as the medium through which agricultural households, i.e. net food sellers, receive compensations within the context of a broader social protection contract.

4.1 Export Restrictions and Equilibrium Prices

We restrict ourselves to the case of food exporting countries and define X, the quota on exports from *Domestic* to *Foreign*. Alternatively, the analysis applies to importing countries too and the results are unchanged whether quantity or price restrictions are being put into place. There are now two sets of prices; international prices (prices paid by foreign consumers) $\left(\ddot{p}^l, \ddot{q}^l\right)$, while domestic prices are denoted $\left(\dot{p}^l, \dot{q}^l\right)$.

Looking at the foreign country, the trade balance and food market clearing conditions pin down the international price ratio, i.e. $\frac{\ddot{q}^l}{\ddot{p}^l} = \frac{\alpha_i \Gamma_i}{(1-\alpha_i)\Phi_i \varepsilon^l + X}$, that we can rewrite

$$\frac{\ddot{q}^l}{\ddot{p}^l} = \frac{\bar{q}^l}{\bar{p}^l} - \frac{1}{\alpha_i \Gamma_i}\left(\bar{X} - X\right) \tag{17}$$

The effect of a quantitative food export restriction affects the relative price of food in two ways: it both decreases the international supply of food, and at the same time, since trade should balance in equilibrium, it increases the international supply of gold, making food even more expensive relative to gold.

On the other hand, for a given export quota X, domestic food sellers have income $\dot{p}^l\left(\Phi_s - X\right) + \ddot{p}^l X$. The domestic food market clearing condition can therefore be expressed as

$$\alpha_s\left(\Phi_s - X\right) + \alpha_s \frac{\ddot{p}^l}{\dot{p}^l} X + \alpha_b \frac{\dot{q}^l}{\dot{p}^l} \Gamma_b = \Phi_s - X$$

and since the prices of gold equalize across markets, the above condition pins down to

$$\frac{\dot{q}^l}{\dot{p}^l} = \frac{(1-\alpha_s)(\Phi_s - X)}{\alpha_s \frac{\ddot{p}^l}{\ddot{q}^l} X + \alpha_b \Gamma_b}, \tag{18}$$

with the price ratio $\frac{\ddot{p}^l}{\ddot{q}^l}$ defined in (17).

4.2 Trade Insulation as Social Protection

To evaluate the ability of trade policy to act as a substitute for social insurance, let's consider the optimal social insurance policy $\hat{\phi}$, and choose a level of export quota $\dot{X}$ that keeps domestic food buyers at identical welfare level.

Trade insulation as social protection Recall that under a social insurance contract, net food buyers have welfare

$$\hat{V}_b^l = -\alpha_b \ln \frac{\hat{p}^l}{\hat{q}^l} + \ln \left(\Gamma_b + \frac{\hat{p}^l}{\hat{q}^l} \hat{\phi} \right)$$

in times of high food prices. Considering small aggregate food shocks, i.e. $\left|1 - \varepsilon^l\right| \ll 1$, we can rewrite food buyers' welfare as

$$\hat{V}_b^l = -\alpha_b \ln \frac{\bar{p}^l}{\bar{q}^l} + \ln \Gamma_b + \alpha_b \hat{\eta} \hat{\phi} + o\left(1 - \varepsilon^l\right), \tag{19}$$

where

$$\hat{\eta} = \frac{\bar{p}^l}{\bar{q}^l} \left[\frac{1}{\alpha_b \Gamma_b} - (\alpha_b - \alpha_s) \frac{1}{\alpha_b \Gamma_b + \alpha_i \Gamma_i} \right].$$

As we saw previously, any income transfer to a net food buyer translates into a commensurate welfare increase $\frac{\bar{p}^l}{\bar{q}^l} \frac{1}{\alpha_b \Gamma_b}$, but given general equilibrium implications, welfare is however reduced by higher food prices since $\alpha_b > \alpha_s$.

