CENTRE FOR DYNAMIC MACROECONOMIC ANALYSIS
WORKING PAPER SERIES

CDMA12/08

Profits in (Partial) Equilibrium and (General) Disequilibrium

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JULY, 2012

ABSTRACT

In a many-sector production economy where each sector's output is used as input for every sector, a general equilibrium implies zero profit for everyone, whereas one market in excess demand implies positive profits for all others in their partial equilibrium. If more than one market is stuck in excess demand, every market allows positive profits.

JEL Classification: D59, E19, F41.

Keywords: Walras' Law, Input-Output, Sectoral Disequilibria, Profits.

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1 Introduction

Economists have long assumed that every market clears continuously. However, everyday observation contradicts the assumption. According to (the contraposition of) the Walras' Law, the presence of even a single market in excess demand (or in excess supply) suffices to show that the economy as a whole is in a disequilibrium state. *Example*: A fellow who takes a bus this morning and finds no seats available (or sees many seats vacant) can assure his friends that the world economy is currently not in a Walrasian equilibrium. A prerequisite is that his friends have taken EC2xxx, Intermediate Microeconomics.—A friend of his, we hope, would tell in reply more about his own experiences (perhaps more intriguing) from markets for automobiles, houses, loans, and so on.

In this article, we are interested in inter-sectoral consequences of such casual disequilibrium, born in the contraposition of the Walras' Law. Consider a many-sector production economy where each sector's output is used as input for every sector. In this input-output relation as a whole, many sellers and many buyers meet in every market. Now let us allow some frictions by which some markets are stuck in excess demand; for example, credit markets are often found in excess demand due to imperfect information and subject to rationing of loanable funds (Stiglitz and Weiss, 1981). Stepping aside specific market frictions and reasons behind the failure of a Walrasian tâtonnement process, we ask here instead, what can we infer about the other parties' profits from the presence of excess demand in one market?

We find, if one market is stuck in excess demand state, firms in the other markets currently in their partial equilibrium make positive profits. As a corollary, if more than one market is stuck in excess demand state, every market allows positive profits: Perfect competition to the degree of zero-profit is sometimes impossible. For example, the U.S. firms would make positive profits even when their domestic economy be perfectly competitive, if the U.S. firms use Chinese products as inputs for their outputs, for while the People's Bank of China, as someone claims, manipulates its currency value to make their products underpriced overall.

2 The Input-Output Matrix

Consider a production economy that consists of a continuum of sectors, $J = \{j \mid j \in [0,1]\}$. In turn, each sector j consists of a continuum of identical firms of "measure one", which produce a homogeneous good j. So the world is visualized as the unit rectangle, $[0,1]^2$, with a continuum of firms upon it. Each sector j's output, Y_j is used as inputs for every sector. In this input-output relation as a whole, every market is composed of many sellers and many buyers, and thus perfectly competitive from the viewpoint of every individual firm. Henceforth, without loss of generality, we draw attention to a particular section of input-output network in this multi-sector production economy, and focus on a representative "stand-in" doing a business in sector $i \in J$, currently of which output market is in *partial equilibrium* at given market prices vector, $[P_j]_{j\in J}$. We will shorthand the representative firm by "rep".

To conform to many-market-many-firm environment, we assume that production technology for all firms is homogeneous of degree one. Also bearing in mind computability of sectoral disequilibria from a general equilibrium perspective, we model the economy's input-output process in the line with the Dixit-Stiglitz style technology (Dixit and Stiglitz, 1977). Specifically, let the rep produce Y_i using the following production technology;

$$Y_i = \left[\int_{j\in J} (X_{j,i})^{\frac{1}{\eta}} (Y_{j,i})^{\frac{\eta-1}{\eta}} \, dj \right]^{\frac{\eta}{\eta-1}}, \; 1 < \eta < \infty, \tag{1}$$

where $X_{j,i}$ measures the technical contribution of jth good to production of ith good, Y_i. It can be thought as a quality-dimension of jth good. $Y_{j,i}$ is the input amount of jth good used by the rep in sector i. Inputs are neither perfect substitutes nor perfect complements one another; $1 < \eta < \infty$. Also, the input-output network is assumed to work simultaneously across sectors, and therefore notionally the rep can use its own output as input for output. We exclude the Sraffian style self-reflective production, by trivially assuming that $X_{j,j} = 0$ for all j's.

