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Missing trade and lumpy countries

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Urbanisation and Trade:
An alternative explanation for the Missing Trade Puzzle?

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June 2010

Abstract

Lumpiness of production factors within a country might overturn the predictions for the structure of trade by the factor-abundance (HO) model. Trade patterns, as predicted by the HO model, can both be magnified or reversed by uneven concentration of production factors within a country. Cities are the most characteristic manifestation of lumpiness of production factors and as a consequence different patterns of urbanization between countries might cause trade patterns to differ from predictions on the basis of the overall availability of production factors. In this paper we investigate whether urbanization, as such, affects trade and might be an alternative explanation for the 'missing trade' puzzle.

PRELIMINARY AND INCOMPLETE VERSION

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1. Introduction

Tests of the factor-abundance or Heckscher-Ohlin (HO) model are not very successful. Ever since Leontief (1956) discussed the paradox that bears his name it has been demonstrated time and again that empirical tests of the standard model are only marginally better than the toss of a coin (see Leamer, 1984, for a survey of the early literature). This state of affairs led to the conclusion that the HO model "does poorly, but we do not have anything that does better", see Bowen et al. (1987, p.805).

With the availability of better and more detailed data, the 1990s witnessed a revival of empirical work on the HO model. Especially the work by Trefler (1995) was influential in stimulating empirical work. His so-called 'mystery of missing trade' has been a fascinating topic in the international trade literature. This mystery states that if one compares the factor content of trade (the left hand site of the so-called Hecksher-Ohlin-Vanek (HOV) equations) to the predicted factor content of trade (the right hand site of the HOV equations) the two sides of the equations differ in a systematic manner. Trefler (1995) found that the predicted factor content of net exports are smaller than the actual factor content, hence trade is 'missing'. In addition, two groups of countries could be identified: developing and developed countries. For poor countries the difference between actual and predicted factor content of net exports is negative, and for rich countries this is positive. This implies that poor countries are abundant in most factors of production, whereas rich countries are scarce in most factors of production.

An evident solution to this puzzle is to assume that factors of production are less productive in developing countries than in developed countries. Furthermore, consumption differences between groups of countries might be important. In the HOV model it is assumed that countries consume commodities in the same proportion, which need not be the case. Both types of explanations on the mystery of missing trade puzzle reduce the extent of the puzzle. However, allowing for inter-country differences in technology reduces 'missing' trade the most (Davis and Weinstein, 2001; see for surveys Feenstra, 2004, or Baldwin, 2008).

One explanation seems to be ignored in the literature, namely lumpiness of production factors. Within the HOV framework, lumpiness, or the uneven distribution of production

factors within a country, can affect the structure of trade. As shown by Courant and Deardorff (1992) lumpiness can interfere with trade in complicated ways. However, in subsequent work (Courant and Deardorff, 1993), they link lumpiness to regional economics and show that, in general, countries tend export those commodities that are intensive in factors of production that are concentrated in specific areas that offer high levels of amenities. The most apparent manifestation of such regional clustering is the concentration of economic activity in cities. In principle, such clustering can explain why developed countries are scarce in most factors. If mobile factors of production are clustered in urban areas the resulting trade could magnify net trade beyond what is expected on the basis of the overall factor endowments within a country. This paper reviews the evidence to determine if lumpiness might provide an additional explanation for the lack of empirical support for the standard HOV model, that is whether it is an alternative solution to the missing trade puzzle.

Section 2 discusses the theoretical links between the uneven distribution of factors of production (lumpiness) and international trade flows. Section 3 reviews the 'missing trade' puzzle. Section 4 reviews the common approaches used to solving this puzzle and discusses the extent to which lumpiness may serve as an alternative explanation. Section 5 concludes.

