

# Introducing FDI into the Eaton and Kortum Model of Trade\*

Daniel A. Dias<sup>†</sup> and Christine Richmond<sup>‡</sup>

October 2, 2009

## Abstract

This note proposes a method to introduce FDI into the Eaton and Kortum (E&K) model of trade which allows separation between production and ownership of the product. The most attractive features of this extension are: 1) the model continues to have a closed form solution; and 2) it nests the original E&K model as a particular case. A direct implication of this extension is that some of the parameters in E&K must be interpreted carefully, namely, the technological state parameters which do not reflect the exporting country true technological state but instead a combination of its own technological state and of the countries which produce there.

*JEL classification codes:* F10, F23.

*Keywords:* Trade; Technology; Multinational Production.

---

\*We would like to thank Bernardo Morais, Nico Voigtlaender, Romain Wacziarg and Mark Wright for very useful comments and discussions throughout the preparation of this text. The usual disclaimer applies.

<sup>†</sup>Corresponding author. Anderson Graduate School of Management - UCLA and CEMAPRE. 110 Westwood Plaza, Entrepreneurs Hall, Suite C525, Los Angeles, CA 90095-1481, United States. Tel.: +1 310.825.8207, Fax: +1 310.825.4011; Email: daniel.dias.2010@anderson.ucla.edu.

<sup>‡</sup>Anderson Graduate School of Management, UCLA. E-mail: christine.richmond.2010@anderson.ucla.edu.

## 1. INTRODUCTION

One of the most attractive features of the model proposed by Eaton and Kortum (2002) (E&K hereafter) is the fact that this model has a closed form solution. One of the pitfalls of this model is that there is no separation between the firm (country) that produces the good and the firm (country) that has the right to the value of the good. This separation is nowadays more important than ever given the way international trade is now organized with firms designing the product in one country and producing it in other country(ies). One of the difficulties of incorporating such a feature into an economic model is the fact that the decision of where to locate the production to serve different markets is not trivial and that typically causes the model to not have a closed form solution. An example of a model that incorporates this idea of distinguishing between production and ownership is Ramondo and Rodriguez-Clare (2008), which is also an extension of E&K. The problem with the model proposed by Ramondo and Rodriguez-Clare (2008) is that the extra complexity of this model, which is required given the question the authors are trying to tackle, does not allow for a closed form solution. The extension of E&K we are proposing has as interesting features the fact that 1) it has a closed form solution; and 2) it nests the E&K as a particular case. At the same time it generates a simple framework for analyzing questions related to production location and trade and FDI flows.

The remainder of this note is organized as follows: section 2) presents the model extension; section 3) re-interprets the estimates of the technology parameters of E&K; and finally section 4) presents some final remarks.

## 2. AN EXTENSION OF THE EATON AND KORTUM MODEL OF TRADE

The extension of the model we are proposing follows very closely the E&K formulation. Like in E&K we assume perfect competition, iceberg type transportation costs, CRS production technology, random productivity shocks and taste for variety. In order to allow for a separation between producing country and owner country we allow that, in

the production of a given product  $j$ , each country will receive a productivity draw to produce the good in each one of the  $N$  different countries. This means that if there are  $N$  countries, there will be  $n \times n$  productivity draws for each  $j$  product, one for each possible combination of owner and producer country. As in E&K we assume that countries differ from each other with respect to their overall productivity level, that is, with the respect to the average parameter in the productivity distribution. As a barrier to foreign production, we assume that if country  $k$  produces product  $j$  in country  $i$ , its overall productivity will be discounted by a factor  $\tau \in [0, 1]$ . If  $\tau$  is equal to 0 it means that if country  $k$  produces product  $j$  in country  $i$  it will lose all the value of that good, whereas if  $\tau$  is equal to 1, country  $k$  has no cost of producing in country  $i$  or in country  $k$ . As we will show below, the E&K model is equivalent to assuming  $\tau = 0$ .

To be more specific about our assumptions, let:

- $i = 1, \dots, N$  denotes the country where production takes place;
- $k = 1, \dots, N$  denotes the country that owns the production;
- $T_{i,k}\tau_{i,k}$  denotes the overall technological development of country  $k$  when production takes place in country  $i$ . In this formulation, if  $i = k \Rightarrow \tau = 1$ ;
- $c_i$  denote the marginal cost of producing one unit in country  $i$  (notice that this unitary cost does not depend on the country that owns the production but only on the country that produces);
- $d_{n,i} > 1$  denotes the cost of transporting one unit of a given product produced in country  $i$  into country  $n$  (again, the transportation cost does not depend on the country that owns the production but only on the country that produces the good);
- $j \in [0, 1]$  denotes a given product from a continuum of products;
- $z_{i,k}(j)$ , which has C.D.F.  $G(z_{i,k}(j)) = \exp\left\{-T_{i,k}\tau_{i,k}(z_{i,k}(j))^{-\theta}\right\}$ , with  $\theta > 1$ , denotes the productivity that country  $k$  has in producing product  $j$  in country  $i$ . Like

in E&K (2002) we assume that  $z_{i,k}$  is independent across  $i$  and for modelling simplification purposes we also assume that the productivity shocks are independent across  $k$ .

