\\ 159 \\

Fully Revealing Equilibria in
Sequential Economics with Asset Markets

by

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Abstract

We study a financial economy with numeraire assets. There are finitely many states of private information and (possibly) incomplete financial markets. We show that, for an open and dense subset (of full Lebesgue measure) of the space of endowments, all financial equilibria are fully revealing.

1. Introduction

In economies with asymmetric information, a rational expectations equilibrium (REE) is a map from the states of aggregate information into the price domain. Individuals exploit the knowledge of the equilibrium map to refine their information through the information revealed by the observed equilibrium prices. Radner [8] proved that, when the number of states of private information is finite, typically there exists a REE and that, typically, all the REE are fully revealing. Later work has clarified the conditions under which observable equilibrium prices are a sufficient (or a nearly sufficient) statistics for the information available in the economy when the signal space is infinite (see, Allen [1], Jordan [4] and Jordan and Radner [5]).

As in Radner [8], we assume that the set of joint signals is finite. A specification of the fundamentals of the economy corresponds to each joint realization of signals. We depart from the traditional rational expectation model because individuals face a nontrivial sequence of budget constraints in our economy. In the first period, after observing their private signals, individuals trade on spot markets for an arbitrary number of physical commodities and assets. In the second period, asset payoffs are paid and agents trade on spot markets for an arbitrary number of commodities. The sequential nature of trades and the multiplicity of commodities at each spot imply that the model can not be rewritten as one where agents face a unique budget constraint. We do not consider atemporal economies where, after the realization of the signals, individuals' excess demand for commodities must satisfy a unique budget constraint, as in Allen [1]. We do not consider either intertemporal economies where the sequence of budget constraints is reducible to just one, as in Radner [8] and Jordan [4]. They study two period economies with one commodity per spot. Assets are traded in the first period and they pay off in the only existing commodity in the second period spots. Hence, using the sequence of budget constraints, we can define the utility function directly in terms of portfolios. Then, the economy reduces to one with a unique budget constraint (the one in period 0) and trade in a period zero consumption good and as many "composite" commodities as there are assets.

REE have already been studied in intertemporal economies with an asset market. However, the analysis has been focused on the existence of nonrevealing equilibrium prices, obtained exploiting the indeterminacy of equilibrium allocations as a device to interfere with the informational role of prices. For the existence of nonrevealing equilibria in economies with nominal assets, see Polemarchakis and Siconolfi [7] and Rajii [9].

In a related paper, Pietra and Siconolfi [6] exploit the possibility to generate sunspot equilibria even in the presence of real assets to prove that there are robust examples economies where noninformative REE exist, for some well-specified sunspot beliefs. In the economy considered here, however, assets are real and uncertainty purely intrinsic. Hence, equilibria are typically locally unique. A natural conjecture is that, in this set up, rational expectations equilibria typically exist and that all the equilibria are fully revealing. Using an argument similar to the one proposed by Radner [8], it is straightforward to show that, generically, there are fully revealing REE and that, typically, all the equilibria of the *full information economy* are fully revealing REE. In view of the result on the existence of noninformative REE in economies with extrinsic uncertainty, we are particularly interested in the generic non-existence of less than fully revealing REE. While this sort of strenghtening of the result is immediate in Radner's model, it is less so in our case, because of the different structure of the budget constraints.

In REE economies, the information revealed by equilibrium prices decomposes the economy into as many distinct subeconomies as there are distinct equilibrium prices associated to the joint signals. The classical analysis of REE models rests heavily on the fact that, in each subeconomy, agents face a unique budget constraint. Bear in mind that distinct values of some parameters corresponds to distinct realizations of the joint signal. Consider the equilibrium prices of the standard, *full information* Arrow-Debreu economies associated with alternative values of these parameters. Under the usual assumptions, equilibria are locally unique and they are smooth functions of the parameters of the economy. If, in addition, the perturbations of the parameters determined by the signal realization have full rank effect on the aggregate excess demand function, then the equilibrium prices associated with different values of the parameters will typically be distinct. It follows that, typically, there is a REE and that REE are typically fully revealing. The same kind of argument suffices to establish that, typically, there are no partially revealing equilibria.