On the other hand, for a given export quota X, net food buyers have welfare level

$$\dot{V}_b^l(X) = -\alpha_b \ln \frac{\dot{p}^l}{\dot{q}^l} + \ln \Gamma,$$

where prices are given by (17) and (18). Similarly to the case above, if we assume small output shocks, the scope for trade policy vanishes, so that we can write $o\left(1 - \frac{X}{X^l}\right) = o\left(1 - \varepsilon^l\right)$. We can thus linearize domestic prices and write

$$\frac{\dot{q}^l}{\dot{p}^l} = \frac{\bar{q}^l}{\bar{p}^l} \left[1 + \dot{\eta} \left(\bar{X}^l - X \right) \right] + o\left(1 - \varepsilon^l\right),$$

with $\dot{\eta} = -\frac{\bar{p}^l}{\bar{q}^l}\frac{\partial}{\partial X}\left(\frac{\dot{q}^l}{\dot{p}^l}\right)_{X=\bar{X}^l}$. The derivation of $\dot{\eta}$ yields

$$\dot{\eta} = \frac{(1-\alpha_s) + \alpha_s\left[1 - \frac{\bar{p}}{\bar{q}}\frac{\bar{X}^l}{\alpha_i\Gamma_i}\right]}{(1-\alpha_s)\left(\Phi_s - \bar{X}^l\right)}.$$

This implies, for net buyers' welfare,

$$\dot{V}_b^l(X) = -\alpha_b \ln\frac{\bar{p}^l}{\bar{q}^l} + \ln\Gamma_b + \alpha_b\dot{\eta}\left(\bar{X}^l - X\right) + o\left(1-\varepsilon^l\right). \tag{20}$$

Equalizing (19) with (20) and henceforth omitting reference to smaller order terms, quota $\dot{X}^l$ verifies

$$\dot{X}^l = \bar{X}^l - \frac{\hat{\eta}}{\dot{\eta}}\hat{\phi}. \tag{21}$$

Beggar thy neighbor We now look at what distortions are being induced by such trade insulation as opposed to an insurance contract. International prices are thus given by

$$\frac{\ddot{q}^l}{\ddot{p}^l} = \frac{\bar{q}^l}{\bar{p}^l} - \frac{1}{\alpha_i\Gamma_i}\left(\bar{X}^l - \dot{X}\right) = \frac{\bar{q}^l}{\bar{p}^l} - \frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}\hat{\phi},$$

while in the social insurance case,

$$\frac{\hat{q}^l}{\hat{p}^l} = \frac{\bar{q}^l}{\bar{p}^l} - \frac{1}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}(\alpha_b - \alpha_s)\hat{\phi}$$

so that

$$\frac{\hat{q}^l}{\hat{p}^l} - \frac{\ddot{q}^l}{\ddot{p}^l} = \left[\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}} - \frac{\alpha_b - \alpha_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}\right]\hat{\phi},$$

which, after plugging in the values of $\hat{\eta}$ and $\dot{\eta}$ and rearranging, pins down to

$$\frac{\hat{q}^l}{\hat{p}^l} - \frac{\ddot{q}^l}{\ddot{p}^l} = \frac{\alpha_b\bar{q}^l\Gamma_b + \alpha_s\bar{p}^l\bar{X}^l}{\alpha_i\bar{q}^l\Gamma_i - \alpha_s\bar{p}^l\bar{X}^l}\left[1 - (\alpha_b - \alpha_s)\frac{\alpha_b\bar{q}^l\Gamma_b}{\alpha_s\bar{p}^l\bar{X}^l + \alpha_b\bar{q}^l\Gamma_b}\right]\frac{\hat{\phi}}{\alpha_b\Gamma_b}$$

This leads us to the following proposition:

Proposition 4: Welfare loss from trade insulation Comparing with an economy where *Domestic* implements an optimal social protection policy, the enforcement of export quota $\dot{X}^l$ as defined by (21) comes at a welfare loss

$$\Delta V_i^l = \frac{\bar{p}^l}{\bar{q}^l}\frac{\alpha_i\bar{q}^l\Gamma_i - (1-\alpha_i)\bar{p}^l\Phi_i\varepsilon^l}{\bar{p}^l\Phi_i\varepsilon^l + \bar{q}^l\Gamma_i}\frac{\alpha_b\bar{q}^l\Gamma_b + \alpha_s\bar{p}^l\bar{X}^l}{\alpha_i\bar{q}^l\Gamma_i - \alpha_s\bar{p}^l\bar{X}^l}\left[1 - (\alpha_b - \alpha_s)\frac{\alpha_b\bar{q}^l\Gamma_b}{\alpha_s\bar{p}^l\bar{X}^l + \alpha_b\bar{q}^l\Gamma_b}\right]\frac{\hat{\phi}}{\alpha_b\Gamma_b}$$

to international consumers.