Due to the input-output relation with a continuum of firms, the rep takes the continuum vector of market prices, $[P_j]_{j\in J}$, which includes the market price of its own output, as given. Given the continuum vector of market prices, $[P_j]_{j\in J}$, the continuum vector of inputs used by the rep, $[Y_{j,i}]_{j\in J}$, cannot be larger than the continuum vector of sectoral outputs, $[Y_j]_{j\in J}$;

$$[Y_{j,i}]_{j\in J} \leq [Y_j]_{j\in J}, \tag{2}$$

which embeds the market-clearings across all the sectors, $[Y_{j,i}]_{j\in J} = [Y_j]_{j\in J}$, as a special case. Since the rep is normalized of "measure one" while the sector itself consists of a large number of independent firms, we can think of (2) in general as a *competitive rationing* rule in the states of excess demand, thereby every competing firm in the sector has equal access to inputs.

Profit maximization implies that the rep solves

$$\max_{[Y_j]_{j\in J}} \pi_i = P_i Y_i - \int_{j\in J} P_j Y_{j,i} dj, \tag{3}$$

subject to {(1), (2)}. Applying the Kuhn-Tucker Lagrangian, the firm finds the first-order conditions, in addition to {(1), (2)},

$$P_i = M_i \tag{4}$$

$$Y_{j,i} = X_{j,i} Y_i \left(\frac{P_j + \xi_{j,i}}{M_i}\right)^{-\eta}, \tag{5}$$

$$\xi_{j,i}(Y_j - Y_{j,i}) = 0,\ \xi_{j,i} \geq 0, \tag{6}$$

for every $j \in J$. M_i and $\xi_{j,i}$ are the Lagrangian multipliers associated with (1) and (2), respectively, and the usual interpretation of shadow costs applies here: M_i is the marginal production cost of output Y_i, and $\xi_{j,i}$ the shadow cost of binding the given inequality constraint. See Appendix for derivation of the first-order conditions.

Equation (4) is the standard equalization condition between marginal cost and price. Equation (5) is the rep's effective demand schedule for jth input.—Using (4), we can see $(P_j + \xi_{j,i})/M_i = (P_j + \xi_{j,i})/P_i$, and thus think of the term as the effective cost of jth input relative to ith output price. So (5) says that, given the level of the output (Y_i), the rep's demand for jth input increases in the technical contribution ($X_{j,i}$) to production of good i, and decreases in the effective cost of input, $(P_j + \xi_{j,i})/P_i$. Equation (6) comes into effect when some markets are quantity-constrained. In the next section, we combine the first-order conditions and develop a tractable metric for sectoral disequilibria.

3 Costs and Prices

Intuitively, the marginal cost of production, M_i, will increase in input prices and decrease in technical efficiencies of inputs. By plugging (5) back into (1), we can obtain M_i at optimum as a function of input prices and technical efficiencies;

$$M_i = \left[\int_{j \in J} X_{j,i} \left(P_j + \xi_{j,i} \right)^{1-\eta} dj \right]^{\frac{1}{1-\eta}}. \tag{7}$$

Now let AC_i define the average cost of production of Y_i; that is, $AC_i = \{\int_{j \in J} P_j Y_{j,i} dj\}/Y_i$. At the rep's optimal production decision, we can see that

$$AC_i = (M_i)^{\eta} (\tilde{M}_i)^{1-\eta}, \tag{8}$$

where $\tilde{M}_i = \left[\int_{j \in J} X_{j,i} P_j \left(P_j + \xi_{j,i} \right)^{-\eta} dj \right]^{\frac{1}{1-\eta}}$. Notice that $\tilde{M}_i$ is obtained when the integrand of M_i is multiplied by $P_j / \left(P_j + \xi_{j,i} \right)$. So it is clear that the distance between M_i and $\tilde{M}_i$ (and therefore between M_i and AC_i) is fully governed by the relative size of the ongoing market prices over the shadow costs. It means that their distance can be taken as a useful metric for sectoral disequilibria from the viewpoint of the rep i. See Appendix for derivation of (7) and (8).

Lemma. *It holds that*

$$M_i \leq \tilde{M}_i$$

for any rep i whose market is currently in partial equilibrium in this production economy.

Proof. See Appendix. □

Here the equality holds only when $\xi_{j,i} = 0$ for all j's; that is, none of the inputs for production of ith output are quantity-constrained.