In deciding which country exports product  $j$  to country  $n$  there are two layers of decision: 1) each country  $k$ , decides which country  $i$  will serve country  $l$  among all possible sources of production; and 2) given the previous choices it is necessary to find which one is able to serve country  $l$  with the lowest price. What makes this problem very simple is that it is equivalent to finding the minimum price among all possibilities. Therefore, and using the same arguments as in E&K (2002), the distribution of prices in country  $l$  is:

$$\begin{aligned}
G_l(p) &= \Pr(P_l \leq p) = 1 - \Pr(P_l > p) & (1) \\
&= 1 - \Pr_{i,k}(P_{i,k} > p) \\
&= 1 - \Pr_{i,k}\left(\frac{(c_i d_{i,l})}{z_{i,k}} > p\right) \\
&= 1 - \Pr_{i,k}\left(z_{i,k} < \frac{(c_i d_{i,l})}{p}\right) \\
&= 1 - \prod_{i=1}^n \prod_{k=1}^n \exp\left(-T_{i,k} \tau_{i,k} (c_i d_{i,l})^{-\theta} p^\theta\right) \\
&= 1 - \exp\left(-\sum_{i=1}^n \sum_{k=1}^n T_{i,k} \tau_{i,k} (c_i d_{i,l})^{-\theta} p^\theta\right)
\end{aligned}$$

If we re-arrange equation (1) in order to isolate the technology parameters from the country of production parameters we get:

$$\begin{aligned}
G_l(p) &= 1 - \exp\left(-p^\theta \sum_{i=1}^n \left\{ (c_i d_{i,l})^{-\theta} \left( \sum_{k=1}^n T_{i,k} \tau_{i,k} \right) \right\}\right) & (2) \\
&= 1 - \exp\left(-p^\theta \sum_{i=1}^n \left\{ (c_i d_{i,l})^{-\theta} \tilde{T}_i \right\}\right)
\end{aligned}$$

Equation (2) corresponds to the combination of equations (6) and (7) in E&K (2002), with  $\tilde{T}_i$  in our notation corresponding to  $T_i$  in their notation. The difference being that

$\tilde{T}_i = \sum_{k=1}^n T_{i,k} \tau_{i,k}$ , which in this case represents the technological state of the exports from country  $i$  but not the technological state of country  $i$  in general, as it happens in E&K. It is easy to see that if  $\tau_{i,k} = 1$  if  $i = k$  and 0 otherwise, the extension we propose, corresponds exactly to the E&K model. Under these assumptions, all other results from E&K follow naturally with the only difference coming from the technology parameters.

### 3. REINTERPRETING THE TECHNOLOGICAL STATES ESTIMATES OF E&K

In order to illustrate the implications of separating the country that owns the technology from the country that produces the good we use the estimates of technological state presented in E&K (2002) ( $\tilde{T}_i$  in our notation) to recover the true individual technological states ( $T_i$  in our notation). In order to do this we vary the value of  $\tau$  and compare the standard deviation of  $T_i$  with the standard deviation of  $\tilde{T}_i$ .

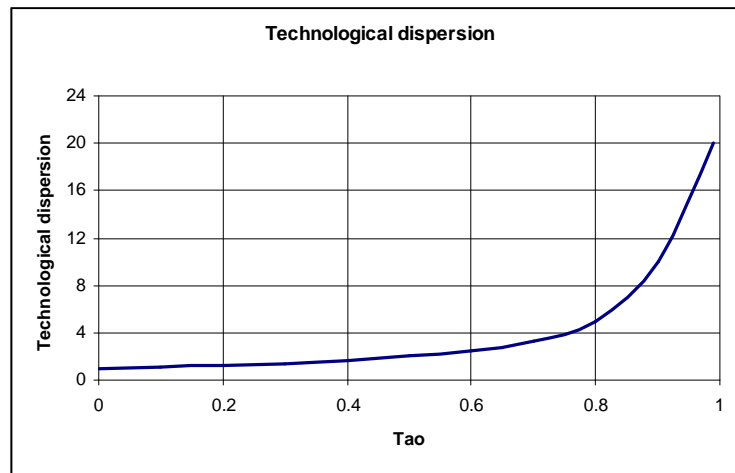


FIG.1 - Technological state dispersion as a function of  $\tau$ .

As it is visible in Fig.1, as the parameter  $\tau$  increases, the dispersion of the true individual technological states that underlie the estimates of  $\tilde{T}_i$ , also increases. What this suggests is that, in the presence of FDI, the estimates of technological states presented in E&K might under-estimate the true technological differences between countries.

#### 4. CONCLUDING REMARKS

In this brief note we suggest a method to introduce FDI into the E&K(2002). The main attractiveness of this extension is that it has a closed form solution and at the same time it nests the E&K model as a particular case. As an illustration of the implications of this extension we show that the true individual technological states can be quite different from the estimates presented in E&K. In particular we show that as the barriers to produce abroad fall (higher  $\tau$ ) the dispersion of technological states increases. This suggests that countries may have larger technological difference than suggested by E&K(2002).

#### REFERENCES

1. Eaton, J. and Kortum, S., 2002, "Technology, Geography and Trade.", *Econometrica*, Vol. 70, No. 5, pp. 1741-1779;
2. Ramondo, N. and Rodriguez-Clare, A. (2008), "The Gains from Openness: Trade, Multinational Production, and Diffusion", mimeo.