Appendix 1: The Gravity Model

Economic Gravity models are based on an analogy to the law of gravity in physics: "after controlling for size, trade between two regions is decreasing in their bilateral trade relative to the average barrier of the two regions to trade with all their partners. Intuitively, the more resistant to trade with all others a region is, the more it is pushed to trade with a given bilateral partner".

In his pioneering article, McCallum (1998) estimated the following gravity equation in a Canada-USA context:

$$\ln x_{ij} = \alpha_1 + \alpha_2 \ln y_i + \alpha_3 \ln y_j + \alpha_4 \ln d_{ij} + \alpha_5 \delta_{ij} + \varepsilon_{ij} \tag{i}$$

where x_{ij} stands for exports from region i to region j, y_i and y_j are gross domestic product per capita of the importing and exporting regions, d_{ij} is distance between the capitals of regions and δ_{ij} is a dummy equal to 1 for inter-provincial trade and zero for state province trade. The exponential of the dummy variable coefficient, α_5, is the "border effect", or the effect of the border on the ratio of inter-provincial trade to state province trade after controlling for distance and size. Based on 1988 data, McCallum estimated that inter-provincial trade is 22 times larger than state-province trade.

Anderson and Wincoop (2001) have criticized McCallum's work and subsequent studies based on "theoretical" gravity models on the grounds that they failed to capture the key implication of the theoretical gravity equation that "trade between regions is determined by relative trade barriers" and therefore have overestimated the border effect. Anderson and Wincoop (2001) estimated a non-linear regression that is consistent with the theoretical underpinnings of the gravity model as developed by Anderson (1979). In effect they develop a term they call multilateral resistance variable that effectively measures the average barrier implied in the gravity theory. Based on the assumption that the exporter passes on to the importer the trade costs they incur (nominal information costs, design costs, transport costs, legal and regulatory costs) Anderson and Wincoop take into account two price index terms (in a two country model) that take the following form[30]

$$p_j = \left[\sum_i \left(\frac{\beta_i t_{ij} p_i}{p_j} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \forall i,j \tag{ii}$$

where σ is the elasticity of substitution between imported and domestic goods, t_{ij} are the trade costs that the authors proceed in assuming they are symmetrical

---

[30] This is derived from a CES preferences and goods that are differentiated by region of origin. The authors also assumed that each region is specialized in producing one good following Deardorff (1988).