International Trade with Domestic Regulation under Asymmetric Information: A Simple General Equilibrium Approach*

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January 12, 2010

Abstract: This paper investigates the consequences of designing domestic incentive regulation under asymmetric information in the general equilibrium context of an open economy. We discuss the implications of such incentive regulation for international specialization and the conditions for trade openness to be still welfare-improving. More specifically, we append to an otherwise standard 2×2 Heckscher-Ohlin model of a small open economy a continuum of intermediate sectors producing non-tradable goods used in tradable sectors. Those goods are produced by local firms which are privately informed on their technologies but are regulated by a domestic regulator. Even when domestic regulation is optimally designed at the sectoral level, asymmetric information generates distortions which cannot be corrected. The small country becomes relatively richer in the factor which is informationally sensitive so that asymmetric information might reverse patterns of trade. Free trade is Pareto-dominated by autarky when it exacerbates the distortions due to asymmetric information. As an aside, our methodology provides a *constrained First Welfare Theorem* under asymmetric information of general interest beyond our trade model.

Keywords: Incentive regulation, trade, specialization, asymmetric information.

JEL Classification: D82; F12; L51.

*We thank Yolande Hiriart, Humberto Moreira and Marcelo Olarreaga for very useful comments on an earlier draft. Financial support from the World Bank is gratefully acknowledged. The usual disclaimer applies. All errors are ours.

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1 Introduction

One of the founding principles of Neoclassical Trade Theory is that free trade improves welfare under perfect competition, in the absence of externality, and when markets are complete. Of course, economists have long been aware that this result may fail when any of those conditions no longer holds. Still, the common wisdom remains that, with enough policy instruments to correct for domestic distortions, a small economy always benefits from open borders.

This paper reconsiders this general principle in a framework where asymmetric information remains a fundamental obstacle to the correction of domestic distortions. A basic tenet of the Incentive Regulation literature[1] is indeed that efficiency and redistributive concerns are deeply linked under asymmetric information. Any regulatory policy aimed at correcting allocative distortions which could be necessary to enjoy the full the gains from trade has necessarily strong distributional consequences between those agents who retain private information and those who remain uninformed. This basic principle of the Incentives literature stands in sharp contrast with the common wisdom that the absence of frictions in redistributing gains from trade between winners and losers is a necessary condition to ensure the optimality of free trade.

With those conflicting insights in mind, this paper traces out the implications of asymmetric information within domestic markets for the degree of international competitiveness and the choice of specialization faced by a small open country. Embedding the lessons of the Incentive Regulation literature into a general equilibrium environment, we derive normative implications of a joint use of trade integration and optimal domestic regulation on trade patterns. Finally, we ask whether trade openness remains welfare-improving compared to autarky when asymmetric information is a fundamental obstacle to the design of efficient domestic regulations.

More specifically, consider a small open economy with two factors (capital and labor) and two final goods. Those goods are traded on international markets and produced by competitive sectors. In this typical Heckshер-Ohlin environment, one of the final good sectors is capital intensive while the other is instead labor intensive. Those sectors also use some non-tradable intermediate goods which are produced domestically. One may think of those goods as telecommunications, energy, transportation, utilities and services. Each of those intermediate sectors is run by a local monopolist which, for simplicity, uses capital as its sole input. Owners of those monopolies have private information on their technologies. Insights from the Incentive Regulation literature[2] indicate that those owners may withdraw some information rent from being privately informed. To correct

[1] Laffont and Tirole (1993) and Laffont and Martimort (2002) for instance.
[2] Laffont and Tirole (1993) among others.

therefore for the distortions due to market and informational powers, regulation of those intermediate sectors is needed. However, any such corrective policy remains by and large constrained by asymmetric information.[3]

Patterns of trade. Our first contribution is to show how asymmetric information in regulated sectors affects this small country's pattern of specialization.

Two effects are at play in explaining changes in the pattern of trade.

First, standard Incentives Theory[4] teaches us that inducing information revelation from privately informed firms requires to leave them some costly information rents. Moreover, those rents increase with production in those sectors. Optimal regulation reduces thus information rents by downsizing production in regulated sectors. Since these sectors use capital only, more capital becomes available for the capital intensive tradable good. This makes that good relatively cheaper to produce. With asymmetric information, everything happens thus as if the small country was relatively richer in the factor which is informationally sensitive. This first effect may change the pattern of trade with the rest of the world compared with what arises under complete information.

Second, in a general equilibrium framework, information rents end up being pocketed by a (representative) consumer and therefore boost demands for final tradable goods. *In fine*, under asymmetric information, this consumer enjoys not only his income associated to the usual factor endowments of this economy but also the equivalent of an *"informational endowment"* reflecting the factor content of the information rents captured by intermediate sectors. With Cobb-Douglas preferences (and more generally homothetic preferences), this additional wealth does not change the relative demand for tradable goods. In such a context, the pattern of trade is entirely dictated by the lower production cost of the capital intensive good due to the "informationally induced" contraction of output in the intermediate sectors.

Free trade may be welfare-deteriorating. Our second contribution consists in assessing the normative implications of free trade in this context with asymmetric information. A priori, there are two possible sources of distortions in our small open economy. First, monopolies in intermediate sectors might have market power and charge a mark-up. Second, asymmetric information might also affect the allocation of resources.

The first distortion could easily be fixed under complete information by means of convenient subsidies. In such a highly hypothetical context, free trade would always dominate autarky for a small open economy. The conventional wisdom that well-designed "behind-the-border" policies do no conflict with free trade would prevail.

[3]Given that optimal regulation concerns a non-tradable sector, that "behind-the-border" policy is *de facto* non-discriminating against foreign firms.

[4]Laffont and Tirole (1993) and Laffont and Martimort (2002, Chapter 2) for instance.

Asymmetric information is a more serious concern even when the largest set of regulatory policies is available. Asymmetric information is indeed the source of a mark-up that remains even *after* policy intervention. Given the dead-weight loss associated to those distortions, free trade may not always dominate autarky.

When consumers have Cobb-Douglas preferences, we provide conditions under which free trade dominates autarky even under asymmetric information. However, free trade can now be sometimes *Pareto inferior to autarky.* The intuition is quite simple. To minimize information rents in intermediate sectors, optimal regulation reduces output in those sectors. If trade openness induces a pattern of specialization which reinforces this domestic distortion, this additional distortionary effect may outweigh the traditional gains from trade. Free trade is then dominated by autarky.

Literature review. This paper lies at the the intersection of the Trade and Regulation literatures and borrows insights from both. Starting with Bhagwati (1971), the Trade literature has built an analytical framework that allows to assess distortions away from free trade and discuss how such distortions can be corrected.[5] Following Bhagwati's taxonomy, distortions found in the absence of non-pecuniary externalities might arise from market imperfections or from misguided policy interventions which are exogenously set. In both cases, well-designed policies could avoid the distortion. Asymmetric information creates instead a more basic source of distortions which has so far been overlooked in general equilibrium environments. Incentive compatibility constraints limit the set of feasible allocations even when the most complete set of policy instruments is available. Distortions are not *a priori* imposed by exogenously restricting those instruments as in the earlier trade literature. They are instead deeply linked to the underlying information structure.

This last point is in fact closely related to a burgeoning literature that analyzes optimal taxation in open economies (Naiko 1996, Gabaix 1997a and 1997b, Guesnerie 1998 and 2001 and Spector 2001). This literature has investigated also how asymmetric information imposes limits on domestic redistributive policies. Extending the framework developed by Stiglitz (1982) to a 2×2 trade model, these papers show that free-trade can be socially inferior, at least locally, to autarky. In these papers, the demand side of the economy has private information on the source of factor income (skilled versus unskilled labor income) and incentive compatibility constraints affect the trade-off between consumption and leisure. Our model of optimal regulation investigates instead informational asymmetries on the production side of the economy. Focusing on the production side makes welfare analysis much more tractable. On top, it facilitates our derivation of a *constrained First Welfare Theorem*: the competitive equilibrium of the economy under

[5] See Srinavasan (1987) for instance.

asymmetric information also solves a social planner problem where feasibility constraints are conveniently modified to account for informational endowment. No such result was available in the Taxation literature quoted above. Beyond our specific trade model, our methodology can be used elsewhere to derive welfare properties of competitive equilibrium under asymmetric information.

This paper builds also on the Incentive Regulation literature developed by Baron and Myerson (1982), Laffont and Tirole (1993) and Armstrong and Sappington (2005) among others. One of its important insight is that, under asymmetric information, there is always a fundamental trade-off between giving up to regulated firms some information rents which are socially costly and reaching allocative efficiency. Although this literature has proved to be particularly useful in assessing sectoral interventions, it is cast in a partial equilibrium framework and nothing is known on the consequences of such sectoral regulations in open economies. This is clearly an important issue given the current globalization trend and the role that domestic regulated sectors like local transportation, telecommunications, electricity, utilities and various accounting and financial services play in shaping the whole production pattern of countries. In other words, our paper contributes to a better understanding of how "behind-the-border" regulations affect patterns of trade.

Section 2 describes both the domestic and international sides of the economy. Section 3 discusses the benchmark economy under complete information. Section 4 considers an economy with asymmetric information. It starts with a characterization of the autarkic equilibrium and goes on by characterizing how patterns of trade with the rest of the world are affected by informational asymmetries. Section 5 considers the normative implications of openness. Section 6 concludes. Proofs are relegated to an Appendix.

