The Opportunity Costs of Entrepreneurs in International Trade

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ABSTRACT

We show that a trade model with an exogenous set of heterogeneous firms with fixed operating costs has the same aggregate outcomes as a span-of-control model. Fixed costs in the heterogeneous-firm model are entrepreneurs' forgone wages in the span-of-control model.

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*The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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1. Introduction

Melitz (2003) develops a seminal model in which heterogeneous firms face fixed costs of entering monopolistically competitive markets. A popular variation is that of Chaney (2008), who makes three simplifying assumptions: the underlying distribution of firm efficiencies is Pareto; a global equity fund pays agents equal shares of the profits of firms in all countries; and the measure of potential firms is exogenous. The first two assumptions simply the model, making it analytically tractable. Here, we provide a reinterpretation of the third assumption.

We extend the closed economy span-of-control model of Lucas (1978) to n countries, each requiring a fixed cost to service a foreign market and each populated by agents with Dixit-Stiglitz (1977) love-for-variety preferences. Each agent is endowed with an entrepreneurial talent and one unit of labor. If the agent chooses to operate a firm, he forgoes the wage he could have earned supplying labor. This is equivalent to operating a firm in the heterogeneous-firm model when the fixed cost is one unit of labor. Consequently, the extended span-of-control model and the model developed by Chaney (2008) have identical aggregate equilibrium variables. In the span-of-control model, however, firms are owned by individual agents, so individual income and consumption vary.

In our span-of-control model, trade liberalization generates a change in the distribution of income. The change in firm profits induced by liberalization is passed through to the owner's income. Melitz (2003) focuses on the case where trade liberalization causes more productive firms to expand and their profits to increase and other, less productive, firms to exit the market. In this case, trade liberalization causes income distribution to become more unequal.

There is limited research that uses span-of-control models to analyze international trade. Ma (2015) develops a span-of-control model where, as here, trade is generated by Dixit-Stiglitz preferences. Antras, Garicano, and Rossi-Hansberg (2006) develop a version of the Garicano (2000) model — which can be interpreted as a generalization of the Lucas model — in an international framework to study offshoring.

2. A trade model with fixed costs and a fixed measure of potential firms

Chaney (2008) assumes that all agents own shares in a global equity fund. We assume, instead, that agents earn only the profits of the firms in their own country. To show that our version of the Chaney model has an equilibrium in which the aggregate variables are the same as in the span-of-control model, we initially impose three assumptions: First, the fixed cost of setting up a firm to produce for domestic consumption is one unit of labor. Second, parameter values are such that any firm that finds it profitable to export also finds it profitable to produce for domestic consumption. Third, the measure of potential firms is equal to the measure of workers. We later generalize these assumptions.

2.1. Agents

Country i, $i=1,...,n$, is populated by a continuum of agents of measure $\overline{\ell}_i$, each endowed with one unit of labor. There are homogeneous-good producers and differentiated-good producers. Each agent owns an equal share in all firms in his country so that his income is $w_i + \pi_i / \overline{\ell}_i$ where w_i is the wage. Since the utility function is homothetic, we model a representative agent who supplies $\overline{\ell}_i$ units of labor, receives profits, π_i, and solves

$$\max_{c_{0i}, c_i(\omega)} (1-\alpha)\log(c_{0i}) + (\alpha/\rho)\log\int_{M_i} c_i(\omega)^\rho \, d\omega \tag{1}$$

$$\text{s.t. } p_{0i}c_{0i} + \int_{M_i} p_i(\omega)c_i(\omega)^\rho \, d\omega = w_i\overline{\ell}_i + \pi_i,$$

where c_{0i} is the consumption of the homogeneous good, and p_{0i} is its price; M_i is the set of differentiated goods consumed in country i; $c_i(\omega)$ is the consumption of variety ω; $p_i(\omega)$ is its price; and $0<\alpha<1$, $0<\rho<1$

The consumer's demand for good ω is

$$c(\omega, p_i(\omega), P_i, w_i\overline{\ell}_i + \pi_i) = \frac{\alpha(w_i\overline{\ell}_i + \pi_i)}{p_i(\omega)^{\frac{1}{1-\rho}} P_i^{\frac{-\rho}{1-\rho}}}, \tag{2}$$

where

$$P_i = \left[\int_0^{m_i} p_i(\omega)^{\frac{-\rho}{1-\rho}} d\omega\right]^{-\frac{1-\rho}{\rho}}. \tag{3}$$

2.2. Homogeneous-good firms

The homogeneous good is produced using the production function $y_{0i} = a_i \ell_{0i}$ and sold in competitive markets. Good 0 is freely traded, so

$$p_0 = p_{0i} = \frac{w_i}{a_i} \tag{4}$$

if country i produces good 0. We choose good 0 as the numeraire and set $p_0 = 1$.