Furthermore, ΔV_i^l goes to zero as preference heterogeneity $(\alpha_b - \alpha_s)$ becomes arbitrarily close to 1.■

Trade insulation as a "second-best" substitute for the optimal social protection scheme comes with a price distortion since *Domestic* and *Foreign* prices now diverge. This induces *Domestic* agents to over-consume food while *Foreign* agents under-consume. However, as preference heterogeneity increases, the relative loss to international consumers decreases and eventually vanishes in the extreme case where food buyers only value food, and food sellers only value gold; in such degenerate case, the inefficiency disappears since there is no longer scope for the substitution effect to operate.

5 Concluding Remarks

We argued above that trade insulation policies are not necessary to exacerbate food price shocks. Instead, trade policies are viewed as a mere instrument used to implement an underlying optimal social protection scheme. Such use of trade policy comes with some price distortions that need to be evaluated against distortions generated by alternative schemes. However, a priori there are no theoretical grounds for trade-based instruments to be systematically dominated by "free trade" alternatives from either domestic or international perspectives.

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A Proofs

A.1 Proof of Proposition 1

Trade balance and the condition that insurance premia must be actuarially fair implies that in equilibrium

$$\frac{\pi}{1-\pi}\frac{\hat{q}^h}{\hat{q}^l}\frac{\hat{q}^l}{\hat{p}^l}\hat{\gamma} = \hat{\phi}.$$

Plugging in the equilibrium values of $\hat{\phi}$ and $\hat{\gamma}$ obtained from (12) implies

$$\pi\left(1-\frac{\hat{p}^h}{\hat{p}^l}\right)\Phi_s = \frac{\pi}{1-\pi}\frac{\hat{q}^h}{\hat{q}^l}\frac{\hat{q}^l}{\hat{p}^l}(1-\pi)\left(1-\frac{\hat{q}^l}{\hat{q}^h}\right)\Gamma_b$$

or

$$\frac{\hat{q}^h}{\hat{q}^l} = 1-\frac{\hat{p}^h}{\hat{q}^h}\left(\frac{\hat{p}^l}{\hat{p}^h}-1\right)\frac{\Phi_s}{\Gamma_b}$$

Furthermore, the following identity holds:

$$\frac{\hat{q}^l}{\hat{q}^h} = \frac{\hat{q}^l}{\hat{p}^l}\frac{\hat{p}^l}{\hat{p}^h}\frac{\hat{p}^h}{\hat{q}^h}$$

so that

$$\frac{\hat{q}^l}{\hat{p}^l}\frac{\hat{p}^l}{\hat{p}^h}\frac{\hat{p}^h}{\hat{q}^h} = 1-\frac{\hat{p}^h}{\hat{q}^h}\left(\frac{\hat{p}^l}{\hat{p}^h}-1\right)\frac{\Phi_s}{\Gamma_b}$$

that we can rewrite:

$$\frac{\hat{p}^l}{\hat{p}^h} = \left(\frac{\hat{q}^h}{\hat{p}^h}+\frac{\Phi_s}{\Gamma_b}\right)\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)^{-1}$$

We can now plug in the expressions for the relative prices as given by (13)

$$\begin{aligned}\frac{\hat{p}^l}{\hat{p}^h} &= \left(\frac{(1-\alpha_s)\,\Phi_s+(1-\alpha_i)\,\Phi_i\varepsilon^h+(\alpha_b-\alpha_s)\,\frac{1-\pi}{\pi}\frac{\hat{p}^l}{\hat{p}^h}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}+\frac{\Phi_s}{\Gamma_b}\right)\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)^{-1}\\ &= \left(\frac{(1-\alpha_s)\,\Phi_s+(1-\alpha_i)\,\Phi_i\varepsilon^h}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}+\frac{\Phi_s}{\Gamma_b}+\frac{(\alpha_b-\alpha_s)\,\frac{1-\pi}{\pi}\frac{\hat{p}^l}{\hat{p}^h}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\right)\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)^{-1}\end{aligned}$$