2 The Model

Our model has two building blocks. The first one describes trade between a small economy and the rest of the world. The second one analyzes the design of optimal regulation for intermediate sectors within that country. On the trade side, we consider a standard Hecksher-Ohlin model with two tradable goods, manufactures M and agricultural products A, and two factors, labor and capital. On top of these standard features, we add a continuum of intermediate sectors run by domestic monopolies which use only capital as an input.[6] One can think of those non-tradable inputs as electricity, telecommunication, transportation and utilities which are produced locally, regulated, and not traded on international markets. Those examples show that capital (generally under the form of infrastructures) is the main input for producing those intermediate goods and this aspect

[6]Given the symmetry of our model, all conclusions are reversed if intermediate sectors use only labor.

will be a basic point of our modeling.

In those intermediate sectors, production technologies are highly idiosyncratic and owners of those firms have private information on their technologies. In the short-run, competition by potential entrants in those sectors is of little value and domestic regulation is the only device to limit market power. Even though regulators face no restriction in their choice of instruments to curb market power, such intervention is nevertheless constrained by their incomplete knowledge of the production technology.

We analyze each building block in turn and we describe the equilibrium under autarky. Then, we introduce market openness and analyze its role on the pattern of trade.

• **Preferences.** To simplify the analysis and make it as tractable as possible, consumers have preferences over consumptions of tradable goods M and A given by a standard Cobb-Douglas utility function:

$$U(C_M, C_A) = \alpha ln C_M + (1-\alpha) ln C_A \quad \text{where } \alpha \in (0,1).$$

• **Final Sectors.** Final goods M and A are produced by competitive firms. We denote by p the price of the manufactured good whereas the agricultural good is taken as the numeraire. Each final sector uses a continuum of intermediate non-tradable inputs and production factors. In lines with standard trade factor endowment theory, we assume that sector M is capital intensive while sector A is labor intensive. More precisely, the production functions in each sector are respectively given by

$$Y_M = D_M^{\beta} K^{1-\beta} \quad \text{and} \quad Y_A = D_A^{\beta} L^{1-\beta},$$

where $\beta \in (0,1)$ and $D_i = \left(\int_0^1 x_{ji}^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\sigma}{\sigma-1}}$ with $\sigma > 1$ for $i = M, A$. The amount of intermediate good j used in the final sector i is denoted by x_{ji}. The index j varies continuously on $[0,1]$. σ is the elasticity of substitution between any two intermediate goods in the production process of good i.

The assumption of a continuum of intermediate sectors is made for tractability only. Later on, it allows us to use the Law of Large Numbers to simply characterize optimal regulation in those sectors and to define an aggregate productivity index that parameterizes the whole economy.[7] With such a formulation, all non-tradable intermediate inputs enter symmetrically in the production of the tradable sectors.[8]

This small economy is endowed with respectively $\bar{L}$ units of labor and $\bar{K}$ units of capital. Let r be the rental rate of capital and w the wage.

[7] A more cumbersome analysis could be done with a finite number of those sectors.

[8] Breaking this symmetry leads to a more complex analysis without changing the main insights of the paper.

We denote t_{jM} and t_{jA} the payments made by the final sectors to intermediate ones to obtain the inputs needed in their production processes. Profits in each final good sector can thus be written respectively as:

$$\Pi_M = p\left(\int_0^1 x_{jM}^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\beta\sigma}{\sigma-1}} K^{1-\beta} - rK - \int_0^1 t_{jM} dj$$

and

$$\Pi_A = \left(\int_0^1 x_{jA}^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\beta\sigma}{\sigma-1}} L^{1-\beta} - wL - \int_0^1 t_{jA} dj.$$

Under asymmetric information, it is a significant loss of generality to restrict the payments of the final sectors to be linear in the quantity of intermediate goods they buy. Incentives Theory teaches us that menus of options are useful devices to screen informed parties according to their private information. We discuss below the precise form of those incentive payments. For the time being, it is only useful to see those payments as being decided by the regulator in charge of regulating intermediate sectors.

• **Intermediate Sectors.** Producing x_j units of intermediate good j requires $\theta_j x_j$ units of capital.[9] The productivity of each intermediate sector j is affected by a random shock θ_j. Over the whole continuum of sectors, these shocks are independently and identically distributed on a set $\{\underline{\theta}, \bar{\theta}\}$ with respective probabilities ν and $1-\nu$. Those probabilities are common knowledge. Let $\underset{\theta}{E}(\cdot)$ be the expectation operator w.r.t. θ.

Production shocks in sector j are observed only by firm j's owners. This assumption is motivated by the fact that the technology for each intermediate sector is highly specific to that sector and cannot be easily compared with technologies for producing other intermediate inputs.[10]

Without regulation, firms in the intermediate sectors would fix prices above their marginal costs. Such market power calls for regulatory policies whose goal is to improve allocative efficiency by shifting down price closer to marginal costs and increasing demand of the final sector for the intermediate goods. However, asymmetric information in intermediate sectors still creates important trade-offs between allocative efficiency

[9] Our assumption that services are produced with capital only and that the manufacture and agriculture sectors use either labor or capital but not both is just made for analytical convenience. What matters is the relative intensities in these three sectors and, especially in our context, which of the two tradable sectors uses more intensively the input factor also used in the regulated sectors.

[10] The reader may find our representative customer a little bit schizophrenic. On the one hand, as an owner of the intermediate sectors, he is privately informed on the shocks hitting each of these sectors. On the other hand, as an owner of the firms in the final sector and a consumer, he ignores this piece of information. This modeling difficulty can easily be avoided by considering different classes of owners knowing different pieces of information but having the same Cobb-Douglas utility function. There would be as much classes as intermediate sectors. Using Gorman aggregation rule, it is standard to show that the behavior of those agents can be aggregated and summarized by the behavior of a single representative agent having the whole the endowment of the economy.

and extraction of the monopolies' information rents even when an optimal regulation is designed.

Given the payments received from the final sectors, profits in the intermediate sector j can be written as:

$$U_j = t_{jM} + t_{jA} - r\theta_j(x_{jM} + x_{jA}), \qquad \text{for } j \in [0, 1].$$

To ensure that firms in the intermediate sectors break-even, the regulatory payments received by those firms must cover their costs. This yields the condition $U_j \geq 0$.

To model a meaningful trade-off between efficiency and rent extraction, we follow the Incentive Regulation literature[11] and assume that the regulatory agency in charge with curbing market power in intermediate sector j maximizes the profits of the final sectors which consume those intermediate goods for their own production process, namely:

$$W = \Pi_M + \Pi_A.$$

As the sequel will make clear, this regulator takes final goods prices and factor prices as given when designing an optimal regulatory scheme. In other words, this means that the regulator has no tools to influence what happens on the final sector. This fits with regulatory policies used in practice for electricity, telecommunication or transports where regulatory agencies have restricted sectoral objectives directly related to the interests of customers of those regulated sectors (here the tradeable sectors). There is therefore still significant scope for markets and prices to equilibrate aggregate supply and demand in the economy even after regulatory tools have been set up.

Although the regulator maximizes the profit of firms in the final sector, he does not introduce any distortion in the relationship with consumers. Instead, his sole concern is to reduce as much as possible distortions due to the intermediate firms' behavior. Indeed, under complete information, the regulator would like to ensure that intermediate sectors charge a price equal to marginal cost so that production decisions in the final sectors are not distorted. Because the regulator is only concerned by profits in the final sectors, he wants also to minimize the information rent left to the intermediate sectors. This will induce some distortions and a wedge between price and marginal cost in the intermediate sectors.

Expressing profits in the final sector as a function of the information rents of the intermediate ones, the regulator's objective function can be rewritten as:

$$\underbrace{p\left(\int_0^1 x_{jM}^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\beta\sigma}{\sigma-1}} K^{1-\beta} + \left(\int_0^1 x_{jA}^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\beta\sigma}{\sigma-1}} L^{1-\beta} - wL - r\left(\int_0^1 \theta_j(x_{jM} + x_{jA})dj + K\right)}_{\text{Allocative Efficiency}}$$

[11]Baron and Myerson (1982), Laffont and Tirole (1993) and Armstrong and Sappington (2005).

$$-\underbrace{\int_0^1 U_j dj}_{\text{Information Rents}} .$$

This expression stresses the trade-off faced by the regulator. On the one hand, the regulator is concerned by an efficient use of resources, namely finding the vector of inputs (K, L, x_{jM}, x_{jA}) which maximizes aggregated profits in all production sectors (first bracketed term). On the other hand, the regulator is also interested in minimizing the information rents left to the intermediate sectors.[12,13]

3 Trade and Regulation under Complete Information

Let us start with the case of complete information. This will provide a useful benchmark against which one can assess how asymmetric information might change trade patterns.

• **Supply Side.** Suppose that the regulator is fully informed on the whole vector of shocks $\vec{\theta} = (\theta_1, \ldots, \theta_j, \ldots)$ hitting intermediate sectors. Given that there is a continuum of symmetric intermediate sectors, the Law of Large Number applies and we have:

$$D_i = \left[\int_0^1 x_{ji}^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}} = \left(\underset{\theta}{E}\left(x_{ji}(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\sigma}{\sigma-1}} \quad i = M, A,$$

where $x_{ji}(\theta)$ is the output of the intermediate goods j for sector i when the productivity shock hitting this sector is θ. Because of symmetry, all sectors produce the same outputs in equilibrium when they are hit by similar shocks. Therefore, the index j can be omitted and we can denote $x_{ji}(\theta) = x_i(\theta)$ for any θ. Similarly, we also denote by $U(\theta)$ the profit or information rent of a given intermediate sector when it is hit by shock θ.