In (nontrivial) sequential economies, the states of the economy are the product of the set of joint signals, Σ, and the set of states of nature that realize in the second period, S. Express agent h's knowledge about the set of joint signals Σ (prior to the observation of equilibrium prices) as a partition T_h over the set Σ. At a REE, an agent refines his information T_h through the information conveyed by the equilibrium price function, the partition $T(p^0,q)$. Let $T_h(p^0,q)$ be the partition of Σ so obtained. To each $T_h(p^0,q)$ it corresponds a particular sequence of budget constraints. Hence, in studying the generic properties of REE in intertemporal economies, we need to consider explicitly all the various possible information structures induced by the equilibrium prices, i.e., all the distinct partitions T over Σ. Given a fixed partition T, consider the equilibria of the fictitious economy where agents refine their private information by taking its join with T. Only if the equilibrium (p, q) of this fictious economy satisfy $T(p^0,q) = T$, (p, q) is indeed a REE. Luckily, as we argue in more detail in the paper, economies with partially revealing equilibria decompose into subeconomies characterized either by full revelation or by total non revelation. Therefore, we just study a full information economy, where individuals observe the joint signal, and prove that generically prices are one-to-one in the realization of the joint signal. This implies that typically there exists fully revealing REE. It does not prove, though, that, typically, all the REE are fully revealing. This last step is established studying the "noninformative" economy where individuals are endowed with the partitions T_h. An equilibrium (p, q) of the noninformative economy is a noninformative REE if T(p,q) is the trivial partition, i.e., if $(p^0(\sigma), q(\sigma))$ are costant across σ. We show that generically this is not the case. This, together with the decomposition property of partially revealing equilibria, establish the analogous of Radner's result. Namely, also in intertemporal economies with real assets, typically there exists a REE and, typically, all the REE are fully revealing.

There is a second twist that the structure of the model gives to the standard analysis of rational expectations economies. The information structure available to the agents translates into measurability constraints on their asset and (period zero) consumption choices. In the fictitious economy with fixed (and not full) information structure T, the multiplicity of period zero constraints an agent must satisfy and these measurability restrictions introduce a new possible source of discontinuity in the budget constraint, hence in the demand function. Given that we are interested in the non-existence of nonrevealing equilibria, we are able to deal with this sort of discontinuity in a straightforward way (see section 3.1).

2. The model

We consider the canonical model of a general equilibrium economy with asymmetric information: There is a finite set of agents (denoted by a subscript h). At time 0, each agent h observes a signal $\sigma_h \in \Sigma_h \equiv \{1, ..., \Sigma_h\}$. The space of signals is given by $\Sigma \equiv \prod_h \Sigma_h$. A collection of signals is $\sigma \equiv (\sigma_1, ..., \sigma_H)$. Often, we will use the notation $\Sigma_{-h} \equiv \prod_{k\neq h} \Sigma_k$, with typical element σ_{-h}, and $\sigma \equiv (\sigma_h, \sigma_{-h})$. For each joint signal σ, we have a particular realization of the fundamentals of the economy. There are two periods: At period 0, after receiving a signal, each individual trades in a given set of assets and of period 0 commodities. Given σ, at period 1, in each one of the S state of nature (indexed by a superscript s = 1, ..., S), returns on the portfolio holdings are paid and agents trade on a complete set of spot commodity markets.

At each spot there are C physical commodities, denoted by a superscript c = 1, ..., C. Individual h's consumption vector at state (s, σ) is $x_h^1(s,\sigma) \equiv (..., x_h^c(s,\sigma), ...)$ (and $x_h^0(\sigma)$). Individual h's consumption vector, associated with signal σ, is $x_h(\sigma) \equiv (x_h^0, (..., x_h^1(s,\sigma), ...))$, while $x_h \equiv (..., x_h(\sigma), ...)$. We use an analogous notation to refer to the endowment vectors (ω_h), to the excess demand vectors $(z_h = (x_h - \omega_h))$ and to the commodity price vectors (p).

There are A assets. The asset price vector, given signal σ, is $q(\sigma) \equiv (..., q^a(\sigma), ...)$, while $q = (..., q(\sigma), ...)$. Assets are *numeraire* assets. Given that in the sequel we normalize prices so that $p^{01} = p^{11}(s,\sigma) = 1$ for each (s, σ), asset a's yield is $r^a(s,\sigma)$, where $r^a(s,\sigma)$ specifies the quantity of commodity 1 that one unit of asset a pays off if signal σ and state s realize. Let $R(\sigma)$ be the matrix of the asset yields. Without loss of generality, we assume that $R(\sigma)$ has maximal rank A, for each σ.

By restricting the analysis to numeraire assets we sidestep some technical complications (related to one possible possible source of non-existence of equilibria, the one tackled in Duffie and Shafer [2]), which are not germane to the problem we want to analyze.

It is easy to check that all the results hold if we impose further restrictions on R, such as, for instance, if we require it to be σ-invariant.

Individual h portfolio, given σ, is $y_h(\sigma) \in \mathbb{R}^A$, while $y_h = (..., y_h(\sigma), ...)$.

Finally, let $\pi(\sigma)$ be the probability of the joint signal σ and let $\pi = (..., \pi(\sigma), ...)$.

2.1 The space of the economies

For each signal σ, agent h's preferences are described by a utility function $u_h^\sigma(x_h(\sigma)) \in C^\infty$, strictly monotone, differentiably strictly-concave. Moreover, the utility function satisfies the boundary condition: $\{ x_h \in \mathbb{R}_{++}^{C(S+1)\Sigma} \mid \sum_\sigma \pi(\sigma)u_h^\sigma(x_h(\sigma)) \geq \sum_\sigma \pi(\sigma)u_h^\sigma(x_h^*(\sigma)) \}$ is closed in $\mathbb{R}_{++}^{C(S+1)\Sigma}$ for each $x_h^* >> 0$.