2.3. Differentiated-good firms

Country i is endowed with a measure of potential differentiated-good firms, μ_i. We assume that $\mu_i = \overline{\ell}_i$. Each potential firm can produce a unique good, ω, with marginal efficiency $x_i(\omega) \geq 0$ drawn from the cumulative probability distribution $G_i(x)$. Chaney assumes that this distribution is Pareto. If $G_i(x)$ is Pareto with the same curvature parameter all countries, then the equilibrium can be calculated analytically.

The firm in country i that produces good ω for sale in country j has the production function

$$y_{ij}(\omega) = \frac{x_i(\omega)}{\tau_{ij}} \max[\ell_{ij} - \kappa_{ij}, 0]. \tag{5}$$

Here κ_{ij}, is the fixed cost of exporting from country i to country j, and $\tau_{ij} / x_i(\omega)$ is the variable cost. We assume that $\kappa_{ii} = 1$. The firm must ship $\tau_{ij} \geq 1$ units of the good for one unit to arrive; we set $\tau_{ii} = 1$.

The firm acts as a monopolistic competitor, taking demand $c(\omega, p_{ij}(\omega), P_j, w_j \overline{\ell}_j + \pi_j)$ as given and choosing its price $p_{ij}(\omega)$ to solve

$$\pi_{ij}(\omega) = \max_p \left\{ \left(p - \frac{w_i \tau_{ij}}{x_i(\omega)} \right) c(\omega, p, P_j, w_j \overline{\ell}_j + \pi_j) - w_i \kappa_{ij}, 0 \right\} \tag{6}$$

by setting

$$p_{ij}(\omega) = \frac{w_i \tau_{ij}}{\rho x_i(\omega)} \quad . \tag{7}$$

The pricing rule (7) allows us to index a firm by its efficiency $x = x_i(\omega)$.

2.4. Market clearing and equilibrium

The set of firms that export to country j, Ω_{ij}, is characterized by a cutoff value, $\hat{x}_{ij}$ such that

$$\pi_{ij}(\hat{x}_{ij}) = 0 \, . \tag{8}$$

Firms with productivity greater than $\hat{x}_{ij}$ sell to country j, and firms with productivity less than $\hat{x}_{ij}$ do not. We assume that parameters are such that $\hat{x}_{ij} \geq \hat{x}_{ii}$ for all country pairs i, j. If countries are symmetric, then the assumption that $\kappa_{ij} > \kappa_{ii}$ for $j \neq i$, ensures that this condition holds. Since we allow for considerable asymmetries across countries, we assume the condition directly. In equilibrium $\hat{x}_{ii}$ is strictly larger than the lower bound on x_i, that is, the measure of firms that operate, $\mu_i(1 - G_i(\hat{x}_{ii}))$ is strictly less than μ_i. Otherwise, all of $\overline{\ell}_i$ would be used to pay fixed costs since $\mu_i = \overline{\ell}_i$ and $\kappa_{ii} = 1$.

In each country i the condition that the market for labor clear is

$$\ell_{0i} + \mu_i \sum_{j=1}^{n} \int_{\hat{x}_{ij}}^{\infty} (\ell_{ij}(x) + \kappa_{ij}) dG_i(x) = \overline{\ell}_i \, . \tag{9}$$

Notice that

$$M_i = \bigcup_{j=1}^{n} \Omega_{ji} \tag{10}$$

is the set of goods consumed in country i, while Ω_{ii} is the set of goods produced in i.

3. A span-of-control model with international trade

We generalize Lucas's (1978) span-of-control model to incorporate international trade and imperfect competition. Agent ω in country i has a talent for operating a firm, $x_i(\omega)$. More talented agents choose to operate their own firms while less talented agents supply labor to other firms.

3.1. Agents

The world economy again consists of n countries, each populated by a continuum of agents of measure $\overline{\ell}_i$, each endowed with one unit of labor. Agent ω' has income $I(\omega')$ and solves a utility maximization problem like (1), except that agents' incomes are heterogeneous. Since the utility function is homothetic, the demand function of agent ω' for good ω is

$$c(\omega, p_i(\omega), P_i, I_i(\omega')) = c(\omega, p_i(\omega), P_i, 1) I_i(\omega'), \tag{11}$$

and the aggregate consumption of any differentiated good depends on the aggregate income of individuals, but not on the distribution of this income across agents,

$$\int_0^{\overline{\ell}_i} c(\omega, p_i(\omega), P_i, I_i(\omega')) d\omega' = c(\omega, p_i(\omega), P_i, \int_0^{\overline{\ell}_i} I_i(\omega') d\omega'). \tag{12}$$

3.2. Firms

Homogeneous-goods firms are the same as in the previous model, but differentiated-good producers are different. Rather than the disembodied technologies of the heterogeneous-firm model, we assume that each agent is endowed with a technology that only he can operate by supplying his one unit of labor as part of the management of the firm. This is why we assume that $\kappa_{ii} = 1$.