Under complete information, the regulator's problem is thus given by:

$$\max_{\{K,L,x_i(\cdot),U(\cdot)\}} p\left(\underset{\theta}{E}\left(x_M(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\beta\sigma}{\sigma-1}} K^{1-\beta} + \left(\underset{\theta}{E}\left(x_A(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\beta\sigma}{\sigma-1}} L^{1-\beta}$$

$$-wL - rK - r\underset{\theta}{E}\left(\theta(x_M(\theta) + x_A(\theta))\right) - \underset{\theta}{E}(U(\theta))$$

$$\text{subject to } U(\theta) \geq 0, \text{ for all } \theta \text{ in } \{\underline{\theta}, \bar{\theta}\} \quad (1)$$

[12]Our modeling of the regulator's objective function could nevertheless be extended, at the cost of an increased complexity, to the case where a positive, but less than one, weight is given to the intermediate sectors. See Baron and Myerson (1982) for that assumption in a partial equilibrium model. An alternative interpretation of such assumption is that one cannot finance the informational rents left to managers of the intermediate sectors through non-distortionary taxation (Laffont and Tirole, 1993).

[13]With this regulatory objective, everything happens as if the incentive contracts given to the intermediate sectors were actually offered by the final sectors producers in an unregulated framework. This interpretation of the model gives a broader scope to our analysis.

where (1) are participation constraints in the intermediate sectors.[14]

Solving this problem is straightforward. The corresponding solution characterizes the supply side of this economy when regulation takes place under complete information.

Proposition 1 *Under complete information, the optimal regulation of the intermediate sectors entails the following properties.*

- *For any realization of the productivity shock, firms in the intermediate sectors get zero information rent:*

$$U^{FI}(\theta) = 0, \quad \text{for all } \theta \text{ in } \{\underline{\theta}, \bar{\theta}\}.$$

- *Zero-profit conditions in the final sectors yield*

$$r^{\beta} w^{1-\beta} = (1-\beta)^{1-\beta} \beta^{\beta} \Theta^{-\beta} \tag{2}$$

and

$$p = \omega^{-(1-\beta)} \tag{3}$$

where $\Theta = \left(\underset{\theta}{E}(\theta^{1-\sigma}) \right)^{\frac{1}{1-\sigma}}$ *is an aggregate productivity index and* $\omega = \frac{w}{r}$ *is the relative factor price.*

Under complete information, the optimal regulation of the supply side of the economy maximizes the whole profit of the vertically integrated structure obtained by merging final and intermediate sectors. Everything happens as if intermediate sectors were selling their inputs at marginal cost to final good producers and making zero profit. Because of constant returns to scale, the whole profit of this integrated structure will also be zero.

Firms in the intermediate sectors produce more when they are hit by a good shock $\underline{\theta}$ than by a bad shock $\bar{\theta}$. Accordingly, we shall refer in the sequel to the efficient (resp. inefficient) firm $\underline{\theta}$ (resp. $\bar{\theta}$).

Importantly, (2) defines a downward sloping curve, $r = r_1^{FI}(w)$ which captures the zero profit condition on the agricultural sector under constant returns to scale: a higher wage must be compensated by a lower cost of capital. We will refer to that curve as the *zero profit locus.*

The parameter Θ reflects the productivity of this economy. As Θ increases, production of intermediate goods out of capital becomes more difficult. This decreases the demand for complementary inputs, capital and labor, emanating from the final sectors.

[14]Note again that the prices are taken as given by the regulator since he is only concerned by transactions between the final and the intermediate sectors. We nevertheless slightly abuse and simplify notations by omitting the dependence of the optimization variables on the price vector.

• **Demand Side.** Given the Cobb-Douglas preferences of the representative consumer, demands for both consumption goods are respectively

$$C_M = \frac{\alpha R^{FI}}{p} \quad \text{and} \quad C_A = (1-\alpha)R^{FI},$$

where R^{FI} is the consumer's total income under complete information. With constant returns to scale in the production sectors, this income comes from the factor endowment only and $R^{FI} = w\bar{L} + r\bar{K}$.

• **Autarky.** Under autarky, the equilibrium conditions on the agricultural and labor markets yield

$$(1-\alpha)(w\bar{L} + r\bar{K}) = X_A^{\beta}\bar{L}^{1-\beta} = \frac{w}{1-\beta}\bar{L}$$

where the second equality comes from expressing labor demand in the agricultural sector. This can be simplified as:

$$\frac{1}{\omega} = \frac{r}{w} = \frac{\bar{L}}{\bar{K}}\left(\frac{1}{(1-\alpha)(1-\beta)} - 1\right). \tag{4}$$

Those market clearing conditions define thus an upward sloping relationship $r = r_2^{FI}(w)$ linking the rental rate of capital and the labor wage: *the autarky locus.* The relative factor price ω is inversely proportional to the relative endowment of factors. As capital becomes more scarce, the rental rate of capital appreciates in relative terms.

An *autarky equilibrium* is obtained when (2), (3) and (4) hold altogether. Next proposition ensures existence of such an equilibrium and provides useful comparative statics.

Proposition 2 *There exists a unique equilibrium under autarky and complete information. It is characterized by the price system (p^{FI}, w^{FI}, r^{FI}) solving (2), (3) and (4).*

As Θ increases, the zero-profit locus $r_1^{FI}(\cdot)$ is shifted downwards and the autarky locus $r_2^{FI}(\cdot)$ remains unchanged. There is a downward shift in the factor prices w^{FI} and r^{FI}.

As the productivity index deteriorates (Θ increasing), the demand for intermediate goods decreases and demands for both capital and labor diminish. This leads to a lower rental rate of capital and lower wages. (See Figure 1.) Since intermediate sectors enter in the same way in the production technologies of both tradable sectors, the whole impact of a change in the productivity index comes from a shift in the zero-profit locus (2). When the productivity index increases, the autarky locus (4) is unchanged and the relative factor price remains the same, namely $\frac{\bar{L}}{\bar{K}}\left(\frac{1}{(1-\alpha)(1-\beta)} - 1\right)$. In the sequel, we will be particularly interested in the impact of asymmetric information on the productivity index.

• **Free Trade.** Let us now consider the case where this small country opens up trade with the rest of the world. Under free trade, the relative price of final goods is fixed on the world market at some exogenous level p. Note that (2) and (3) are still valid so that remaining prices in the open economy are completely defined.

Define the representative consumer's indirect utility function $V^{FI}(p)$ as follows:

$$(\mathcal{P}^{FI}): \quad V^{FI}(p) \equiv \max_{\{C_M, C_A, X_M, X_A, x_m(\cdot), x_a(\cdot)\}} \alpha ln C_M + (1-\alpha) ln C_A \text{ subject to}$$

$$pX_M^{\beta} K^{1-\beta} + X_A^{\beta} \bar{L}^{1-\beta} \geq pC_M + C_A \tag{5}$$

$$X_M = \underset{\theta}{E} \left(x_M^{\frac{\sigma-1}{\sigma}}(\theta) \right)^{\frac{\sigma}{\sigma-1}} \tag{6}$$

$$X_A = \underset{\theta}{E} \left(x_A^{\frac{\sigma-1}{\sigma}}(\theta) \right)^{\frac{\sigma}{\sigma-1}} \tag{7}$$

$$\bar{K} = K + \underset{\theta}{E} \left(\theta (x_M(\theta) + x_A(\theta)) \right). \tag{8}$$

Constraint (5) is a trade-balance condition whereas (6), (7) and (8) are standard feasibility conditions for goods M, A and capital respectively.

From the First Welfare Theorem, $V^{FI}(\cdot)$ is also the consumer's utility when domestic markets for input factors are competitive. The solution to $(\mathcal{P}^{FI})$ replicates indeed the competitive equilibrium. By definition, $V^{FI}(\cdot)$ is thus minimum at p^{FI} such that the markets for final goods are on autarky (i.e., $C_M = X_M^{\beta} K^{1-\beta}$ and $C_A = X_A^{\beta} \bar{L}^{1-\beta}$) since indeed imposing those extra conditions corresponds to a more constrained optimization. Therefore, free trade is always welfare superior.

More formally, let us denote by $\gamma(p)$ the non-negative multiplier of the trade-balance condition (5) at world price p. The Envelope Theorem yields:

$$\dot{V}^{FI}(p) = \gamma(p) \left(X_M^{\beta}(p) K^{1-\beta}(p) - C_M(p) \right)$$

where the dependence of all variables on the market price p is made explicit. Of course, that right-hand side is precisely worth 0 at p^{FI} since domestic production is equal to domestic consumption under autarky. Going into more details and using the specific Cobb-Douglas preferences, we can easily compute

$$V^{FI}(p) = \alpha ln \alpha + (1-\alpha) ln(1-\alpha) - ln\gamma(p) - \alpha ln p$$

where

$$\frac{1}{\gamma(p)} = R^{FI} = \beta^{\beta} (1-\beta)^{1-\beta} \Theta^{-\beta} \left(p\bar{K} + p^{-\frac{\beta}{1-\beta}} \bar{L} \right).$$

Finally, $V^{FI}(\cdot)$ is minimized for

$$p^{FI} = \left(\frac{\bar{L}}{\bar{K}} \left(\frac{1}{(1-\alpha)(1-\beta)} - 1 \right) \right)^{1-\beta}. \tag{9}$$

Under complete information, one recovers the traditional result that, once domestic regulation is optimally designed, free trade is always Pareto-superior to autarky.