In the sequel, the vector π, the matrices $R(\sigma)$ and the utility functions $u_h^\sigma(x_h(\sigma))$ are fixed parameters. We parameterize the space of economies in terms of endowments. The space of the economies, endowed with the product topology, is then

$$\Omega \equiv \{ \omega \in \prod_h \mathbb{R}_{++}^{C(S+1)\Sigma H} \mid \text{for each } h, \omega_h^0(\sigma) \text{ is } \sigma_h\text{-measurable} \}.$$

As it will become clear in the sequel, as an alternative, we could have parameterized the space of the economies in terms of utility functions. Our choice of the parameterization has two motivations: On one hand, the analysis in terms of endowment perturbations is (marginally) more straightforward. On the other hand, it allows us to use a stronger notion of generic set, as open, dense set of full Lebesgue measure.

2.2 Individual behavior and equilibrium

Let **Q** be the set of noarbitrage asset prices. Given that assets are numeraire assets, there is no loss of generality in restricting the price domain to the set

$$\mathbf{P} \equiv \{ (p, q) \in \mathbb{R}_{++}^{C(S+1)\Sigma} \times \mathbf{Q} \mid \hat{p}^{01}(\sigma) = \hat{p}^{11}(s,\sigma) = 1, \text{ for each } \sigma \text{ and } (s, \sigma) \}.$$

Let us express agent h's knowledge about the set of joint signals Σ (prior to the observation of equilibrium prices) as the partition $T_h \equiv (\Sigma_h \times \{\Sigma_{-h}\})$ over the set Σ. Two distinct joint signals belong to the same element of T_h only if they have the same realization of agent h's private signal. At a REE, an agent refines his information through the information conveyed by the equilibrium price function. More precisely, let $T(p^0,q) \equiv \{..., \theta, ...\}$ be the coarsest partition that makes the REE prices measurable. Evidently, $\theta \equiv \{\sigma \mid (p^0(\sigma), q(\sigma)) = (p^0(\theta), q(\theta))\}$. At the REE prices, the knowledge of agent h can be expressed by the join of his partition with $T(p^0,q)$, i.e., $T_h(p^0,q) \equiv \{..., \theta_h, ...\} = T(p,q) \vee T_h$. After having observed $(p^0(\sigma), q(\sigma); \sigma_h)$, agent h's uncertainty is represented by the element of $T_h(p^0,q)$ associated with it. The finer the partition $T_h(p^0,q)$, the lower the number of future states that an individual is facing (given $(p^0(\sigma), q(\sigma); \sigma_h)$) and, therefore, the lower the number of budget constraints. Therefore, in studying the generic properties of REE in intertemporal economies, we must conjecture a partition T over Σ.

Given $(p, q) \in \mathbf{P}$, having observed $(p^0(\sigma), q(\sigma); \sigma_h)$, each agent h solves

[h] $$\max \sum_{\sigma\in\theta_h} \pi(\sigma|\theta_h)u_h^\sigma(z_h(\sigma)+\omega_h(\sigma)) \quad \text{subject to}$$

$$p^0(\sigma)z_h^0(\sigma) + q(\sigma)y_h(\sigma) = 0, \text{ for each } \sigma \in \theta_h,$$

$$\Psi(\sigma)z_h^1(\sigma) - R(\sigma)y_h(\sigma) = 0, \text{ for each } \sigma \in \theta_h,$$

$$(z_h^0, y_h) \text{ is } \sigma\text{-invariant, for each } \sigma \in \theta_h,$$

where

$$\Psi(\sigma) \equiv \begin{bmatrix} p(1,\sigma) & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & \dots & 0 & p(S,\sigma) \end{bmatrix}.$$

Evidently, the optimal solution to the collection of the $\#T_h(p^0,q)$ optimization problems above is identical to the optimal solution to the ex-ante maximization problem:

$$[h'] \qquad \max \quad \sum_{\theta_h} \quad \sum_{\sigma\in\theta_h} \quad \pi(\sigma|\theta_h)u_h^\sigma(z_h(\sigma)+\omega_h(\sigma)) \qquad \text{subject to}$$

$$p^0(\sigma)z_h^0(\sigma) + q(\sigma)y_h(\sigma) = 0, \text{ for each } \sigma,$$

$$\Psi(\sigma)z_h^1(\sigma) - R(\sigma)y_h(\sigma) = 0, \text{ for each } \sigma,$$

$$(z_h^0,\ y_h) \text{ is } T_h(p^0,q)\text{-measurable.}$$

Definition 1: A *rational expectations equilibrium* is a price system $(\hat{p}, \hat{q}) \in \mathbf{P}$, with associated portfolio and consumption allocation $(\dots, (\hat{x}_h, \hat{y}_h), \dots)$ such that:

i. For each h, $(\hat{x}_h, \hat{y}_h)$ solves the ex-ante optimization problem [h'] at $(\hat{p}, \hat{q})$;

ii. $\sum_h \hat{y}_h \equiv \hat{y} = 0$ and $\sum_h (\hat{x}_h - \omega_h) \equiv \hat{z} = 0$.