Proposition 1. *No rep can make positive profits, if the production economy is in a Walrasian equilibrium at the current market prices vector.*

Proof. See Appendix. Essentially, we show the competitive equalization between marginal cost, average cost, and market price for each sector; that is, $M_i = AC_i = P_i$ for any rep $i \in J$ at the general equilibrium. □

In fact, this result rephrases one of the well-known properties held by a competitive production economy. It sounds self-evident, so does its contraposition: If some reps can achieve positive profits, the production economy as a whole is in a disequilibrium at the ongoing market prices vector. However, its related properties as detailed below are not entirely obvious, and sound even paradoxical.

Proposition 2. *A rep makes positive profits at its partial equilibrium, if and only if it finds some inputs (at least one) that it cannot buy as many as it wants at the ongoing market prices vector.*

Proof. See Appendix. Essentially, we show that the marginal cost diverges above from the average cost ($M_i > AC_i$) at its partial equilibrium, if and only if at least one input is quantity-constrained. □

The key mechanism behind this result is related to the divergence of the marginal cost away from the average cost. If the rep cannot buy some inputs as many as it desires at the ongoing market prices vector, it will substitute them with other inputs. However, because the inputs are imperfect substitutes one another, the rep will have to bear some efficiency loss when producing its output. Given the economy's state of disequilibrium, the shadow costs vector, $[\xi_{j,i}]_{j \in J}$, captures the efficiency loss. As the rep makes rational decision at the margin, it counts the efficiency loss in the marginal cost of production. Since the rep equates the marginal cost with the market price of its output at its optimal production decision, the market price reflects the economic value of the efficiency loss. Everything else equals, the wider range of inputs are quantity-constrained and the more severely constrained, the higher marginal cost incurs. (7) confirms this intuitive relationship; the higher shadow costs, the higher marginal costs.

In sharp contrast, the shadow costs are a double-edged sword in carving the average cost.[1] One the one hand, the shadow costs raise the average cost, exactly for the same reason when they constitute the marginal cost. On the other hand, the shadow costs cut down the average cost, because the shadow costs are mostly associated with excessive use

[1] In principle, the average cost itself does not condition one's optimal production decision, but counts on market prices and actual purchases of inputs. However, since the average cost at optimum can be expressed in terms of the shadow costs and market prices, we can contrast the average cost with the marginal cost w.r.t. their identical arguments; the shadow costs and market prices. So our discussion about the role of the shadow costs in carving the average cost is done at one's optimal production decision.

of relatively "underpriced" inputs, given the technical efficiencies matrix $\left[[X_{j,j'}]_{j'\in J}\right]_{j\in J}$. (8) concisely captures both sides of the shadow costs. Clearly, $(M_i)^{\eta}$, represents "efficiency loss" in production and increases when the shadow costs become larger; whereas $(\tilde{M_i})^{1-\eta}$ represents overuse of "underpriced" inputs and so decreases in the shadow costs. Surrounded by the two opposite forces at work, the rep will see the marginal cost diverge above the average cost and so its business profitable, unless the shadow costs vector is a null at the current market prices vector.

By implication, it immediately follows that if more than one market is stuck in excess demand while all the other markets are in their partial equilibrium, then every firm in the production economy makes positive profits. Notice that this is where no markets are currently in excess supply just as in a "repressed inflation" regime (Green and Laffont, 1981). Such situations cannot be ruled out, because according to the Walras' Law, the presence of excess demand in one market implies the presence of excess supply in other markets at the Walrasian market prices vector, but not necessarily at a non-Walrasian one.

4 Discussion about the Model Environments

It is this article's main premise that a Walrasian tâtonnement process may fail: In a real world, the market prices vector may contain some mispriced entries, for some reasons beyond individual agent's control (and beyond this article's scope). The premise itself is not new. We share it with the Neo-Keynesian literature mostly forwarded during the 1960's to the early 1980's (see, for a review, Benassy, 2008). But the main aim of the present study differs from the literature. We are interested in inter-sectoral consequences of disequilibrium, rather than macroeconomic consequences of nominal rigidity of market prices and wages. Proposition 1 holds when no entries are mispriced. Proposition 2 holds when some entries are mispriced downward. Neither situations underlying the two results can be ruled out.

One may wonder if the results hold here because the free-entry argument were inactivated. However, when it comes to a pure system of logic, the results come in full of scenes of the free-entry argument. In the model, each sector contains infinitely many number of firms that are free to move across sectors with free access to the production technology of homogenous of degree one, and always equate their marginal costs with given market prices.