Patterns of trade. When the world price differs from p^{FI}, two cases are possible.

• $p > p^{FI}$. The world price of manufactures is greater than under autarky. The small country exports good M which is capital intensive and imports good A which is labor intensive final good. An increase in p increases the demand for capital and raises its rental rate above its autarky level. At the same time, the wage rate decreases to guarantee zero profit in the final sectors under constant returns to scale: $w < w^{FI}$ and $r > r^{FI}$.

• $p < p^{FI}$. The world price for M is lower than its value under autarky. By symmetry, we get: $w > w^{FI}$ and $r < r^{FI}$.

Figure 1 below summarizes graphically the two cases.

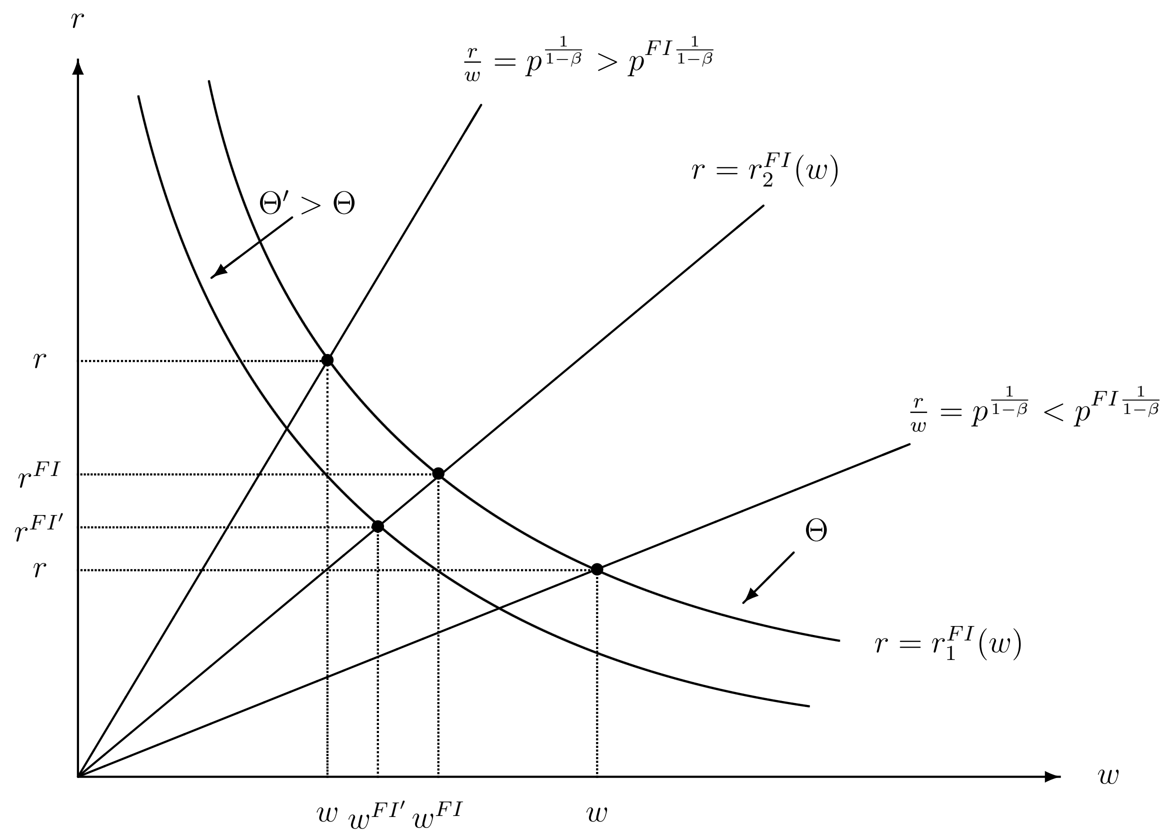

Figure 1: Autarky and free-trade equilibria under complete information.

4 Trade and Regulation under Asymmetric Information

Consider now the case of asymmetric information. Owners of firms in the intermediate sectors are privately informed on the productivity shocks that hit those sectors.

• **Supply Side.** Productivity shocks in any intermediate sector are not observed by the regulator. The regulator has to rely on incentive regulation to induce firms in those sectors to truthfully reveal their productivity parameter.

From the Revelation Principle[15] such an incentive scheme stipulates how much each intermediate sector has to produce as a function of its announcement on its efficiency shock. In full generality, and given that production in the final sectors depend on the whole vector of input factors produced by intermediate sectors, the transfer t_j and the output x_j in sector j should depend on the whole announcement $\hat{\vec{\theta}}$ made by each sector. Given that there is a continuum of symmetric intermediate sectors with i.i.d. shocks, we will use the Law of Large Numbers to approximate the optimal contract by a vector of incentive contracts for each sector which depends only on the announcement of that sector. We thus envision a collection of bilateral regulatory contracts for each sector which take the form $\{t(\hat{\theta}), x(\hat{\theta})\}_{\hat{\theta}\in\{\underline{\theta},\bar{\theta}\}}$ where $\hat{\theta}$ is the announced productivity parameter in that sector, $t(\hat{\theta})$ and $x(\hat{\theta})$ being respectively the payment and the production of that sector.

It is a by-now standard result in the Theory of Incentives[16] that, in two types adverse selection models, the binding incentive constraint at the optimum is that of an efficient firm $\underline{\theta}$ whereas the binding participation constraint is that of an inefficient firm $\bar{\theta}$. Still, using symmetry among all sectors, those constraints can be written respectively as

$$U(\underline{\theta}) \geq t_M(\bar{\theta}) + t_A(\bar{\theta}) - r\underline{\theta}\left(x_M(\bar{\theta}) + x_A(\bar{\theta})\right) = U(\bar{\theta}) + r\Delta\theta\left(x_M(\bar{\theta}) + x_A(\bar{\theta})\right), \qquad (10)$$

and

$$U(\bar{\theta}) \geq 0. \qquad (11)$$

Under asymmetric information, the regulator's problem becomes:

$$\max_{\{K,L,x_i(\cdot),U(\cdot)\}} p\left(\underset{\theta}{E}\left(x_M(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\beta\sigma}{1-\sigma}} K^{1-\beta} + \left(\underset{\theta}{E}\left(x_A(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\beta\sigma}{1-\sigma}} L^{1-\beta}$$

$$-wL - rK - r\underset{\theta}{E}\left(\theta(x_M(\theta) + x_A(\theta))\right) - \underset{\theta}{E}(U(\theta))$$

subject to (10) and (11).

[15] Myerson (1982).

[16] Laffont and Martimort (2002, Chapter 2) for instance.

Since the last two constraints are binding at the optimum, the agency costs coming from asymmetric information can be identified with the positive amount of expected information rent that must be left to firms in the intermediate sectors, namely

$$\underset{\theta}{E}(U(\theta)) = r\nu\Delta\theta\left(x_M(\bar{\theta}) + x_A(\bar{\theta})\right)$$

where remember again that those optimization variables depend on the equilibrium price vector but this dependence has been omitted for notational simplicity.

This expected rent, which is view as an extra cost by the regulator, is proportional to the production of inefficient firms in the intermediate sectors. This is where the trade-off between allocative efficiency and distribution bites: the more production is requested from the intermediate sectors, the more information rent must be left to those sectors.

Inserting this expression of the expected information rent into the regulator's objective function, one can easily see that everything happens as if the regulator's optimization problem was the same as under complete information with the only change coming from the fact that the true productivity parameter $\bar{\theta}$ is now replaced by a so-called *virtual parameter* $\tilde{\bar{\theta}} = \bar{\theta} + \frac{\nu}{1-\nu}\Delta\theta$ which is greater. At the same time, the virtual productivity of the efficient firm is kept unchanged $\tilde{\underline{\theta}} = \underline{\theta}$. As a result, we can directly import our previous results from Proposition 1 to characterize the supply side of this economy.

Proposition 3 *Under asymmetric information, the optimal regulation of the intermediate sectors entails the following properties.*

• *Firms in the intermediate sectors get a positive information rent if and only if they are hit by a good productivity shock* $\underline{\theta}$*;*

$$U^{AI}(\underline{\theta}) = r\Delta\theta(x_M^{AI}(\bar{\theta}) + x_A^{AI}(\bar{\theta})), \text{ and } U^{AI}(\underline{\theta}) = 0.$$

• *(3) still holds whereas (2) is replaced by*

$$r^\beta w^{1-\beta} = (1-\beta)^\beta \beta^\beta \tilde{\Theta}^{-\beta} \tag{12}$$

where the virtual productivity index $\tilde{\Theta} = \left(E(\tilde{\theta}^{1-\sigma})\right)^{\frac{1}{1-\sigma}}$ *is now greater than the full information productivity index* Θ*.*

Under asymmetric information, the regulator wants to reduce the intermediate sectors firms' incentives to report being less efficient than what they really are. To induce participation by the least efficient firm $\bar{\theta}$, the regulator must increase the overall payments from the final sectors for the inputs produced by those firms. This increases the incentives of an efficient firm to pretend being less efficient and reap such large payments. If it does so, it can produce the same output than an inefficient firm by using less capital and benefitting from the high price offered to the inefficient firms. Owners of efficient firms enjoy then a positive information rent as it can be seen from (10).