A rational expectations equilibrium is *fully revealing* if $(\hat{p}^0(\sigma), \hat{q}(\sigma)) \neq (\hat{p}^0(\sigma'), \hat{q}(\sigma'))$ for each pair σ and σ'. It is *nonrevealing* if $(\hat{p}^0(\sigma), \hat{q}(\sigma)) = (\hat{p}^0(\sigma'), \hat{q}(\sigma'))$ for each pair σ, σ'. It is *partially revealing*, otherwise.

3. Results

The main result of the paper is given by the following theorem:

Theorem 1: Under the maintained assumptions, there is a (relatively) open, dense set of full Lebesgue measure, $\Omega'' \subset \Omega$, such that, for each economy $\omega \in \Omega''$, there is a rational expectations equilibrium and all the financial equilibria are fully revealing rational expectations equilibria.

The result follows from two intermediate steps:

a. Generically in Ω, there are no nonrevealing equilibria (Proposition 1);

b. Generically, there are fully revealing equilibria (Proposition 2).

These two results are also sufficient to establish that, generically, there are no partially revealing equilibria. Given the structure of individual agents' optimization problems, if there is partial revelation, the economy essentially decomposes into as many disjoint subeconomies as there are distinct period zero price vectors. Each one of the subeconomies is characterized by nonrevelation. Hence, generic non-existence of partially revealing equilibria follows by (a) applied to each subeconomy and by the fact that the collection of possible distinct subeconomies is of finite cardinality.

3.1 Generically there are no nonrevealing equilibria

Let $\mathbf{P}^* \equiv \{(p, q) \in \mathbf{P} \mid (p^0(\sigma), q(\sigma)) \text{ is } \sigma\text{-invariant}\}$. $\mathbf{P}^*$ is given by the intersection of a linear subspace of dimension $((C - 1)(\Sigma S + 1) + A)$ with $\mathbf{P}$. Hence, it is a smooth manifold without boundary of dimension $((C - 1)(\Sigma S + 1) + A)$.

For $(p, q) \in \mathbf{P}^*$, the ex-ante maximization problem of individual h becomes

$$[h''] \quad \max \quad \sum_{\sigma\in\Sigma} \pi(\sigma)u_h^\sigma(z_h(\sigma)+\omega_h(\sigma))) \qquad \text{subject to}$$

$$p^0(\sigma)z_h^0(\sigma) + q(\sigma)y_h(\sigma) = 0, \text{ for each } \sigma,$$

$\Psi(\sigma)z_h^1(\sigma)$ - $R(\sigma)y_h(\sigma) = 0$, for each σ,

(z_h^0, y_h) is $(\Sigma_h \times \{ \Sigma_{-h} \})$-measurable.

Let $\zeta_h^*(p,q;\omega_h) \equiv (z_h, y_h)(p,q;\omega_h)$ be the optimal solution to optimization problem [h"], given $(p, q) \in \mathbf{P}^*$. Moreover, let $\zeta^*(p,q;\omega_h) \equiv \Sigma_h \zeta_h^*(p,q;\omega_h)$.

The map $\zeta^*(p,q;\omega_h)$ is non continuous on the entire domain **P**, due to two different sources of discontinuity:

i. The first one characterizes all rational expectations, general equilibrium models. It is related to the change in the information structure of the agents when a sequence of fully revealing prices hits a non fully revealing price system;

ii. The second one characterizes the particular class of rational expectations models with an explicit structure of financial markets we are considering here. Consider the matrix given by the asset price vectors $(q(\sigma_h,\sigma_{-h}), ..., q(\sigma_h',\sigma_{-h}))$. When the system of asset prices varies within the noarbitrage set, the rank of the matrix can collapse, inducing a discontinuity in the excess demand map. The collapse of rank of the asset payoff matrix is well-known to generate discountinuities of this sort. However, the collapse of rank is usually due to either the existence of a general (i.e., nonnumeraire) set of real assets (see Duffie and Shafer [2]) or to sequential trade in assets. To the contrary, here the problem is due to the multiplicity of period zero budget constraints and to the measurability restrictions on the asset portfolio.

However, the map $\zeta_h^*(p,q;\omega_h)$ is continuous (actually, smooth) on the domain $\mathbf{P}^*$and this is all that matter for our purposes. To show that (generically in the space Ω) there are no nonrevealing equilibria is equivalent to show that, generically, there are no financial equilibria in the set $\mathbf{P}^*$, i.e., that $\zeta^{*-1}(0) \cap \mathbf{P}^* = \emptyset$. For this purpose, continuity of ζ on the set $\mathbf{P}^*$ is sufficient. Our approach is based on the transversality theorem applied to an appropriate subset of the system of equations $\zeta^*(p,q;\omega_h) = 0$, obtained eliminating the redundant market clearing equations.