2. Lumpiness and trade[2]

The relation between urbanization and its potential effect on trade can best be explained by an Edgeworth-box, depicted in Figure 1. We assume that the country under consideration is small, so that prices are given. The figure – made popular by Dixit and Norman (1980) – depicts the so-called integrated equilibrium. Suppose we start with a perfectly integrated country, in which there are no distortions, with two factors of production – skilled labor S and labor L - and two goods, X and Y, produced under constant returns to scale. Moreover, consumer preferences are identical and homothetic. The amounts of skilled labour and labour are given and fixed. The total amount of labour is depicted on the horizontal axis, and the total amount of skilled labour along the vertical axis. The final equilibrium is characterized by equilibrium goods prices, factor prices, and full employment of factors of production. This equilibrium is welfare maximizing under standard circumstances. Equating demand and supply gives us the equilibrium prices for X and Y; factor market clearing –

[2] This section is based on Courant and Deardorff, 1992.

together with the prices of X and Y – give us the factor prices w_l and w_s for labor and skilled labor respectively.

Figure 1. The integrated equilibrium and lumpiness

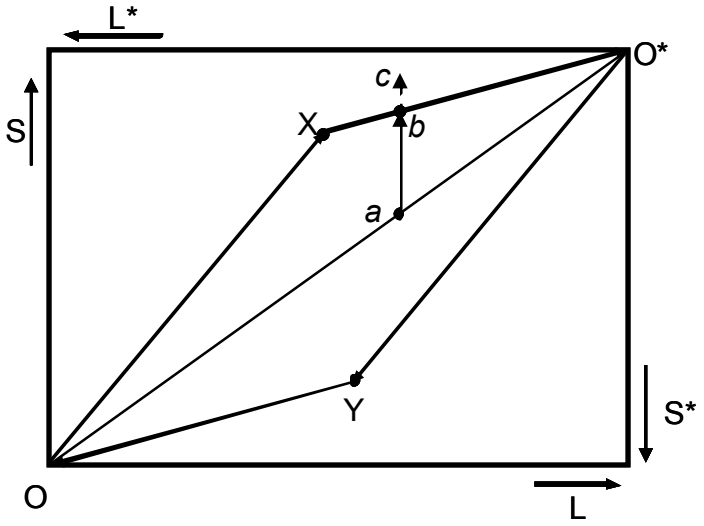
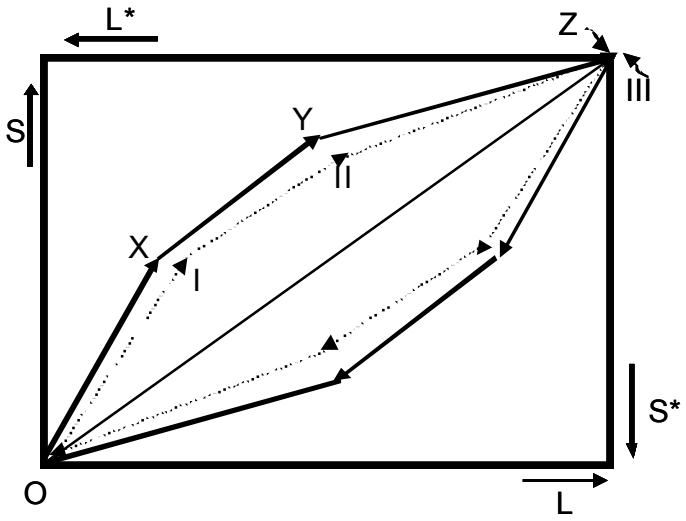


Figure 1 depicts the equilibrium. Suppose the origin is indicated by O, then the total supply in the integrated equilibrium is characterized by *OX* of good *X*, and *OY* of good *Y* (with an appropriate unit of measurement). The slope of the vectors indicate that we have assumed that X is skilled labor intensive and Y is labour intensive. If we perform a vector summation on *OX* and *OY*, total factor usage in both sectors is exactly equal to the total amount of available factors of production. Note that this also holds for total consumption (which is obvious because in equilibrium supply equals demand)