so that

$$\frac{\hat{p}^l}{\hat{p}^h}\left[1-\frac{(\alpha_b-\alpha_s)\,\frac{1-\pi}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)^{-1}\right] = \left(\frac{(1-\alpha_s)\,\Phi_s+(1-\alpha_i)\,\Phi_i\varepsilon^h}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}+\frac{\Phi_s}{\Gamma_b}\right)\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)^{-1}$$

which can be rearranged as

$$\frac{\hat{p}^l}{\hat{p}^h}\left[\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)-\frac{(\alpha_b-\alpha_s)\frac{1-\pi}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\right]=\frac{(1-\alpha_s)\,\Phi_s+(1-\alpha_i)\,\Phi_i\varepsilon^h}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}+\frac{\Phi_s}{\Gamma_b}$$

or

$$\frac{\hat{p}^l}{\hat{p}^h}=\left[\frac{(1-\alpha_s)\,\Phi_s+(1-\alpha_i)\,\Phi_i\varepsilon^h}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}+\frac{\Phi_s}{\Gamma_b}\right]\left[\left(\frac{\hat{q}^l}{\hat{p}^l}+\frac{\Phi_s}{\Gamma_b}\right)-\frac{(\alpha_b-\alpha_s)\frac{1-\pi}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\right]^{-1}$$

Taking the definition of benchmark no-commitment prices, we can write

$$\frac{\hat{p}^l}{\hat{p}^h}=\frac{\frac{\bar{q}^h}{\bar{p}^h}+\frac{\Phi_s}{\Gamma_b}}{\frac{\bar{q}^l}{\bar{p}^l}+\frac{\Phi_s}{\Gamma_b}-\frac{(\alpha_b-\alpha_s)\frac{1}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}}. \tag{22}$$

Equation (22) defines a "food price volatility" curve, while (12) defines a demand for insurance curve that we rewrite

$$\begin{cases}\frac{\hat{p}^h}{\hat{p}^l} & =1-\frac{\hat{\phi}}{\pi\Phi_s}\\ \frac{\hat{p}^h}{\hat{p}^l} & =\left(\frac{\bar{q}^h}{\bar{p}^h}+\frac{\Phi_s}{\Gamma_b}\right)^{-1}\left[\frac{\bar{q}^l}{\bar{p}^l}+\frac{\Phi_s}{\Gamma_b}-\frac{(\alpha_b-\alpha_s)\frac{1}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\right]\end{cases}$$

Substituting:

$$\begin{aligned}\left(1-\frac{\hat{\phi}}{\pi\Phi_s}\right)\left(\frac{\bar{q}^h}{\bar{p}^h}+\frac{\Phi_s}{\Gamma_b}\right) &= \frac{\bar{q}^l}{\bar{p}^l}+\frac{\Phi_s}{\Gamma_b}-\frac{(\alpha_b-\alpha_s)\frac{1}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\\ \frac{\bar{q}^h}{\bar{p}^h}+\frac{\Phi_s}{\Gamma_b}-\frac{\hat{\phi}}{\pi\Phi_s}\left(\frac{\bar{q}^h}{\bar{p}^h}+\frac{\Phi_s}{\Gamma_b}\right) &= \frac{\bar{q}^l}{\bar{p}^l}+\frac{\Phi_s}{\Gamma_b}-\frac{(\alpha_b-\alpha_s)\frac{1}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\\ \frac{\bar{q}^h}{\bar{p}^h}-\frac{\hat{\phi}}{\pi\Phi_s}\left(\frac{\bar{q}^h}{\bar{p}^h}+\frac{\Phi_s}{\Gamma_b}\right) &= \frac{\bar{q}^l}{\bar{p}^l}-\frac{(\alpha_b-\alpha_s)\frac{1}{\pi}\hat{\phi}}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\\ \frac{1}{\pi}\hat{\phi}\left[\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s}+\frac{1}{\Gamma_b}\right)-\frac{(\alpha_b-\alpha_s)}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\right] &= \left(\frac{\bar{q}^h}{\bar{p}^h}-\frac{\bar{q}^l}{\bar{p}^l}\right)\end{aligned}$$

so that

$$\hat{\phi}=\frac{\pi\left(\frac{\bar{q}^h}{\bar{p}^h}-\frac{\bar{q}^l}{\bar{p}^l}\right)}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s}+\frac{1}{\Gamma_b}\right)-\frac{(\alpha_b-\alpha_s)}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}},$$

which concludes the first part of the proof.