The firm operated by agent ω' produces differentiated good ω' with marginal efficiency $x(\omega')$, where the distribution of technologies across households is again described by $G_i(x)$.[1] If an agent operates his technology, he forgoes the wage he would have earned by working for another firm. Since each agent is endowed with one unit of labor, this opportunity cost is w_i.

3.3. Market clearing and equilibrium

The market clearing condition for the labor market in country i remains the same as (9) in the heterogeneous-firm model. Now

[1] In Lucas's (1978) perfect-competition model, an agent's entrepreneurial talent multiplies a production function with decreasing returns to scale in the other factors. In our monopolistic-competition model, the agent's entrepreneurial talent multiplies a production function with constant or increasing returns to scale. The concavity of profits with respect to inputs follows from demand.

$$\mu_i \int_{\hat{x}_{ii}}^{\infty} \kappa_{ii} dG_i(x) = \mu_i \int_{\hat{x}_{ii}}^{\infty} dG_i(x) = \mu_i (1 - G_i(\hat{x}_{ii})) \quad (13)$$

is the measure of agents who operate their own firms, the number of entrepreneurs. Their opportunity cost of not working in other firms is the total fixed cost of operating firms for domestic production.

If an agent chooses to become an entrepreneur, he earns

$$\pi_i(x(\omega)) = \sum_{j=1}^{n} \pi_{ij}(x(\omega)). \quad (14)$$

If he chooses to supply labor to another entrepreneur, he earns w_i. An agent's income is

$$I_i(\omega) = \max\{w_i, \pi_i(x(\omega))\}. \quad (15)$$

The cutoff agent is indifferent between operating his own firm and providing labor to another firm:

$$\pi_i(\hat{x}_{ii}) - w_i = 0. \quad (16)$$

Agents with talent greater than $\hat{x}_{ii}$ choose to operate their firms, while individuals with talent less than $\hat{x}_{ii}$ provide labor.

4. The heterogeneous-firm model as a span-of-control model

In the heterogeneous-firm model, there are agents and anonymous technologies, whereas, in the span-of-control model, technologies are embodied in the agents. The firm's problem in the heterogeneous-firm model and the entrepreneur's problem in the span-of-control model coincide, and the same set of technologies are operated in both models. Since preferences are homothetic, aggregate consumption expenditures and aggregate trade flows in the two models are identical.

While the aggregate variables are identical in the two models, the agent-level consumption and income in the two models are not. In the heterogeneous-firm model agents own equal shares in operating firms, but, in the span-of-control model, the entrepreneur earns the profits of his firm only. If we wanted to equate the agent-level distribution of income and consumption across the two models, we could randomly assign one technology to each agent in the trade model.

To generalize the assumptions that the fixed cost of setting up a firm is one unit of labor and that the potential measure of firms is equal to the measure of workers, we could simply change the units in which labor is measured. With natural units for firms and labor, however, say number of firms and number of workers — or number per year in a dynamic model — however, we can change the assumption $\mu_i = \bar{\ell}_i$ to the assumption that $\mu_i \le \bar{\ell}_i$. In this case, $\bar{\ell}_i - \mu_i$ would be the measure of workers with no ability to set up a firm. We could also choose $\kappa_{ii} > 1$ and impose $\kappa_{ii} - 1$ as an additional fixed cost to be covered by hiring additional workers for setting up a firm in the span-of-control model.

We can generalize the assumption that parameters are such that $\hat{x}_{ii} \le \hat{x}_{ij}$ for all country pairs i, j in one of two ways. First, we could require that, in addition to the fixed costs κ_{ii} of producing for domestic consumption and κ_{ij} of exporting, there is a fixed cost of one unit of labor to set up the firm to engage in any sort of activity. With this specification, we would not require that $\kappa_{ii} \ge 1$. Second, and alternatively, we could require firms to pay the fixed costs of producing for domestic production whenever they choose to export. In this case, losses in producing for domestic production could be covered by profits in exporting, and the cutoff productivity for domestic production, (8), would become

$$\pi_{ii}(\hat{x}_{ii}) + \sum\nolimits_{j \ne i} \max[\pi_{ij}(\hat{x}_{ii}), 0] = 0 \tag{17}$$

where $\pi_{ii}(\hat{x}_{ii})$ can be negative. Now, the cutoff for exporting from country i to country j would be the maximum of the zero-profit cutoff $\hat{x}_{ij}$ defined by condition (8) and the cutoff $\hat{x}_{ii}$ defined by condition (17).

Our span-of-control model easily generalizes to a model in which agents have heterogeneous labor abilities as well as heterogeneous entrepreneurial abilities. Such a model is equivalent to a heterogeneous-firm model with heterogeneous fixed costs.

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