Those information rents are perceived as costly by the regulator. However, he can reduce that cost by simply requesting less production $x_M(\bar{\theta})$ and $x_A(\bar{\theta})$ than under complete information values (keeping the rental price of capital as given). That extra distortion amounts to an implicit tax on inefficient firms which is formally captured by replacing $\bar{\theta}$ and Θ respectively by their virtual values $\tilde{\bar{\theta}}$ and $\tilde{\Theta}$. Because of asymmetric information, everything happens as if there were now a wedge between the unit price at which inefficient firms in the intermediate sectors can sell their goods and their marginal cost. Output is inefficiently low for those firms. Asymmetric information creates a dead-weight loss in the economy. Moreover, because information rents are proportional to the rental rate of capital, the dead-weight loss increases with r. This latter effect is particularly important for what follows.

Asymmetric information does not change the overall trend between the rental price of capital and labor wage. The zero-profit condition for final sectors (12) still yields a curve $r = r_1^{AI}(w)$ which is still downward sloping exactly as under complete information. However, asymmetric information replaces the productivity index by a greater virtual productivity index. The curve (12) is shifted downwards below (2). Overall, zero-profit is obtained at lower prices for capital and labor.

However, this is not the only effect of asymmetric information in a general equilibrium model. Information rents in the intermediate sectors are also redistributed to the representative consumer as an owner of those intermediate sectors. That consumer enjoys thus income flows not only from the standard capital and labor endowments in this economy but also from an additional *"informational endowment"*. In other words, the proceeds of the implicit tax that asymmetric information imposes on the production of inefficient firms are pocketed by the representative consumer who owns intermediate sectors.

• **Demand Side.** Under asymmetric information, the total endowment of the representative consumer can be then written as:

$$R^{AI} = \underbrace{w\bar{L} + r\bar{K}}_{\text{Standard Endowment}} + \underbrace{r\nu\Delta\theta(x_M^{AI}(\bar{\theta}) + x_A^{AI}(\bar{\theta}))}_{\text{Informational Endowment}}. \tag{13}$$

Using the expressions of the intermediate sectors outputs given in the Appendix (equation (A10)), we get:

$$R^{AI} = (w\bar{L} + r\bar{K})\left(1 + \frac{\mu\lambda}{1+\mu}\right) \tag{14}$$

where $\lambda = \frac{\nu\Delta\theta\tilde{\bar{\theta}}^{-\sigma}}{\nu\underline{\theta}^{1-\sigma}+(1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}}$ and $\mu = \frac{\beta}{1-\beta}\left(\frac{\nu\underline{\theta}^{1-\sigma}+(1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}}{\nu\underline{\theta}^{1-\sigma}+(1-\nu)\tilde{\bar{\theta}}^{1-\sigma}}\right)$.

Everything happens thus as if, because of his informational endowment, the true income perceived by the representative customer was now *scaled up* by a factor $1 + \frac{\mu\lambda}{1+\mu}$. Thanks to Cobb-Douglas preferences, such change in revenue does not affect the relative demand for the two final goods, it modifies only their magnitudes.

For the rest of the paper, we will assume that the following condition holds:

Assumption 1

$$\frac{1}{(1-\alpha)(1-\beta)} > 1 + \frac{\mu\lambda}{1+\mu}.$$

Tedious computations show that this condition is always satisfied when $\Delta\theta$ is small enough, i.e., when the adverse selection problem is not too significant. Assumption 1 ensures existence of a a competitive equilibrium as we see below.[17]

4.1 Autarky

We are now ready to characterize equilibrium prices under autarky. Market clearing conditions on the agricultural and labor markets yield:

$$(1-\alpha)R^{AI} = X_A^{\beta}\bar{L}^{1-\beta} = \frac{w}{1-\beta}\bar{L}$$

where the second equality comes from expressing labor demand in the agricultural sector. Using the expression for R^{AI} given in (14), we obtain:

$$\frac{1}{\omega} = \frac{r}{w} = \frac{\bar{L}}{\bar{K}}\left(\frac{1}{(1-\alpha)(1-\beta)\left(1+\frac{\mu\lambda}{1+\mu}\right)} - 1\right). \tag{15}$$

When Assumption (1) holds, the market equilibrium equation (15) still defines an *autarky locus under asymmetric information* $r = r_2^{AI}(w)$ which is upward sloping.

However, $r_2^{AI}(\cdot)$ is always below $r_2^{FI}(\cdot)$. The intuition comes from a careful analysis of the supply and demand curves on the agricultural market. First, remember that the representative consumer's income is scaled up under asymmetric information. Therefore, the demands for both final goods increase and, given the Cobb-Douglas preferences, they do so at the same rate. This income effect is captured by the scale factor $1 + \frac{\mu\lambda}{1+\mu}$ on the l.h.s. of (15). Second, production on the agricultural market is proportional to labor wages exactly as under complete information and (up to changes in the equilibrium level of

[17] Had it not hold, asymmetric information would be incompatible with competitive behavior. We leave the analysis of this interesting case for further research.

wages) is unchanged. Hence, equilibrium on the agricultural market can only be obtained when the rental rate of capital decreases so that the demand boost due to the income effect is compensated by a decreased in income from factor endowments. Assumption 1 ensures that this relative price adjustment mechanism is strong enough to overcome the income effect due to the existence of (endogenous) information rents. If it were not the case, then the income effect associated to information rents would produce an increased equilibrium rental rate of capital which in turn would feed back into increased information rents. This multiplier effect would render impossible the existence of a competitive equilibrium.

We can now complete the description of our autarkic equilibrium.

Proposition 4 *When Assumption (1) holds, there always exists a unique equilibrium under autarky and asymmetric information. It is characterized by the price system* (p^{AI}, w^{AI}, r^{AI}) *that solves (3), (12) and (15).*

First, observe that the autarky price of the manufactured good decreases with asymmetric information. Indeed asymmetric information contracts intermediate sectors which use capital as an input. More capital becomes available for the capital intensive final good which becomes cheaper.

$$p^{AI} = \left(\frac{\bar{L}}{\bar{K}} \left(\frac{1}{(1-\alpha)(1-\beta)\left(1+\frac{\mu\lambda}{1+\mu}\right)} - 1 \right) \right)^{1-\beta} < p^{FI}. \quad (16)$$

A priori, it is hard to compare autarky input factor prices under complete and asymmetric information. On the one hand, the downward shift of the zero-profit locus (12) due to the deterioration of the productivity index suggests that the equilibrium rental rate of capital and wage are lower under asymmetric information. On the other hand, the downward shift of the autarky locus increases the equilibrium wage (see Figure 2 below). The total impact of asymmetric information on the rental rate of capital ends up being unambiguous. However, its impact on wages depends on the parameters as shown below.

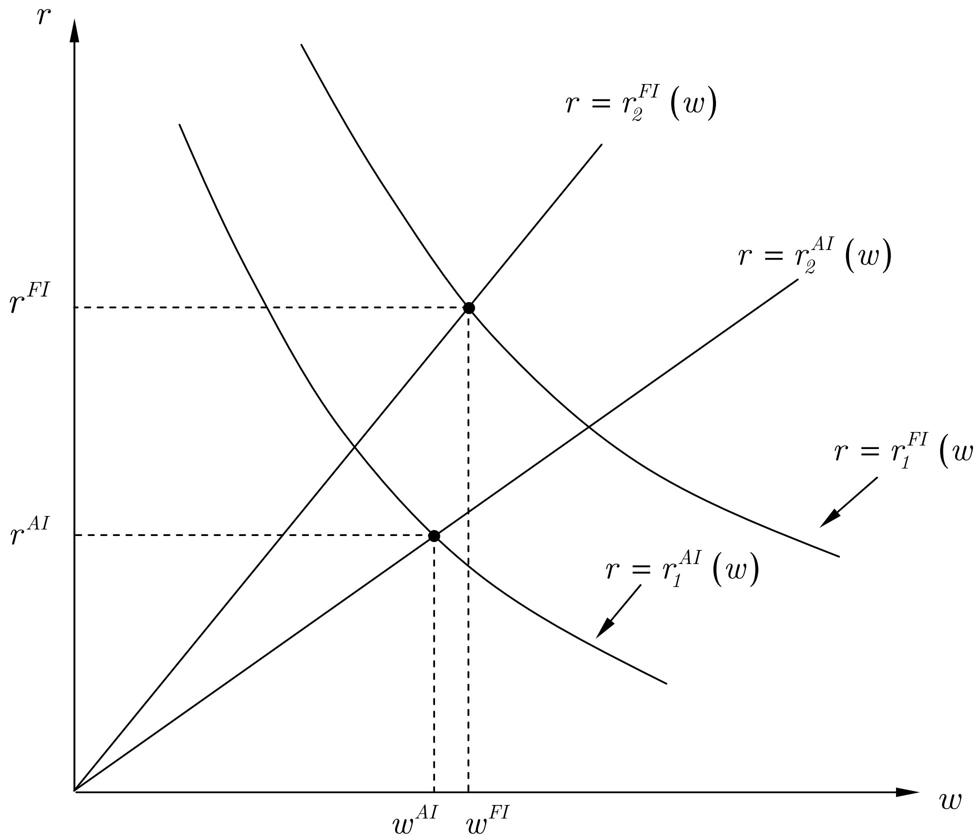

Figure 2: Equilibrium under autarky with and without asymmetric information.