The first result of this section is given by the following Proposition:

Proposition 1: Under the maintained assumptions, there is a (relatively) open, dense set of full Lebesgue measure, $\Omega' \subset \Omega$, such that, for each economy $\omega \in \Omega'$, there are no nonrevealing equilibria.

To establish the Proposition we need a few preliminary results and some more notation.

Let $\mathbf{1} \in \{\Sigma\}$ be the H-tuple of signal realizations with $\sigma_h = 1$ for each h. Also, define as $\mathbf{1}_{-h}$ $\in \{\Sigma_{-h}\}$ the (H-1)-tuple of signal realizations such that, for $k \neq h$, $\sigma_k = 1$. Define

$$\Sigma^* \equiv \{\mathbf{1}, ((\sigma_h, \mathbf{1}_{-h}), \sigma_h \in \Sigma_h \setminus \{1\}, \text{ for } h = 1, ..., H)\}.$$

Observe that $\#\Sigma^* = (\sum_h \#\Sigma_h) - (H - 1)$.

Let $(\zeta^0)_{\Sigma^*}$ be the excess demand (indexed by $\sigma \in \Sigma^*$) for all the assets and for all period 0 commodities but commodity 1. Let $(\zeta^1)_\Sigma$ be the aggregate excess demand function for all commodities but commodity (1, s, σ) for each (s, σ), with $\sigma \in \Sigma$. Let $\zeta \equiv ((\zeta^0)_{\Sigma^*}, (\zeta^1)_\Sigma)$. To restrict the analysis to the system of equations ζ means to drop the market clearing conditions for commodity 1 at each spot and for all the period 0 commodities and assets for each signal $\sigma \notin \Sigma^*$. Lemma 1 shows that these market clearing conditions are actually redundant when $(p, q) \in \mathbf{P}^*$, once one takes into account the sequence of budget constraints each consumer faces *and* the measurability restrictions on the demand functions.

Similarly, define $(\zeta^0_h)_{\Sigma^*}$, $(\zeta^1_h)_\Sigma$ and ζ_h.

Evidently, ζ: $\mathbf{P}^* \times \Omega \dashrightarrow \mathbb{R}^{(C-1+A)\#\Sigma^* + (C-1)S\Sigma}$. Given that dim $\mathbf{P}^* = ((C - 1)(\Sigma S + 1) + A)$, the dimension of the domain of the map ζ_ω (obtained from the map ζ by fixing the vector ω) is smaller than the dimension of its range.

In Lemma 1 we establish that the set of nonrevealing equilibria of an economy ω is given by

$\zeta_\omega^{-1}(0)$. Lemma 2 establishes that $\zeta \pitchfork 0$ and that, generically in Ω, $\zeta_\omega \pitchfork 0$. Then, Proposition 1 follows from these two Lemmata and the fact that dim $\mathbf{P}^*$ is smaller than the dimension of the range of ζ_ω: These facts together imply that $\zeta_\omega^{-1}(0) = \varnothing$.

Lemma 1: Given $\omega \in \Omega$, $\zeta^*(p^*,q^*;\omega) = 0$ if and only if $\zeta(p^*,q^*;\omega) = 0$.

Proof of Lemma 1.

The "only if" part is obvious. To establish the "if" part, observe that, by definition of the map ζ, $\zeta(p^*,q^*;\omega) = 0$ implies that

(1) $$\sum_h y_h(\sigma_h,\mathbf{1}_{-h}) = 0 \text{ and } \sum_h z_h^{0c}(\sigma_h,\mathbf{1}_{-h}) = 0, \text{ for each } \sigma_h, \text{ each h and each } c > 1.$$

Since $\zeta_k^0(\sigma_h,\mathbf{1}_{-h})$ is σ_h-invariant, for each $k \neq h$, while $\zeta_h^0(\sigma_h,\sigma_{-h})$ is σ_{-h}-invariant, (1) implies that, $y_h(\sigma) = y_h$ and $z_h^{0c}(\sigma) = z_h^{0c}$, for each h and $c > 1$. Hence, $\zeta = 0$ implies that $\sum_h y_h(\sigma) = 0$ and $\sum_h z_h^{0c}(\sigma) = 0$, for each σ and $c > 1$. Given that $(p^0(\sigma), q(\sigma))$ is σ-invariant. As we have seen, for each h, both $y_h(\sigma)$ and $z_h^{0c}(\sigma)$ are σ-invariant for each σ and each $c > 1$. Hence, for each σ and each h, by the period 0 budget constraints, $p^0(\sigma)z_h^0(\sigma) + q(\sigma)y_h(\sigma) = 0$, $z_h^{01}(\sigma)$ is also σ-invariant for each h. Therefore, $\sum_h z_h^{01}(\sigma) = 0$, for each σ .