Moreover, where at least one market is stuck in excess demand, the free-entry argument does not work as a forcing device toward zero-profit due to the inter-sectoral input-output network of this production economy: For example, when positive profits attract more firms, it will only aggravate the current state of sectoral disequilibria because newcomers mean more demand for the inputs already in excess demand. If actually desired to explicitly incorporate the inter-sectoral relocation within a simple static setup, one might introduce a non-uniform measure of sectors and let each sector be of different measure between zero and one in general, whereby the free-entry argument is brought up at a first place in a form of perfect equalization of profits across sectors, rather than as a forcing device toward zero-profit. But still then, one would still see the first-order conditions remain unaffected irrespective of sector's scale, and so do both results above. Of course, such an extension incorporating the inter-sectoral relocation would be fruitful if it is made in a full dynamic setup.

Explicitly incorporating excess supply into the analysis goes beyond the simple static setup adopted in this article, since it is irrational even for price-takers to produce more while they know they cannot sell out. So it would be necessary to introduce some justifiers like uncertainty, expectations, inventory transition process, and so on; and in turn, to rely on a richer solution concept by which economic agents make decisions while forming rational beliefs about all possible states of general disequilibrium (Gordon, 1981). See, for example, Benassy (1986), where the concept of a Nash equilibrium between monopolistically competitive agents is facilitated to establish a general equilibrium/disequilibrium.

5 Conclusion

This article considers a many-sector production economy where each sector's output is used as input for every sector, and focuses on a particular section of the input-output network within a representative framework. It finds that if one market is stuck in excess demand state, then firms in the other markets make positive profits; and if more than one, then every firm upon this production network.

Though the model economy is static, tersely built, and production-oriented, the proposed results on sectoral disequilibria have wide implications in economics. First, the results can be appreciated in a context of banking and finance: For example, credit rationing for loanable funds may also indicate positive profits for user sectors of rationed loans, not only for banking sector, because where the Modigliani-Miller theorem breaks down, funds become imperfect substitutes depending on their sources of finance. Second, the 'inter-sectoral' framework of the model economy is ready for use in the context of 'international' macroeconomics. For example, the inter-sectoral consequences of disequilibrium studied in this article imply that the international transmission of monetary policy and exchange rate shocks would run in an asymmetric way in the new open economy macroeconomic models, mainly from countries distant from a Walrasian ideal to countries closer to the ideal.

Appendix

Derivation of {(4), (5), (6)} Let us form the Lagrangian for the maximization problem (3) subject to {(1), (2)}:

$$\begin{aligned}\mathcal{L}_i &= P_i Y_i - \int_{j\in J} P_j Y_{j,i} dj \\ &- M_i \left\{ Y_i - \left[\int_{j\in J} (X_{j,i})^{\frac{1}{\eta}} (Y_{j,i})^{\frac{\eta-1}{\eta}} dj \right]^{\frac{\eta}{\eta-1}} \right\} + \mathbf{1}^J [\xi_{j,i}(Y_j - Y_{j,i})]_{j\in J},\end{aligned}$$

where $\mathbf{1}^J$ denotes a J-continuum unit vector that is conformable to the continuum vector of sectors, J. We find the first-order conditions (FOCs, henceforth) that hold $\partial\mathcal{L}_i/\partial Y_i = 0$, $\partial\mathcal{L}_i/\partial Y_{j,i} \leq 0$, $Y_{j,i}(\partial\mathcal{L}_i/\partial Y_{j,i}) = 0$, $\partial\mathcal{L}_i/\partial M_i = 0$, $\partial\mathcal{L}_i/\partial\xi_{j,i} \geq 0$, and $\xi_{j,i}(\partial\mathcal{L}_i/\partial\xi_{j,i}) = 0$, for every $j \in J$. Since the inputs are imperfect substitutes one another ($1 < \eta < \infty$), we are interested in the cases for which $Y_{j,i} > 0$ for all j's. We then have (4), (6), and

$$M_i (X_{j,i})^{\frac{1}{\eta}} (Y_{j,i})^{-\frac{1}{\eta}} \left[\int_{j\in J} (X_{j,i})^{\frac{1}{\eta}} (Y_{j,i})^{\frac{\eta-1}{\eta}} dj \right]^{\frac{1}{\eta-1}} = P_j + \xi_j.$$

Finally, substituting (2) into the above equation leads to (5).