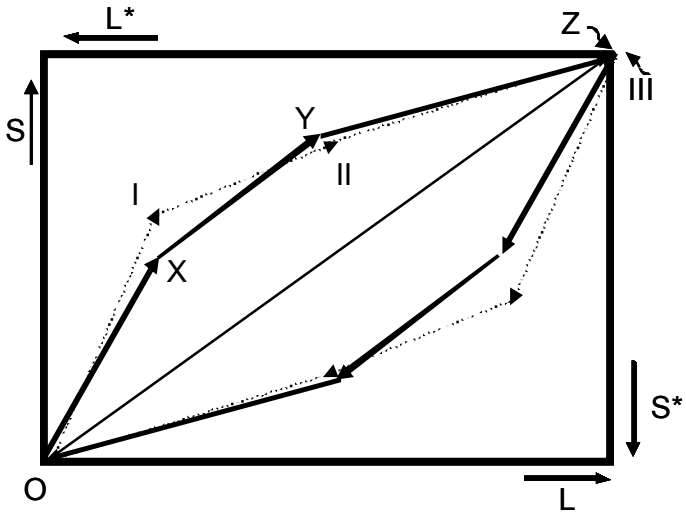
The central questions in our case are what happens if factors of production are distributed unevenly across space; under what circumstances can the welfare maximizing equilibrium be reproduced once the integrated country is split into two separate areas, and whether lumpiness of production factors could affect the structure of trade. Activity from area *I* is measured from *O*, and for area *II* from *O**. For explanatory purposes we assume that the country under consideration initially does not trade.

The answer to the first question is standard, and as long as the distribution of production factors is within the factor price equalizatoin (FPE) set the answer is 'yes' (see Dixit and Norman, 1980 for a detailed explanation). Courant and Deardorff (1992) answer the second question, which can best be explained starting from point *a* on the diagonal, assuming that the country is self-sufficient. The two areas have identical relative endowments of skilled and unskilled labor, and total production of *X* and *Y* is simply divided over the two areas in the ratio *Oa/aO**, which only indicates the size difference between the two areas. If we redistribute skilled and unskilled labor such that we follow the arrow starting in *a*, production of *X* increases and *Y* decrease in area *I*, and the production of *X* decreases and *Y* increases in area *II*. These are standard Rybczynski effects in both areas. Along the arrow *ab* the integrated equilibrium can be reproduced and the redistribution of skilled and unskilled labor has no effect on trade. This is possible until one or both areas are completely specialized. As drawn, at point *b* area *I* still produces both *X* and *Y*, but area II is completely specialized in *Y*. The total amounts of both X and Y correspond to the integrated equilibrium. If we follow the arrow from the point of complete specialization, say, from *b* to *c*, the amount of *X* in *I* increases, but without the accompanying decrease of *X* in *II*. The amount of *Y* decreases in both countries, due to the familiar Rybczynski effect in *I*, and a further reduction of factor endowments in *II,* that is specialized in *Y*. This unambiguously raises the relative supply of *X,* which will be exported to make up for the fall in *Y*, which is imported. Outside the parallelogram *OXO*Y* the country will trade and the trade pattern depends on which area is specialized in what good. Outside the cone of diversification trade patterns are difficult to establish. Moving horizontally, instead of vertically from *a*, and applying a similar reasoning as above, results in the exports of Y, outside *OXO*Y* . This example already shows that partial equilibrium reasoning already makes predictions about trade patterns complicated. Introducing a second country in which lumpiness matters makes it even more difficult; Lumpiness might strengthen predictions by the HO model or might go completely in the opposite direction.

Figure 2 The lens condition



2a lens condition satisfied



2b lens condition violated

It is relatively easy to generalize Figure 1 into a country with many areas, and many goods/sectors in this two production factors world; it results in the so-called *'lens condition'* (Deardorff 1994, Debeare and Demiroglu, 2003). It states that if we rank factor intensities according to decreasing skilled-labor/labor intensities above the diagonal (and vice versa below the diagonal) and if we next concatenate the corresponding vectors of production factor use, the resulting line should enclose a similar construction of factor intensities of skilled-labor/labor endowments of areas in the country under consideration. It is called the lens condition because if we introduce a large number of goods and areas the figures look

like lenses.[3] Figure 2, illustrates the condition for a three goods, *X, Y*, and *Z*, three region, *I*, *II*, *III*, example; note that the origin now indicates the starting point of measurement. Panel 2a shows the case for which the condition is satisfied, and 2b for which it is violated and lumpiness might affect the structure of trade as predicted by the HOS model.