Plugging in the value of $\hat{\phi}$ to (12) yields:

$$
\begin{aligned}
\frac{\hat{p}^h}{\hat{p}^l} &= 1 - \frac{\hat{\phi}}{\pi \Phi_s} \\
&= 1 - \frac{\left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)}{\left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}} \\
&= \frac{\left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i} - \left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)}{\left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}} \\
\frac{\hat{p}^h}{\hat{p}^l} &= \frac{\left(\frac{\bar{q}^l}{\bar{p}^l} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}{\left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}
\end{aligned}
$$

We can now substitute in the expression for $\hat{\phi}_s^h$:

$$
\begin{aligned}
\hat{\phi}_s^h &= \frac{1-\pi}{\pi} \frac{\hat{p}^l}{\hat{p}^h} \hat{\phi} \\
&= \frac{1-\pi}{\pi} \frac{\left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}{\left(\frac{\bar{q}^l}{\bar{p}^l} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}} \frac{\pi\left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}} \\
\hat{\phi}_s^h &= \frac{(1-\pi)\left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)\Phi_s}{\left(\frac{\bar{q}^l}{\bar{p}^l} + \frac{\Phi_s}{\Gamma_b}\right) - \frac{(\alpha_b - \alpha_s)\Phi_s}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}},
\end{aligned}
$$

which concludes the proof of Proposition 1.■

B Proof of Proposition 2

The expression for the ratio of food prices is unchanged and equal to

$$
\frac{\hat{p}^l}{\hat{p}^h} = \left(\frac{\hat{q}^h}{\hat{p}^h} + \frac{\Phi_s}{\Gamma_b}\right)\left(\frac{\hat{q}^l}{\hat{p}^l} + \frac{\Phi_s}{\Gamma_b}\right)^{-1}
$$

Since only aggregate endowment is affected, we can now plug in the expressions for the relative prices as given by (15)

$$
\frac{\hat{p}^l}{\hat{p}^h} = \left(\frac{(1-\alpha_s)\Phi_s + (1-\alpha_i)\Phi_i\varepsilon^h + \theta(\alpha_b - \alpha_s)\frac{1-\pi}{\pi}\frac{\hat{p}^l}{\hat{p}^h}\hat{\phi}_\theta}{\alpha_b\Gamma_b + \alpha_i\Gamma_i} + \frac{\Phi_s}{\Gamma_b}\right)\left(\frac{\hat{q}^l}{\hat{p}^l} + \frac{\Phi_s}{\Gamma_b}\right)^{-1}
$$

or, following the same steps as earlier in the proof of Proposition 1,

$$\frac{\hat{p}^l}{\hat{p}^h} = \frac{\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}}{\frac{\bar{q}^l}{\bar{p}^l} + \frac{\Phi_s}{\Gamma_b} - \frac{\theta(\alpha_b - \alpha_s)\frac{1}{\pi}\hat{\phi}_\theta}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}. \tag{23}$$

Similarly, equation (23) defines a "food price volatility" curve, while (12) defines a demand for insurance curve that we rewrite

$$\begin{cases} \frac{\hat{p}^h}{\hat{p}^l} & = 1 - \frac{\hat{\phi}_\theta}{\pi\Phi_s} \\ \frac{\hat{p}^h}{\hat{p}^l} & = \left(\frac{\bar{q}^h}{\bar{p}^h} + \frac{\Phi_s}{\Gamma_b}\right)^{-1}\left[\frac{\bar{q}^l}{\bar{p}^l} + \frac{\Phi_s}{\Gamma_b} - \frac{\theta(\alpha_b - \alpha_s)\frac{1}{\pi}\hat{\phi}_\theta}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}\right] \end{cases}$$