Finally, by period 1 budget constraints, for each h and each (s, σ),

$$p^1(s,\sigma)z_h^1(s,\sigma) = r(s,\sigma)y_h(\sigma).$$

Summing the budget constraints over h and taking into account that $\zeta = 0$ implies that $\sum_h y_h(\sigma) = 0$ and $\sum_h z_h^{1c}(\sigma) = 0$, for each σ and $c > 1$, one obtains that $\sum_h z_h^{11}(\sigma) = 0$, for all σ. ■

Lemma 2: Under the maintained assumptions, $\zeta \pitchfork 0$ for $(p, q; \omega) \in \mathbf{P}^* \times \Omega$.

Proof of Lemma 2.

We prove the Lemma by defining directions of endowments perturbations $\bar{\omega}$ such that the corresponding directional derivatives of the map ζ satisfy $D_{\vec{\omega}}\zeta$ = I, the identity matrix.

We identify $\vec{\omega}$ with a $(((C - 1 + A)(\sum_h \Sigma\#_h - (H - 1)) + (C - 1)S\Sigma) \times (HC(S + 1)\Sigma))$-dimensional matrix. The columns of $\vec{\omega}$ are $(HC(S + 1)\Sigma)$-dimensional vectors indexed by

$(c,o,\sigma)_{c>1,\sigma\in\Sigma^*}$, $(a,\sigma)_{a=1,\ldots,A,\sigma\in\Sigma^*}$ and $(c, 1, s, \sigma)_{c>1,s\in S,\sigma\in\Sigma^*}$.

The column indexed by $(c, 0, (\sigma_h, \mathbf{1}_{-h}))$ has all entries equal to zero, but $d\omega_h^{01}(\sigma_h,\sigma_{-h}) = p^{0c'}$ and $d\omega_h^{0c'}(\sigma_h,\sigma_{-h}) = -1$, for each $\sigma_{-h} \in \Sigma_{-h}$. Evidently, this perturbation of agent h's endowment vector only affects his excess demand just for commodities $(1, 0, \sigma_h, \sigma_{-h})$ and $(c, 0, \sigma_h, \sigma_{-h})$, for all σ_{-h}. Bear in mind that the excess demand for commodity $(c, 0, \sigma_h, \sigma_{-h})$, for each c and for $\sigma_{-h} \neq \mathbf{1}_{-h}$, do not enter into the definition of the map ζ. Also notice that the definition of the column $(c,0,(\sigma_h,1_{-h}))_{c>1,\sigma_h\in\Sigma_h}$ of the matrix $\vec{\omega}$ is such that the perturbation of agent h's endowment satisfies the maintained measurability restrictions. Finally, observe that $D_{\vec{\omega}(c',0,\sigma_h,1_{-h})} z^{0c'}(\sigma_h,\mathbf{1}_{-h}) = 1$, while

$D_{\vec{\omega}(c',0,\sigma_h,1_{-h})} z^{0c}(\sigma_h,\mathbf{1}_{-h}) = 0$, for $c \neq c'$, and $c > 1$. Morever, $D_{\vec{\omega}(c',0,\sigma_1.1_{-1})} y^{a}(\sigma_h,\mathbf{1}_{-h}) = 0$

and $D_{\vec{\omega}(c',0,\sigma_h,1_{-h})} z^{1c}(\sigma_h,\mathbf{1}_{-h}) = 0$ for each s, σ and c.

All the other perturbations defined in the sequel also affect just the excess demand for the commodity (or the asset) with the same index and they always satisfy the measurability restrictions.

In particular, all the entries of the column (a, σ_h, $\mathbf{1}_{-h}$) are nihil, but the entries $d\omega_h^{01}(\sigma_h,\sigma_{-h}) = q^a$ and $d\omega_h^{11}(s,\sigma_h,\sigma_h) = -r^a(s,\sigma)$, for each $\sigma_{-h} \in \Sigma_{-h}$. All the entries of the column (a, (σ_h, $\mathbf{1}_{-h}$)), $\sigma_h \in \Sigma_h \backslash \{1\}$ are zero, but the entries $d\omega_h^{01}(\sigma_h,\sigma_{-h}) = q^a$ and $d\omega_h^{11}(s,\sigma_h,\sigma_{-h}) = -r^a(s,\sigma)$, for each $\sigma_{-h} \in \Sigma_{-h}$. The column indexed by (c, 1, s, σ), for each c > 1 and (s, σ) $\in S\times\Sigma$, have all the entries equal to zero, but the entries $d\omega_1^{11}(s,\sigma) = p^{1c}(s,\sigma)$ and $d\omega_1^{1c}(s,\sigma) = -1$.

Let $\vec{\omega}$ be the matrix defined as

$$\vec{\omega} \equiv [(\vec{\omega}(c,0,\sigma)_{c>1,\sigma\in\Sigma}, \vec{\omega}(a,\sigma)_{a=1,\ldots,A,\sigma\in\Sigma^*}, \vec{\omega}(c,1,s,\sigma)_{c>1,(s,\sigma)\in S\times\Sigma}].$$

Evidently, $D_{\vec{\omega}}\zeta = I$. ■

Proof of Proposition 1.