Empirical evidence provided by Debaere (2004) using the lens condition on regional data, indicates that lumpiness is not a big issue at the regional level as the lens condition is not violated. Bernard et al. (2005) criticize the lens condition for being subject to aggregation problems.[4] Central in their argument is that the size of both the goods lens and the factor endowment lens is sensitive to the level of aggregation. Lenses constructed using more disaggregate data are larger than lenses with more aggregate data. This is immediately clear by inspecting Figure 2. Suppose, for example, that the goods vector OX is further disaggregated into two commodities that together use OX, one of these will use more skill intensive production methods, whereas the other uses less skill intensive production methods compared to OX.[5] This implies that the goods lens in the more disaggregate case will envelop the aggregate case depicted in Figure 2 with regards to the goods lens. The same holds for the factor endowment lens. Because theory does not guide us with regard to the most optimal level of (dis) aggregation of both goods and regions, tests of the lens condition are subject to these biases. Using a different methodology for the Mexican case Bernard et al. (2004) find that lumpiness might matter. Using evidence regarding the differences of relative skilled wages across Mexican regions – these are negatively correlated with the distribution of relative factor endowments – lumpiness of production factors across Mexican states might affect the trading outcomes relative to the implied trade caused by the overall distribution of production factors.

The findings of Bernard et al. (2004) for Mexico also point in an interesting direction; urban agglomeration. Urbanization is one of the more obvious determinants of factor lumpiness. Regions are often the result of ad hoc spatial differentiations that are made for administrative- and not necessarily economic reasons. Urban agglomerations, however,

[3] See Debeare and Demiroglu, (2003) for a more detailed discussion of the lens condition.
[4] The criticism refers to, for example, Wong and Yun (2003).
[5] In the – unlikely – case that both disaggregated goods use the same factor intensities as the combined vector *OX*, the lens is exactly the same.

might provide more meaningful economic lumpiness concepts than the administrative region definitions, which might not have a relation with more sensible economic definitions. This discussion on the most relevant unit of observation refers to the so-called modifiable areal unit problem or MAUP, which in our case states that lumpiness should reflect economic relevant concentration of production factors and not differences in administrative geographical units (Briant et al. 2008). In Courant and Deardorff (1993), the link between urbanization and lumpiness is explicitly analyzed. Outside the FPE set factor prices differ between regions or urbanized areas. One cause of these factor price differences could be differences of the level of amenities between locations, which attract mobile production factors within countries. Combining the trade, lumpiness of production factors and urbanization results in the following hypothesis: the more a mobile production factor is concentrated, the more likely it becomes that a country will export the good that relatively intensely uses this production factor. Note, that it is relative lumpiness that matters. The country with the most lumpy distribution, will export this particular commodity (Courant and Deardorff, 1992).

3. Missing trade

We use the terminology below to explain Trefler's (1995) 'Mystery of the Missing Trade'. Let c be an index of finitely many countries and f an index of finitely many factors of production. We denote the endowment of factor f in country c by V_{fc}, such that world endowments are: $V_f = \sum_c V_{fc}$. Similarly, country c's GNP is given by Y_c and world GNP by $Y = \sum_c Y_c$. If we let B_c be country c's trade balance, we define this country's consumption share by: $s_c = (Y_c - B_c)/Y$. Let $\mathbf{T_c}$ denote country c's net trade vector (production minus consumption) and let $\mathbf{A}$ be the (common) technology matrix indicating the amount of primary factors needed to produce one unit of output in each sector.[6] Finally, let $\mathbf{F_c}$ denote

[6] This matrix includes both directly used primary factors and indirectly used factors through intermediate inputs. As production functions are constant returns to scale, technology is summarized using unit outputs.

the *factor content of trade* vector for country *c*, that is the net balance of the use of primary factors of production in a country's trade flows. It is defined as:[7]

(1) $\mathbf{F_c} = \mathbf{AT_c}$

The 'HOV' equation mentioned in the introduction implied by the usual factor abundance assumptions is given in equation (2), stating that a country *c* that is relatively abundant in factor *f* (so $V_{fc} > s_c V_f$) will on net export that factor ($F_{fc} > 0$).