to finally obtain

$$\hat{\phi}_\theta = \frac{\pi\left(\frac{\bar{q}^h}{\bar{p}^h} - \frac{\bar{q}^l}{\bar{p}^l}\right)}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{\theta(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}},$$

which concludes the proof.■

C Proof of Proposition 3

Taking the derivative of $\hat{V}_b^l(\theta)$ with respect to θ gives

$$\begin{aligned}
\frac{d\hat{V}_b^l(\theta)}{d\theta} &= \frac{\bar{p}^l}{\bar{q}^l}\frac{\hat{\phi}_\theta}{\Gamma_b}\left\{\frac{\hat{\phi}'_\theta}{\hat{\phi}_\theta}\left[1 - \theta\frac{\alpha_b\Gamma_b}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}(\alpha_b - \alpha_s)\right] - \frac{\alpha_b\Gamma_b}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}(\alpha_b - \alpha_s)\right\} \\
&= \frac{\bar{p}^l}{\bar{q}^l}\frac{\hat{\phi}_\theta}{\Gamma_b}\left\{\frac{\frac{(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{\theta(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}\left[1 - \theta\frac{\alpha_b\Gamma_b}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}(\alpha_b - \alpha_s)\right] - \frac{\alpha_b\Gamma_b}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}(\alpha_b - \alpha_s)\right\} \\
&= \frac{\frac{\bar{p}^l}{\bar{q}^l}\frac{\hat{\phi}_\theta}{\Gamma_b}\frac{(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{\theta(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}\left\{\left[1 - \theta\frac{\alpha_b\Gamma_b}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}(\alpha_b - \alpha_s)\right] - \alpha_b\Gamma_b\left[\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{\theta(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}\right]\right\} \\
&= \frac{\frac{\bar{p}^l}{\bar{q}^l}\frac{\hat{\phi}_\theta}{\Gamma_b}\frac{(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}{\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right) - \frac{\theta(\alpha_b - \alpha_s)}{\alpha_b\Gamma_b + \alpha_i\Gamma_i}}\left\{1 - \alpha_b\Gamma_b\left[\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s} + \frac{1}{\Gamma_b}\right)\right]\right\}
\end{aligned}$$

Since

$$\frac{\bar{q}^h}{\bar{p}^h} = \frac{(1 - \alpha_s)\Phi_s + (1 - \alpha_i)\Phi_i\varepsilon^h}{\alpha_b\Gamma_b + \alpha_i\Gamma_i},$$

we have the following equivalence:

$$\frac{\bar{q}^h}{\bar{p}^h} < \frac{(1-\alpha_s)\,\Phi_s}{\alpha_b\Gamma_b} \tag{24}$$

is and only if

$$\frac{1-\alpha_s}{\alpha_b}\frac{\Phi_s}{\Gamma_b} > \frac{1-\alpha_i}{\alpha_i}\frac{\Phi_i}{\Gamma_i}\varepsilon^h. \tag{25}$$

Thus

$$\alpha_b\Gamma_b\left[\left(\frac{\bar{q}^h}{\bar{p}^h}\frac{1}{\Phi_s}+\frac{1}{\Gamma_b}\right)\right] < 1$$

if and only if (25) holds. Since (25) is a necessary and sufficient condition for *Domestic* to be a food exporter, this concludes the proof.■

D Proof of Proposition 4

Welfare of the international consumer is driven by her total income, i.e.