The map ζ: $\mathbf{P}^*\times\Omega$ --> $\mathbb{R}^{(C-1+A)\#\Sigma^*+(C-1)S\Sigma}$ smoothly maps the smooth manifold $\mathbf{P}^*\times\Omega$ into the smooth manifold $\mathbb{R}^{(C-1+A)\#\Sigma^*+(C-1)S\Sigma}$. By Lemma 2, $\zeta \pitchfork 0$. Hence, by the transversality theorem, there exists a dense subset of Ω, Ω', of full Lebesgue measure such that, for each $\omega \in \Omega$, $\zeta_\omega \pitchfork 0$. Given that dim $\mathbf{P}^* \equiv ((C - 1)(S + 1)\Sigma + A\Sigma) < ((C - 1 + A)\#\Sigma^* + (C - 1)S\Sigma)$, this means that $\zeta_\omega^{-1}(0) = \varnothing$.

By a straightforward argument, the boundary conditions (satisfied by the aggregate excess demand function) imply that the set Ω' is (relatively) open. ■

3.2 Generic existence of a fully revealing equilibrium

Generic existence of fully revealing rational expectations equilibria follows by the argument first proposed by Radner [8]: We consider the equilibria of the fictitious economy where agents have full information (i.e., the equilibria of the associated *full information* economy) and we show that, generically in endowment space, all the full information equilibria satisfy the property ($p^0(\sigma)$, $q(\sigma)$)

$\neq (p^0(\sigma'), q(\sigma'))$ whenever $\sigma \neq \sigma'$, i.e., that they can be supported as rational expectations, fully revealing equilibria of the economy.

Proposition 2: Under the maintained assumptions, there is a (relatively) open, dense set of full Lebesgue measure, $\Omega' \subset \Omega$, such that, for each economy $\omega \in \Omega'$, all the full information equilibria are rational expectations fully revealing equilibria.

Proof of Proposition 2.

Consider the *full information* economy, i.e., the one where each agent receives the signal σ. It is easy to check that the full information economy decomposes into a collection of $(\#\Sigma)$ independent σ-subeconomies. Each σ-subeconomy is a standard general equilibrium economy with numeraire assets. By, say, Geanakoplos and Polemarchakis [3], for each σ there is a REE equilibrium $(\hat{p}(\sigma), \hat{q}(\sigma))$.

The Proposition follows by iterating a transversality argument over $\sigma \in \Sigma$. Consider σ and σ', $\sigma \neq \sigma'$. By definition, σ and σ' can be rewritten as $\sigma \equiv (\sigma_h, \sigma_{-h})$ and $\sigma' \equiv (\sigma_h', \sigma_{-h}')$ with $\sigma_h \neq \sigma_h'$, for some h. On the two states of information under consideration, there are no measurability restrictions on ω_h. Hence, by (for instance) the kind of argument we used to prove Lemma 2 and choosing appropriate perturbations of agent h's endowment vector, one can easily show that $D_{\omega_h} \zeta$ has maximal rank $((C - 1)(S + 1) + A)$. Let $(p_\sigma, q_\sigma) \in \mathbb{R}_{++}^{(S+1)(C-1)+J}$ be the normalized prices of a σ-subeconomy and let $\omega_h(\sigma) \in \mathbb{R}_{++}^{(S+1)C}$ be agent h's endowment in the σ-subeconomy.

Define the map $H(p_\sigma,q_\sigma,p_{\sigma'},q_{\sigma'},\omega) \equiv (\zeta_\sigma, \zeta_{\sigma'}, ((p_\sigma,q_\sigma) - (p_{\sigma'},q_{\sigma'})))\equiv$

$$(\zeta(p_\sigma,q_\sigma,\omega_h(\sigma),\omega_{-h}(\sigma)),\ \zeta(p_{\sigma'},q_{\sigma'},\omega_h(\sigma'),\omega_{-h}(\sigma')),\ ((p_\sigma,q_\sigma) - (p_{\sigma'},q_{\sigma'}))) = 0$$

Its Jacobian contains the submatrix

$$\begin{bmatrix} D_{(p_\sigma,q_\sigma)}\zeta_\sigma & 0 & D_{\omega_h(\sigma)}\zeta_\sigma & 0 \\ 0 & D_{(p_{\sigma'},q_{\sigma'})}\zeta_{\sigma'} & 0 & D_{\omega_h(\sigma')}\zeta_{\sigma'} \\ I & -I & 0 & 0 \end{bmatrix}$$

where I is the (C - 1 + J)-dimensional, identity matrix. Evidently, $H \pitchfork 0$. By the transversality theorem, there is a dense, full Lebesgue measure subset of Ω, say the set Ω(σ,σ'), such that, for each ω ∈ Ω(σ,σ'), $H_\omega \pitchfork 0$. The boundary conditions guarantee that this set is actually open. Given that the domain of the map so restricted has dimension (2(C - 1)(S + 1) + A), while its range has dimension (2(C - 1)(S + 1) + A + (C - 1 + A)), this implies that $H_\omega^{-1}(0) = \emptyset$.