(2) $F_{fc} = V_{fc} - s_c V_f \,, \quad \forall f, c$

If we let $\mathbf{V_c}$ denote country c's vector of factor endowments and $\mathbf{V}$ the world endowment vector, then equation (2) is written in matrix notation as:

(2') $\mathbf{F_c} = \mathbf{V_c} - s_c \mathbf{V}$

If we have data available on the technology matrix, domestic production and domestic consumption, we can measure the factor content of trade. If we also have data available on factor endowments, we can put equation (2) to the test. Let ε_{fc} be the deviations from the HOV theorem, that is:

(3) $\varepsilon_{fc} = F_{fc} - (V_{fc} - s_c V_f)$

To express the factors in comparable units satisfying the homoscedasticity hypothesis, Trefler scales all units by $\sigma_f s_c^{1/2}$, where σ_f is the standard error of the ε_{fc} for a given *f* and $s_c^{1/2}$ is used to control for country size. Using Trefler's data on 33 countries and 9 factors of production the case of the missing trade is illustrated in Figure 3 below.[8]

[7] If there are N sectors, vector T_c is N×1. If there are M factors, vector F_c is M×1. In which case matrix A is M×N, where the rows relate to the factors and the columns to the sectors.

[8] The countries are: Austria, Bangladesh, Belgium, Canada, Colombia, Denmark, Finland, France, Greece, Hong Kong, Indonesia, Ireland, Israel, Italy, Japan, The Netherlands, New Zealand, Norway, Pakistan, Panama, Portugal, Singapore, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad, United Kingdom, Uruguay, United States, West Germany, and Yugoslavia. The factors are: capital, cropland, pasture, and 6 types oflabor: agricultural, clerical, production, professional/technical, sales, and service.