Proposition 5 *Under asymmetric information, capital is always cheaper than under complete information,* $r^{AI} < r^{FI}$*. Wages are lower, i.e.,* $w^{AI} < w^{FI}$*, if and only if*

$$\frac{\tilde{\Theta}}{\Theta} > \frac{\left(1 + \frac{\mu\lambda}{1+\mu}\right)(1 - (1-\alpha)(1-\beta))}{1 - \left(1 + \frac{\mu\lambda}{1+\mu}\right)(1-\alpha)(1-\beta)}. \tag{17}$$

Using Taylor expansions in the limiting case of small degrees of asymmetric information (i.e., $\Delta\theta$ small enough), it can be verified that condition (17) amounts to Assumption 1. Changes in input prices are thus mostly explained by changes in the productivity index so that both r and w decreases with asymmetric information.

4.2 Free Trade

Under free trade, p is again fixed on the world market at an exogenous value. Following the same logic as under complete information, the pattern of trade can be immediately derived and depends on whether p is above or below p^{AI}.

Proposition 6 *Assume that $p^{FI} > p > p^{AI}$, then under complete information, the small economy contracts its production of the capital intensive good and expands that of the labor intensive one whereas it is the reverse under asymmetric information.*

Under those circumstances, asymmetric information changes the pattern of trade. To better understand this result, it is useful to come back on the definition of p^{AI} and rewrite

$$p^{AI} = \left(\widetilde{\left(\frac{\bar{L}}{\bar{K}}\right)}\left(\frac{1}{(1-\alpha)(1-\beta)} - 1\right)\right)^{1-\beta}$$

where

$$\widetilde{\left(\frac{\bar{L}}{\bar{K}}\right)} = \frac{\bar{L}}{\bar{K}}\left(\frac{\frac{1}{1+\frac{\mu\lambda}{1+\mu}} - (1-\alpha)(1-\beta)}{1-(1-\alpha)(1-\beta)}\right) < \frac{\bar{L}}{\bar{K}}.$$

That expression highlights that, under asymmetric information, the relative factor endowment $\frac{\bar{L}}{\bar{K}}$ of the economy has to be replaced by its *virtual* value $\widetilde{\left(\frac{\bar{L}}{\bar{K}}\right)}$ which is lower. With asymmetric information, everything happens thus as if the small country was relatively richer in the factor which is more intensively used by sectors affected by agency problems. Indeed, since these sectors contract their activity, capital is relatively cheaper and the small country specializes more easily in the capital intensive good. Asymmetric information induces a specialization bias.[18]

5 Normative Analysis

The traditional normative conclusions of Trade Theory change under asymmetric information. One should not always expect free trade to be necessarily welfare-improving even for a small open economy that has optimally designed its domestic regulation.

Define first now the representative consumer's indirect utility function $V^{AI}(p)$ in the open economy under asymmetric information as follows:

$$(\mathcal{P}^{AI}): \quad V^{AI}(p) \equiv \max_{\{C_M, C_A, X_M, X_A, x_m(\cdot), x_a(\cdot)\}} \alpha ln C_M + (1-\alpha) ln C_A$$

subject to (5), (6), (7) and

$$\nu\Delta\theta(x_M(\bar{\theta}, p) + x_A(\bar{\theta}, p)) + \bar{K} = K + \underset{\theta}{E}\left(\tilde{\theta}(x_M(\theta) + x_A(\theta))\right) \quad (18)$$

where $x_M(\bar{\theta}, p)$ and $x_A(\bar{\theta}, p)$ solve the maximization problem above.

The following proposition holds.

[18]In our model, capital is the only factor affected by asymmetric information issues. More generally, what matters for trade patterns is the relative factor endowment of the economy, adjusted for the *factor content* of information rents.

Proposition 7 *Under asymmetric information, $V^{AI}(p)$ is the representative consumer's utility function when the world price of manufactured good is p. In other words, the allocation of resources that solves $(\mathcal{P}^{AI})$ is the market equilibrium under asymmetric information in the open economy.*

Proposition 7 characterizes a *constrained* First Welfare Theorem under asymmetric information. It shows that the equilibrium allocation is in fact the solution to a centralized problem $(\mathcal{P}^{AI})$ provided that the resource constraint for the informationally sensitive input (18), here capital, is carefully modified. That modification encapsulates implicitly the constraints that asymmetric information imposes in redistributing wealth from the representative consumer viewed as an informed shareholder of the intermediate sector to the representative consumer viewed as an uninformed player.

As under complete information, the resource constraint (18) accounts for the capital endowment $\bar{K}$ but it differs from (8) on both sides. First, the new extra term $\nu\Delta\theta(x_M(\bar{\theta},p) + x_A(\bar{\theta},p))$ has been added on the resource side. Second, the efficiency parameter $\bar{\theta}$ has been replaced by its virtual value $\tilde{\bar{\theta}}$ on the right-hand side. The intuition for these modifications is straightforward. Under asymmetric information, virtual efficiency parameters are the right concept to evaluate the marginal opportunity cost of using resources. Hence, any centralized maximization problem that aims at replicating the behavior of competitive markets for input factors must take into account those virtual efficiency parameters. Going from efficiency parameters to their virtual counterparts amounts to an implicit tax $\frac{\nu}{1-\nu}\Delta\theta$ (counted here in units of capital) on the use of capital by inefficient firms of the intermediate sectors. In a general equilibrium environment, the proceeds of that tax have to be included on the resource side which explains the newly added term $\nu\Delta\theta(x_M(\bar{\theta},p) + x_A(\bar{\theta},p))$ on the left-hand side of (18). Finally, $x_M(\bar{\theta},p)$ and $x_A(\bar{\theta},p)$ are obtained as fixed-points out of the optimization $(\mathcal{P}^{AI})$. This problem is self-generating in the sense that some of its constraints itself depends on the solution.

Let us again denote by $\gamma(p)$ the non-negative multiplier of the trade-balance condition (5) and by $\gamma(p)r(p)$ the non-negative multiplier of the feasibility condition (18) at world price p for the manufactured good. The Envelope Theorem gives us:

$$\dot{V}^{AI}(p) = \gamma(p)\left(\left[X_M^{\beta}(p)K^{1-\beta}(p) - C_M(p)\right] + r(p)\nu\Delta\theta\left(\frac{\partial x_M}{\partial p}(\bar{\theta},p) + \frac{\partial x_A}{\partial p}(\bar{\theta},p)\right)\right).$$

At the autarky price p^{AI}, only the first bracketed term is zero since domestic production is equal to domestic consumption of that manufactured good. Intuitively, moving away from the autarky price by a small amount has now a first-order effect on welfare since it changes information rents in the intermediate sectors.

Slightly increasing p above p^{AI} boosts the domestic production of good M. This raises demand for capital and increases its rental rate which finally decreases production by inefficient firms in intermediate sectors. Starting from the autarky price, opening borders increases exportation but this also reduces information rents and welfare.

Using the specific Cobb-Douglas preferences, we can go further and easily compute

$$V^{AI}(p) = \alpha ln\alpha + (1-\alpha)ln(1-\alpha) - ln\gamma(p) - \alpha lnp$$

where now

$$\frac{1}{\gamma(p)} = R^{AI}(p) = \beta^{\beta}(1-\beta)^{1-\beta}\tilde{\Theta}^{-\beta}\left(1+\frac{\mu\lambda}{1+\mu}\right)\left(p\bar{K}+p^{-\frac{\beta}{1-\beta}}\bar{L}\right).$$

$V^{AI}(\cdot)$ is again U-shaped and minimized, as $V^{FI}(\cdot)$, for p^{FI} which is greater than p^{AI}. Hence, $\dot{V}^{AI}(p^{AI}) < 0$. The following proposition follows immediately.

Proposition 8 *Under asymmetric information, free trade is welfare-decreasing when* $p^{AI} < p < p^{FI}$ *whereas it is welfare-increasing when* $p < p^{AI} < p^{FI}$.

The intuition for this proposition is straightforward. Remember that optimal regulation contracts the output of the intermediate sectors. If opening borders induces a specialization which reinforces this domestic distortion, the additional distortionary effect offsets any gains from trade. A free trade regime is eventually Pareto inferior to autarky.

When $p > p^{AI}$, the domestic economy has a comparative advantage in the capital intensive tradable good. Free trade induces specialization in that sector. By increasing the demand for capital, free trade increases the rental rate of capital and reduces output in the intermediate good sectors. This specialization exacerbates the initial downward output distortion of the intermediate sectors due to asymmetric information. This additional social cost has to be evaluated against the traditional gains from trade in production and consumption of the Hecksher-Ohlin framework.

When $p < p^{AI}$, the economy has a comparative advantage in the labor intensive agricultural good. Free trade induces a specialization in that sector and a reduction of production of the capital intensive tradable good. This, in turn, expands intermediate sectors. This expansion mitigates the initial downward output distortion due to asymmetric information. Opening borders improves the allocation of resources in the economy and increases welfare. In that case, free trade generates two sources of social gains: the usual Hecksher-Ohlin gains from trade and the reduced domestic distortions associated with the existence of information rents. Free trade is better than autarky.

Proposition 8 shows how asymmetric information may dramatically change the standard positive and normative predictions of trade models. Under complete information, trade openness allows a better specialization of a small country and optimal regulation does not affect the pattern of trade. The increase in income of the export sector more than offset the loss incurred by the import sector. The utility of the representative consumer increases. All efficiency gains coming from a better specialization can be passed onto the representative customer. Of course, this requires that there is no constraint on redistributing wealth between owners of the tradable good who win from trade openness and owners of the sector who lose from it.