Repeating the same argument for all possible pairs σ and σ' of distinct joint signals, we obtain a finite collection of open and dense sets of full Lebesgue measure. Define $\Omega' \equiv \bigcap_{(\sigma,\sigma')\in(\Sigma\times\Sigma)} \Omega(\sigma,\sigma')$. Evidently, Ω' is an open, dense set of full Lebesgue measure. Moreover, by construction, for each ω ∈ Ω', if (p, q) and (p', q') are equilibria of the full information economy (associated with two distinct joint signals σ and σ'), $(p^0, q) \neq (p^{0\prime}, q')$. Hence, each REE equilibrium of the *full information* economy is also a fully revealing REE of the actual economy. ■

Proof of Theorem 1

Given Proposition 1 and 2, we just need to establish that, generically, there are no partially revealing equilibria. Given that #Σ is finite, there is a finite number of possible distinct partitions of the set Σ. Let us index these partitions with t = 1, ..., T. A typical partition is $T_t \equiv \{..., \theta, ...\}$. Remember that $T(p^0,q)$ is the coarsest partition such that (p^0, q) is measurable. Let $P^{-1}(t) \equiv \{(p, q) \in \mathbf{P} \mid T(p^0,q) = T_t\}$. Consider the artificial economy where each agent has an information structure given by the join $T_h \equiv \Sigma_h \vee T_t$, for some exogenously given partition T_t. To establish the Theorem, it suffices to show that, for each t, there is a open, dense set of full Lebesgue measure, **Ω(t)**, such that, if (p, q) is an equilibrium of the artificial economy with endowment $\omega \in \mathbf{\Omega(t)}$, then (p, q) $\notin P^{-1}(t)$. Evidently, this implies that, for each actual economy $\omega \in \mathbf{\Omega(t)}$, there are no partially revealing equilibria whose prices induce the information structure T_t. Consider the open, dense set of full Lebesgue measure, $\Omega'' \equiv \cap_t \mathbf{\Omega(t)}$. Evidently, for each economy $\omega \in \Omega''$ there are no partially revealing equilibria.

Pick an arbitrary partition of Σ, $T_t \equiv \{..., \theta ,...\}$. For each h and each θ, let $T_{h,\theta}$ be restriction to θ of the partition $T_h \equiv T_h \vee T_t$. Given the information structure T_t, the economy decomposes into ($\#T_t$) completely independent θ-subeconomies, where agent h has the fixed information structure $T_{h,\theta}$. By definition, if (p, q) $\in P^{-1}(t)$, (p^0, q) is invariant over $\sigma \in \theta$, for each $\theta \in T_t$. Hence, if, for at least one θ-subeconomy, typically there are no nonrevealing equilibria, then, typically, there are no partially revealing equilibria inducing the partition T_t. Generic non existence of nonrevealing equilibria in a given θ-subeconomy follows immediately from Proposition 1 applied to each θ-subeconomy. Hence, for each t, there is a open, dense set of full Lebesgue measure, $\mathbf{\Omega(t)}$, such that, if (p, q) is an equilibrium of the economy $\omega \in \mathbf{\Omega(t)}$, then (p, q) $\notin P^{-1}(t)$. As explained above, this suffices to establish the Theorem. ■

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100. Mario Forni [1994] "Consumption Volatility and Income Persistence in the Permanent Income Model", pp. 30

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111. Paolo Bosi [1995] "Regionalismo fiscale e autonomia tributaria: l'emersione di un modello di consenso", pp. 38

112. Massimo Baldini [1995] "Aggregation Factors and Aggregation Bias in Consumer Demand", pp. 33

113. Costanza Torricelli [1995] "The information in the term structure of interest rates. Can stocastic models help in resolving the puzzle?" pp. 25

114. Margherita Russo [1995] "Industrial complex, pôle de développement, distretto industriale. Alcune questioni sulle unità di indagine nell'analisi dello sviluppo." pp. 45

115. Angelika Moryson [1995] "50 Jahre Deutschland. 1945 - 1995" pp. 21

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118. Mario Forni e Marco Lippi [1995] "Permanent income, heterogeneity and the error correction mechanism." pp. 21

119. Barbara Pistoresi [1995] "Co-movements and convergence in international output. A Dynamic Principal Components Analysis" pp. 14

120. Mario Forni e Lucrezia Reichlin [1995] "Dynamic common factors in large cross-section" pp. 17

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123. Giovanni Bonifati [1995] "Cambiamento tecnico e crescita endogena: una valutazione critica delle ipotesi del modello di Romer" pp. 21

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130. Carlo Alberto Magni [1996] "Vaghezza e logica fuzzy nella valutazione di un'opzione reale" pp. 20

131. Giuseppe Marotta [1996] "Does trade credit redistribution thwart monetary policy? Evidence from Italy" pp. 20

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133. Carlo Alberto Magni [1996] "Un esempio di investimento industriale con interazione competitiva e avversione al rischio" pp. 20

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