Figure 3 The case of the missing trade

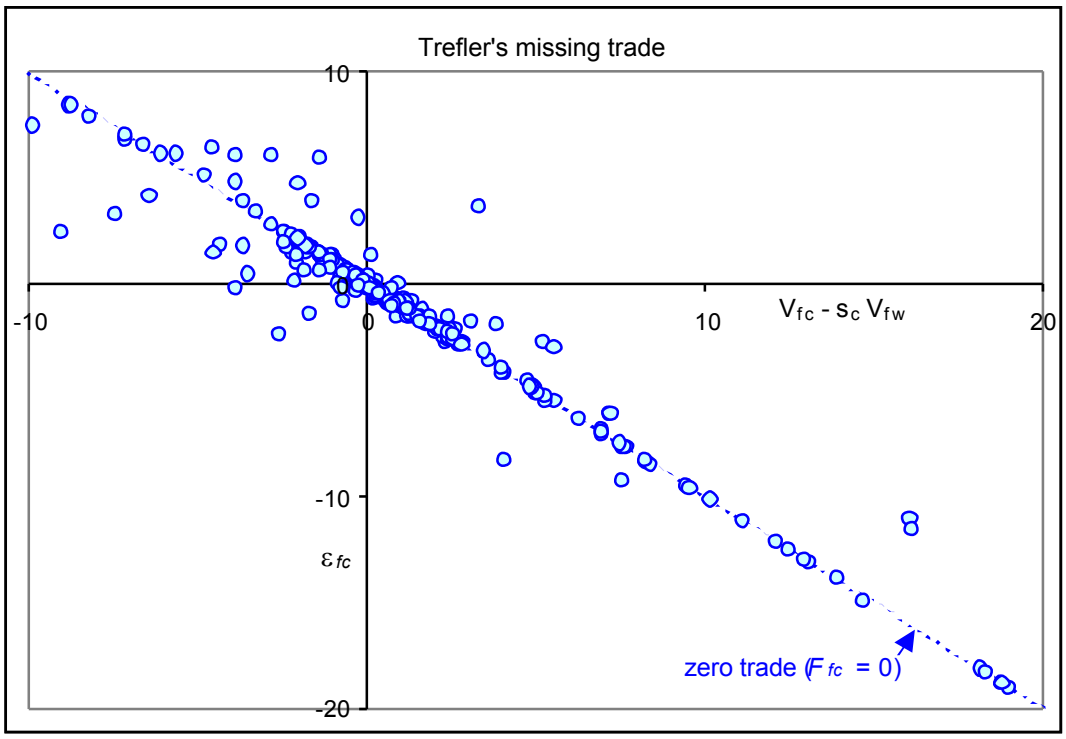


Figure 3 depicts relative factor abundance $V_{fc} - s_c V_f$ on the horizontal axis and the deviation from the HOV theorem ε_{fc} on the vertical axis. As noted by Trefler, there is a remarkable systematic empirical deviation between the HOV theorem and observed trade flows: most observations are close to the zero trade line ($F_{fc} = 0$, so $\varepsilon_{fc} = -(V_{fc} - s_c V_f)$), such that (in absolut terms) factor service trade is much smaller than its factor endowments prediction, a phenomenon called "the case of the missing trade" by Trefler (1995, p. 1032).

4. Explanations for missing trade

The standard 'solution' to the missing trade puzzle in the literature is to point at technology differences between countries (see Feenstra, 2004, for a survey), possibly accompanied by Armington (1969) type home demand bias. Trefler himself, for example, analyzes a system of neutral technology differences in which country c's technology matrix $\mathbf{A_c}$ is proportional to the American technology matrix, that is $\mathbf{A_c} = \delta_c \mathbf{A_{US}}$ (and $\delta_{US} = 1$). Defining $\mathbf{F_c^{US}} = \mathbf{A_{US}} \mathbf{T_c}$ Trefler shows that:

(4) $$F_{fc}^{US} = \delta_c V_{fc} - s_c \sum_j \delta_j V_{fj}$$

Estimating the neutral technology differences and calculating the correlation between the actual (righ-hand-side) and predicted (left-hand-side) values of equations (2) and (4), implies that allowing for these technology differences increases the correlation from 0.28 to 0.59.