The key difference under asymmetric information comes from the existing endogenous dead-weight loss which makes such redistribution costly. Asymmetric information creates a wedge between price and marginal cost. Even though, *in fine*, the representative consumer pockets both the profits of final good sectors and the information rent of intermediate ones, the total size of this cake is less than under complete information.

6 Conclusion

Standard results from Trade Theory must be modified when asymmetric information makes it impossible to fully redistribute gains from trade within the domestic country. First, free trade even when accompanied by a set of optimally designed domestic regulations may no longer be welfare-improving even for a small economy. Second, that country's comparative advantages may be reversed compared to complete information.

The basic reason for this challenge of two of the most familiar insights from the Trade literature is simple: asymmetric information in intermediate sectors producing key inputs for tradeable goods introduces distortions that cannot be eliminated even when the largest set of policy instruments are available to regulate those sectors.

Trade openness improves welfare only when it mitigates distortions induced by asymmetric information. It worsens welfare otherwise.

Because asymmetric information creates a wedge between prices and marginal costs in intermediate sectors, its impact on the gains from trade looks, at a rough level, like what one would obtain if we had instead assumed complete information but left intermediate sectors unregulated. In that case also, a decrease in the price of the capital intensive good increases also the price of capital in the small economy. This in turn increases the dead-weight loss of monopoly pricing and may finally decrease welfare. It should be stressed that, under complete information, there is no obstacle to implement corrective policies. Implicit in any such analysis of the distortions associated with monopoly pricing in intermediate sectors under complete information is the idea that the regulator faces exogenous constraints when choosing his instruments. Our framework with asymmetric information clearly endogenizes those constraints by giving them informational foundations and makes a similar point without any ad hoc restrictions on corrective instruments. This is where Bhagwati's insight that well-designed policies could avoid distortion definitively fails.

Still on the normative side, it should be clear however that our results could be generalized to the case of partial trade liberalization. Depending on the starting point (positive trade with initial frictions due to transports costs or the imposition of an import tariff), further trade integration can be immiserizing.

Our model could also be extended by considering a more symmetric environment with two countries of similar size, each being affected by similar informational problems. Trade pattern depends then on the *virtual factor endowments* of those countries and, in particular, on the respective degrees of asymmetric information that their domestic regulations face. These factor endowments will have to account for the *factor content* of information rents that result from the respective degrees of asymmetric information that these economies face. Hence, even though countries may look quite similar in their factor endowments, differences in information structures may already be a source of trade. Following the lessons of our model, one expects countries whose regulated sectors are using more of a given input factor and which face the most significant information problem on these factors to export final goods using less of it. The intuition built for a small economy already suggests two aspects of the pattern of trade. First, optimal domestic regulations may affect resources allocation in the foreign country through the induced terms of trade effects. This opens scope for a strategic design of those regulatory policies. Second, free trade may not be always welfare-improving from the worldwide viewpoint.

By assuming monopolies in the intermediate sectors, we have make stronger the inefficiency due to asymmetric information. Two possible modifications of our basic model could make asymmetric information less of a concern and make trade openness more attractive even though the main results of our analysis would carry over.

The first one would consist in introducing more competition in the intermediate sectors. Consider thus several firms competing for the right to serve any intermediate market. This more competitive environment can easily be modeled as an auction between privately informed competing firms having possibly independently distributed efficiency parameters. Assuming enough symmetry among competing firms, the optimal regulation would consist in first selecting the most efficient firm in each sector and then offering to that winning firm a regulatory contract close to that used in the monopoly case. The major difference with our set-up comes from the fact that incentives for looking less efficient are somewhat reduced by the threat of losing the market even though these incentives remain present to a large extent. This reduces both inefficiency due to asymmetric information and the information rent that owners of the intermediate sectors grasp. Both effects go in the direction of making the asymmetric information model closer to the complete information environment but this does not change our major conclusions even though it affects their magnitudes.

Another modification of our set-up worth to tackle would consist in giving to regulators a more active role in bridging the informational gap between the industry and the final sector. Regulators may gather informative signals on the intermediate sectors. If regulators use this knowledge to defend the interests of final sectors, distortions and information rents in the intermediate sectors will be lower and although the results of the model would come closer to the complete information environment, we would still keep the same kind of conclusions than obtained so far. Of course, this access to privileged information opens also the door to influence activities and regulatory capture by the intermediate sectors.[19] Such extensions may be worth exploring in our general equilibrium environment.

Finally, one could also depart from our representative consumer assumption to introduce some heterogeneity among factor owners. This would pave the way for a political economy analysis of trade and regulatory policies in a setting where asymmetric information is the source of the stakes that various interest groups may have to resist or to favor free trade. We plan to work on these issues in the next future.

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Appendix

• **Proof of Proposition 1:** The optimal regulation is such that all participation constraints (1) are binding because rents of intermediate sectors are viewed as costly by the regulator.

• Consider first the A sector. Inserting the values so obtained of these rents into the maximand and optimizing respectively w.r.t. $x_A(\theta)$ and L yields the following first-order conditions:

$$\beta X_A^{\beta-\frac{\sigma-1}{\sigma}} L^{1-\beta} x_M^{-\frac{1}{\sigma}}(\theta) = r\theta, \tag{A1}$$

and

$$(1-\beta) X_A^{\beta} L^{-\beta} = w \tag{A2}$$

where $X_j^{\frac{\sigma-1}{\sigma}} = \underset{\theta}{E}\left(x_j(\theta)^{\frac{\sigma-1}{\sigma}}\right)$ for $j = M, A$.

From (A1), we deduce

$$x_A(\theta) = \left(\frac{\beta}{r\theta}\right)^{\sigma} L^{(1-\beta)\sigma} X_A^{\beta\sigma-\sigma+1}. \tag{A3}$$

Taking expectations, we get

$$X_A = \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}} \left(\underset{\theta}{E}(\theta^{1-\sigma})\right)^{\frac{1}{(\sigma-1)(1-\beta)}} L. \tag{A4}$$

Using (A2), we also derive (2) from the zero-profit condition in the agricultural sector:

$$1 = \left(\frac{(1-\beta)}{w}\right)^{1-\beta} \left(\frac{\beta}{r}\right)^{\beta} \left(\underset{\theta}{E}(\theta^{1-\sigma})\right)^{\frac{\beta}{\sigma-1}}.$$

• Consider now the M sector. Optimizing respectively w.r.t. $x_M(\theta)$ and K yields:

$$x_M(\theta) = \left(\frac{\beta p}{r\theta}\right)^{\sigma} K^{(1-\beta)\sigma} X_M^{\beta\sigma-\sigma+1}, \tag{A5}$$

where

$$X_M = \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}} \left(\underset{\theta}{E}(\theta^{1-\sigma})\right)^{\frac{1}{(\sigma-1)(1-\beta)}} K. \tag{A6}$$

Finally, we have:

$$1 = \left(\frac{(1-\beta)p}{r}\right)^{1-\beta} \left(\frac{\beta p}{r}\right)^{\beta} \left(\underset{\theta}{E}(\theta^{1-\sigma})\right)^{\frac{\beta}{\sigma-1}}. \tag{A7}$$

This yields (3).

• Using (A3) and (A4) on the one hand and (A5) and (A6) on the other hand yields the following expressions of the levels of intermediate goods used in the final sectors:

$$x_M^{FI}(\theta) = \theta^{-\sigma}\Theta^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} K \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}} \text{ and } x_A^{FI}(\theta) = \theta^{-\sigma}\Theta^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} L \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}}. \tag{A8}$$

■

• **Proof of Proposition 2:** Existence and uniqueness follow immediately since $r_1(\cdot)$ is decreasing with $r_1(0) = +\infty$, $r_1(+\infty) = 0$ and $r_2(\cdot)$ is increasing over $[0, \infty[$ with $r_2(0) = 0$ and $r_2(+\infty) = +\infty$. For the sake of completeness, we compute the equilibrium values of prices as follows:

$$r^{FI} = (1-\beta)^{1-\beta}\beta^{\beta}\Theta^{-\beta}p^{FI}, \quad w^{FI} = (1-\beta)^{1-\beta}\beta^{\beta}\Theta^{-\beta}\left(p^{FI}\right)^{-\frac{\beta}{1-\beta}} \tag{A9}$$

where p^{FI} is given by (9). ■

• **Proof of Proposition 3:** The proof is identical to that of Proposition 1 except that θ is replaced by $\tilde{\theta}$ and Θ is replaced by $\tilde{\Theta}$ everywhere. In particular, we have

$$X_A^{AI} = \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}} \tilde{\Theta}^{\frac{1}{1-\beta}} L \text{ and } X_M^{AI} = \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}} \tilde{\Theta}^{\frac{1}{1-\beta}} K. \tag{A10}$$

where $X_j^{AI} = \left(\underset{\theta}{E}\left(x_j(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\sigma}{\sigma-1}}$ for $j = M, A$.