$$\begin{aligned}
\ddot{p}^l\Phi_i\varepsilon^l+\ddot{q}^l\Gamma_i &= \left(\frac{\ddot{q}^l}{\ddot{p}^l}\right)^{-(1-\alpha_i)}\Phi_i\varepsilon^l+\left(\frac{\ddot{q}^l}{\ddot{p}^l}\right)^{\alpha_i}\Gamma_i \\
&= \left(\frac{\bar{q}^l}{\bar{p}^l}\right)^{-(1-\alpha_i)}\Phi_i\varepsilon^l\left(1+(1-\alpha_i)\frac{\bar{p}^l}{\bar{q}^l}\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}\hat{\phi}\right)+\left(\frac{\bar{q}^l}{\bar{p}^l}\right)^{\alpha_i}\Gamma_i\left(1-\alpha_i\frac{\bar{p}^l}{\bar{q}^l}\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}\hat{\phi}\right) \\
&= \bar{p}^l\Phi_i\varepsilon^l+\bar{q}^l\Gamma_i+\bar{p}^l\Phi_i\varepsilon^l\,(1-\alpha_i)\frac{\bar{p}^l}{\bar{q}^l}\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}\hat{\phi}-q\Gamma_i\alpha_i\frac{\bar{p}^l}{\bar{q}^l}\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}\hat{\phi} \\
&= \left(\bar{p}^l\Phi_i\varepsilon^l+\bar{q}^l\Gamma_i\right)+\left[(1-\alpha_i)\,\bar{p}^l\Phi_i\varepsilon^l-\alpha_i\bar{q}^l\Gamma_i\right]\frac{\bar{p}^l}{\bar{q}^l}\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}\hat{\phi}
\end{aligned}$$

Since the international consumer is net importer of food, the second term is negative.

Under a social protection policy, the foreign consumer has total income

$$\hat{p}^l\Phi_i\varepsilon^l+\hat{q}^l\Gamma_i=\left(\bar{p}^l\Phi_i\varepsilon^l+\bar{q}^l\Gamma_i\right)+\left[(1-\alpha_i)\,\bar{p}^l\Phi_i\varepsilon^l-\alpha_i\bar{q}^l\Gamma_i\right]\frac{\bar{p}^l}{\bar{q}^l}\frac{1}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}(\alpha_b-\alpha_s)\,\hat{\phi}$$

so that the income difference between the two regimes is

$$\left(\hat{p}^l\Phi_i\varepsilon^l+\hat{q}^l\Gamma_i\right)-\left(\ddot{p}^l\Phi_i\varepsilon^l+\ddot{q}^l\Gamma_i\right) = \frac{\bar{p}^l}{\bar{q}}\left[\alpha_i\bar{q}^l\Gamma_i-(1-\alpha_i)\,\bar{p}^l\Phi_i\varepsilon^l\right]\left[\frac{1}{\alpha_i\Gamma_i}\frac{\hat{\eta}}{\dot{\eta}}-\frac{\alpha_b-\alpha_s}{\alpha_b\Gamma_b+\alpha_i\Gamma_i}\right]\hat{\phi}$$

that translates into welfare difference

$$\Delta V_i^l = \frac{\bar{p}^l}{\bar{q}^l} \frac{\alpha_i \bar{q}^l \Gamma_i - (1 - \alpha_i) \bar{p}^l \Phi_i \varepsilon^l}{\bar{p}^l \Phi_i \varepsilon^l + \bar{q}^l \Gamma_i} \left[\frac{1}{\alpha_i \Gamma_i} \frac{\hat{\eta}}{\dot{\eta}} - \frac{\alpha_b - \alpha_s}{\alpha_b \Gamma_b + \alpha_i \Gamma_i} \right] \hat{\phi}$$

Plugging in the values of $\hat{\eta}$ and $\dot{\eta}$ gives

$$\frac{1}{\alpha_i \Gamma_i} \frac{\hat{\eta}}{\dot{\eta}} - \frac{\alpha_b - \alpha_s}{\alpha_b \Gamma_b + \alpha_i \Gamma_i} = \frac{\alpha_b \bar{q}^l \Gamma_b + \alpha_s \bar{p}^l \bar{X}^l}{\alpha_i \bar{q}^l \Gamma_i - \alpha_s \bar{p}^l \bar{X}^l} \left[1 - (\alpha_b - \alpha_s) \frac{\alpha_b \bar{q}^l \Gamma_b}{\alpha_s \bar{p}^l \bar{X}^l + \alpha_b \bar{q}^l \Gamma_b} \right] \frac{1}{\alpha_b \Gamma_b}.$$

Hence the expression of ΔV_i^l in Proposition 4. As $\alpha_b - \alpha_s$ goes to 1, i.e. α_b goes to 1 and α_s goes to zero, the expression in brackets goes to zero.■