Derivation of {(7), (8)} Plugging the optimal input demand schedule (5) into the production technology (1), we have $Y_i = (M_i)^{\eta} Y_i \left[\int_{j\in J} X_{j,i} (P_j + \xi_{j,i})^{1-\eta} dj\right]^{\frac{\eta}{\eta-1}}$. Dividing both sides by Y_i and then solving for M_i, we obtain (7).

Again substitute (5) into the definition of the average production cost. We then have

$$AC_i = \frac{\int_{j\in J} P_j Y_{j,i} dj}{Y_i} = (M_i)^\eta \left[\int_{j\in J} X_{j,i} P_j \left(P_j + \xi_{j,i}\right)^{-\eta} dj\right].$$

By letting $\tilde{M}_i = \left[\int_{j\in J} X_{j,i} P_j \left(P_j + \xi_{j,i}\right)^{-\eta} dj\right]^{\frac{1}{1-\eta}}$, we obtain (8).

Proof of Lemma Let us rewrite M_i in (7) as

$$M_i = \left[\int_{j\in J} X_{j,i} \left(P_j + \xi_{j,i}\right) \left(P_j + \xi_{j,i}\right)^{-\eta} dj\right]^{\frac{1}{1-\eta}}.$$

It is obvious that

$$\int_{j\in J} X_{j,i} \left(P_j + \xi_{j,i}\right) \left(P_j + \xi_{j,i}\right)^{-\eta} dj \geq \int_{j\in J} X_{j,i} P_j \left(P_j + \xi_{j,i}\right)^{-\eta} dj,$$

for any given $[X_{j,i}, P_j, \xi_{j,i}]_{j\in J}$. In turn, since $1 < \eta < \infty$, we have

$$\left[\int_{j\in J} X_{j,i} \left(P_j + \xi_{j,i}\right) \left(P_j + \xi_{j,i}\right)^{-\eta} dj\right]^{\frac{1}{1-\eta}} = M_i \leq \tilde{M}_i = \left[\int_{j\in J} X_{j,i} P_j \left(P_j + \xi_{j,i}\right)^{-\eta} dj\right]^{\frac{1}{1-\eta}},$$

where the equality holds only when $[\xi_{j,i}]_{j\in J} = \mathbf{0}^J$, where $\mathbf{0}^J$ denotes a J-continuum null vector.

Proof of Proposition 1 Let $\mathbf{0}^{J\times J}$ denote a $J \times J$-continuum null matrix. Having the shadow costs matrix be a null, $[[\xi_{j,i}]_{j\in J}]_{i\in J} = \mathbf{0}^{J\times J}$, is a necessary condition for the production economy to achieve a Walrasian equilibrium at the current market prices vector, $[P_j]_{j\in J}$. So it is sufficient to show that the claim holds with $[[\xi_{j,i}]_{j\in J}]_{i\in J} = \mathbf{0}^{J\times J}$. From Lemma and its proof, it follows that, $M_i = \tilde{M}_i$ when $[\xi_{j,i}]_{j\in J} = \mathbf{0}^J$ for any rep $i \in J$. One can then easily see $AC_i = M_i$ from (8), and $AC_i = M_i = P_i$ from (4) for any rep $i \in J$. So $\pi_i = P_i Y_i - AC_i Y_i = 0$ for all $i \in J$.

Proof of Proposition 2 (A) "*if*": Consider a rep i faces that $[\xi_{j,i}]_{j\in J} \neq \mathbf{0}^J$, Under the market circumstances, we have $M_i < \tilde{M}_i$ according to Lemma. Now take (8), and divide both sides by M_i; $AC_i/M_i = (M_i/\tilde{M}_i)^{\eta-1}$. One can easily see that $AC_i/M_i < 1$

or $AC_i < M_i$, since $M_i < \tilde{M}_i$ and $\eta > 1$ when $[\xi_{j,i}]_{j\in J} \neq \mathbf{0}^J$. It follows from (8) that $AC_i < M_i = P_i$. Consequently, $\pi_i = P_iY_i - AC_iY_i > 0$ *if* $[\xi_{j,i}]_{j\in J} \neq \mathbf{0}^J$.

(B) *"only if"*: Suppose the contrary: the rep i makes positive profits *only if* $[\xi_{j,i}]_{j\in J} = \mathbf{0}^J$. But from Proposition 1, we already know that $\pi_i = 0$ if $[\xi_{j,i}]_{j\in J} = \mathbf{0}^J$. So under the supposition, it is implied that $\pi_i = 0$ if $\pi_i > 0$. Obviously, this is a contradiction.

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