For further references, the productions of intermediate goods in both sectors are respectively given by:

$$x_M^{AI}(\theta) = \tilde{\theta}^{-\sigma}\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} K \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}} \text{ and } x_A^{AI}(\theta) = \tilde{\theta}^{-\sigma}\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} L \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}}. \tag{A11}$$

■

• **Consumer's income under asymmetric information (equation (14)).** Inserting the values of $x_M^{AI}(\theta)$ and $x_A^{AI}(\theta)$ obtained from (5) into (13) yields the following expression for the representative consumer's income under asymmetric information

$$R^{AI} = w\bar{L} + r\bar{K} + r\nu\Delta\theta\tilde{\bar{\theta}}^{-\sigma}\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}} \left(\bar{L} + p^{\frac{1}{1-\beta}} K\right) \tag{A12}$$

where the amount of capital K used in the final sector satisfies

$$K = \bar{K} - \underset{\theta}{E}\left(\theta(x_M^{AI}(\theta) + x_A^{AI}(\theta))\right). \tag{A13}$$

Taking into account (A11) yields:

$$\underset{\theta}{E}(\theta x_M^{AI}(\theta)) = \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}} K\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} \left(\nu\underline{\theta}^{1-\sigma} + (1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}\right)$$

and

$$\underset{\theta}{E}(\theta x_A^{AI}(\theta)) = \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}} \bar{L}\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} \left(\nu\underline{\theta}^{1-\sigma} + (1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}\right).$$

Therefore, (A13) becomes

$$K = \bar{K} - \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}} \tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} \left(\nu\underline{\theta}^{1-\sigma} + (1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}\right)\left(\bar{L} + p^{\frac{1}{1-\beta}} K\right).$$

So that we get

$$\bar{L} + p^{\frac{1}{1-\beta}} K = \frac{\bar{L} + p^{\frac{1}{1-\beta}} \bar{K}}{1 + \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}} \tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} \left(\nu\underline{\theta}^{1-\sigma} + (1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}\right)}.$$

Inserting into (A12) yields

$$R^{AI} = w\bar{L} + r\bar{K} + \frac{r\nu\Delta\theta\tilde{\bar{\theta}}^{-\sigma}\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}}\left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}}\left(\bar{L} + p^{\frac{1}{1-\beta}}\bar{K}\right)}{1 + \left(\frac{\beta p}{r}\right)^{\frac{1}{1-\beta}}\tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}}\left(\nu\underline{\theta}^{1-\sigma} + (1-\nu)\bar{\theta}\tilde{\bar{\theta}}^{-\sigma}\right)}. \tag{A14}$$

Using (3) and (12) yields $p^{\frac{1}{1-\beta}} = \frac{r}{w}$ and $r^{\frac{\beta}{1-\beta}}w = \beta^{\frac{\beta}{1-\beta}}(1-\beta)\tilde{\Theta}^{-\frac{\beta}{1-\beta}}$. Inserting into (A14) and simplifying using the definitions of λ and μ proposed in the text yields (14). ■

• **Proof of Proposition 4.** The proof is similar to that of Proposition 2. We have:

$$r^{AI} = (1-\beta)^{1-\beta}\beta^{\beta}\tilde{\Theta}^{-\beta}p^{AI}, \quad w^{AI} = (1-\beta)^{1-\beta}\beta^{\beta}\tilde{\Theta}^{-\beta}\left(p^{AI}\right)^{-\frac{\beta}{1-\beta}} \tag{A15}$$

where p^{AI} is given by (16). ■

• **Proof of Proposition 5.** Condition (17) follows from comparing (A9) and (A15). ■

• **Proof of Proposition 6.** Immediate. ■

• **Proof of Proposition 7.** The proof consists in identifying the solution to $(\mathcal{P}^{AI})$ to the competitive equilibrium. Denote thus by γ, $\zeta\gamma$, $\eta\gamma$, and $r\gamma$ the respective multipliers of (5), (6), (7) and (18) where the dependency of these multipliers on p is left implicit. The Lagrangean for $(\mathcal{P}^{AI})$ can be written as:

$$L(C_M, C_A, X_M, X_A, K, x_M(\cdot), x_A(\cdot)) = \alpha ln C_M + (1-\alpha) ln C_A$$

$$+\gamma(pX_M^{\beta}K^{1-\beta} + X_A^{\beta}\bar{L}^{1-\beta} - pC_M - C_A)$$

$$+r\gamma\left(\bar{K} + \nu\Delta\theta(x_M(\bar{\theta},p) + x_A(\bar{\theta},p)) - K - \underset{\theta}{E}\left(\tilde{\theta}(x_M(\theta) + x_A(\theta))\right)\right)$$

$$+\zeta\gamma\left(\left(\underset{\theta}{E}\left(x_M(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\sigma}{\sigma-1}} - X_M\right) + \eta\gamma\left(\left(\underset{\theta}{E}\left(x_A(\theta)^{\frac{\sigma-1}{\sigma}}\right)\right)^{\frac{\sigma}{\sigma-1}} - X_A\right).$$

The optimality conditions for $(\mathcal{P}^{AI})$ give us the following set of first-order conditions:

$$\frac{\alpha}{C_M(p)} = p\gamma, \quad \frac{1-\alpha}{C_A(p)} = \gamma; \tag{A16}$$

$$p\beta X_M^{\beta-1}(p)K^{1-\beta}(p) = \zeta, \quad p(1-\beta)X_M^{\beta}(p)K^{-\beta}(p) = r; \tag{A17}$$

$$\beta X_A^{\beta-1}(p)\bar{L}^{1-\beta}(p) = \eta; \tag{A18}$$

$$\zeta x_M(\theta,p)^{-\frac{1}{\sigma}}X_M^{\frac{1}{\sigma}}(p) = \eta x_A(\theta,p)^{-\frac{1}{\sigma}}X_A^{\frac{1}{\sigma}}(p) = r\tilde{\theta}. \tag{A19}$$

Those conditions can be readily identified with behavior on the competitive market.

• **Supply side.** From (A19) and taking expectations, we get

$$\zeta = \eta = r\tilde{\Theta}. \tag{A20}$$

Inserting the conditions (A20) into the first equation in (A17) and also in (A18) yields the same expressions for $X_M(p)$ and $X_A(p)$ as in (A10) with $L = \bar{L}$ when the labor market is at equilibrium.

Inserting those latter values of $X_M(p)$ and $X_A(p)$ into (A19) yields the same expressions for $x_M(\theta, p)$ and $x_A(\theta, p)$ as in (A11) with $L = \bar{L}$ when the labor market is at equilibrium.

Using the expression of ζ coming from (A20) into (A17) yields

$$r = (1-\beta)^{1-\beta}\beta^{\beta}\tilde{\Theta}^{-\beta}p. \tag{A21}$$

• **Demand side.** From (A16), we get

$$1 = \gamma(pC_M(p) + C_A(p)) = \gamma\left(pX_M^{\beta}(p)K^{1-\beta}(p) + X_A^{\beta}(p)\bar{L}^{1-\beta}\right) \tag{A22}$$

where the second equality follows from the slackness condition for (5). Therefore, $\gamma > 0$.

Denote

$$R^{AI} = pX_M^{\beta}(p)K^{1-\beta}(p) + X_A^{\beta}(p)\bar{L}^{1-\beta} \tag{A23}$$

and

$$w = (1-\beta)^{1-\beta}\beta^{\beta}\tilde{\Theta}^{-\beta}p^{-\frac{\beta}{1-\beta}}. \tag{A24}$$

With those notations in hands, (A16) becomes

$$C_M(p) = \frac{\alpha R^{AI}}{p}, \quad C_A(p) = (1-\alpha)R^{AI}. \tag{A25}$$

The slackness condition for (18) (taking into account that $\gamma > 0$) and (A24) altogether imply that one can write

$$\begin{aligned} R^{AI} = &\left[pX_M^{\beta}(p)K^{1-\beta}(p) - rK(p) - r\mathop{E}_{\theta}\left(\tilde{\theta}x_M(\theta,p)\right)\right] \\ &+ \left[X_A^{\beta}(p)\bar{L}^{1-\beta} - w\bar{L} - r\mathop{E}_{\theta}\left(\tilde{\theta}x_A(\theta,p)\right)\right] \\ &+r\left(\bar{K} + \nu\Delta\theta(x_M(\theta,p) + x_A(\theta,p))\right) + w\bar{L}. \end{aligned}$$

Because of constant returns to scale in the final sectors, the two bracketed terms above are zero which yields

$$R^{AI} = r\left(\bar{K} + \nu\Delta\theta(x_M(\theta,p) + x_A(\theta,p))\right) + w\bar{L}. \tag{A26}$$

Inserting into (A25) gives the expression of demand for tradable goods exactly as in the competitive equilibrium. ■

• **Proof of Proposition 8.** The proof is straightforward given what is in the main text. For completeness, we nevertheless check that $x_M(\bar{\theta}, p) + x_A(\bar{\theta}, p)$ decreases with p so that $\dot{V}^{AI}(p^{AI}) < 0$. Tedious computations give us:

$$x_M(\bar{\theta}, p) + x_A(\bar{\theta}, p) = \bar{\tilde{\tilde{\theta}}}^{-\sigma} \tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}} \left(\frac{\beta}{r}\right)^{\frac{1}{1-\beta}} \left(\bar{L} + p^{\frac{1}{1-\beta}} K\right)$$

$$= \frac{\bar{\tilde{\tilde{\theta}}}^{-\sigma} \tilde{\Theta}^{\frac{-1+\sigma-\beta\sigma}{1-\beta}}}{1 + \left(\frac{\beta}{1-\beta}\right)^{\frac{1}{1-\beta}} \tilde{\Theta}^{-1+\sigma} \left(\nu \underline{\theta}^{1-\sigma} + (1-\nu)\bar{\theta}\bar{\tilde{\tilde{\theta}}}^{-\sigma}\right)} \left(p^{-\frac{1}{1-\beta}} \bar{L} + \bar{K}\right).$$

∎