Figure 4 Correlations between observations and predictions

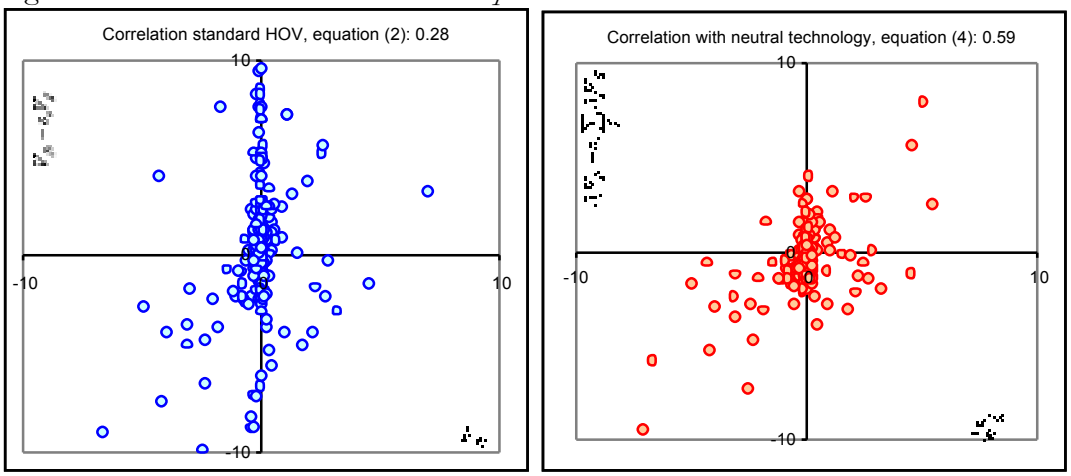
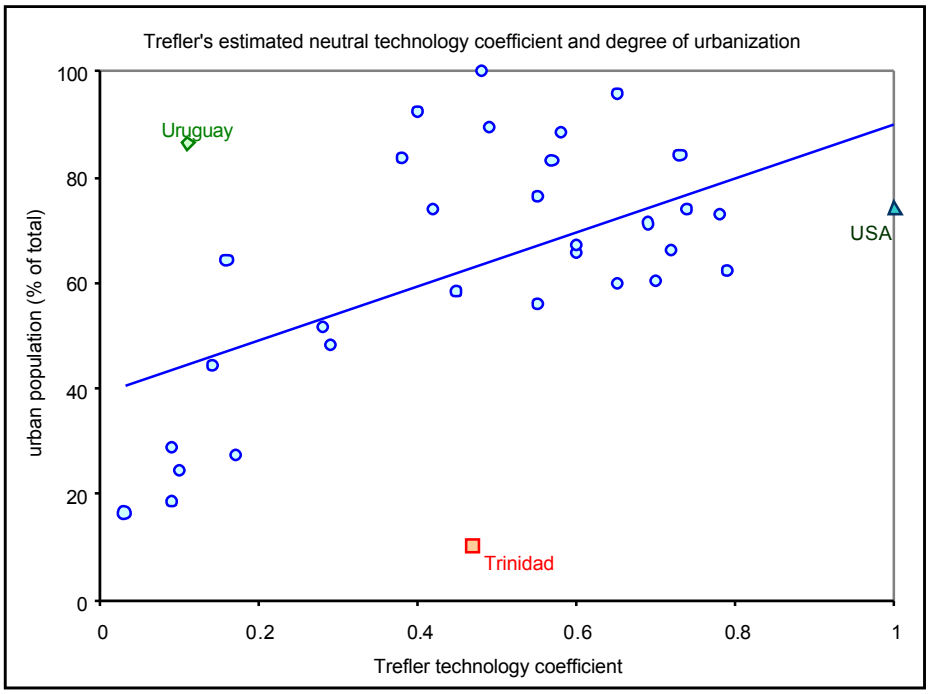


Figure 4 shows the improvement in prediction by allowing for neutral technological differences between countries.[9] Further improvements can be obtained by distinguishing between developing and developed countries (each with their own technology) and combining this with neutral technology differences (to improve the correlation to 0.63). When the latter approach is further combined with Armington demand bias, the correlation further improves to 0.67. Since we are discussing the potential contribution of the uneven distribution of factor endowments across space in understanding the missing trade puzzle, we henceforth ignore demand bias as an explanation and benchmark the power of lumpiness compared to technology differences.

[9] The scale is truncated to be square and comparable between the predictions.

Figure 5 Technology differences and urbanization



A first indication that lumpiness could contribute to understanding the missing trade puzzle is provided by a simple correlation between Trefler's estimated technology neutrality parameters and the observed degree of urbanization, see Figure 5.[10] In general, the higher the degree of urbanization, hence the higher the degree of lumpiness, the higher the estimated technology level to explain the missing trade puzzle. The most obvious outliers are Uruguay (with a low estimated technology coefficient and a high degree of urbanization) and Trinidad (with a medium estimated technology coefficient and a low degree of urbanization).

Of course, the simple correlation in Figure 5 does not take into consideration the degree to which individual factors of production are able to agglomerate (lump together) in a certain location, giving rise to the effect of lumpiness on trade flows. To this end, we will subdivide the factors of production into regionally mobile and immobile factors. Cropland, Pasture, and agricultural labour, for example, are most likely immobile between regions, while capital and the other five types of labour are mobile. We will measure the degree of lumpiness

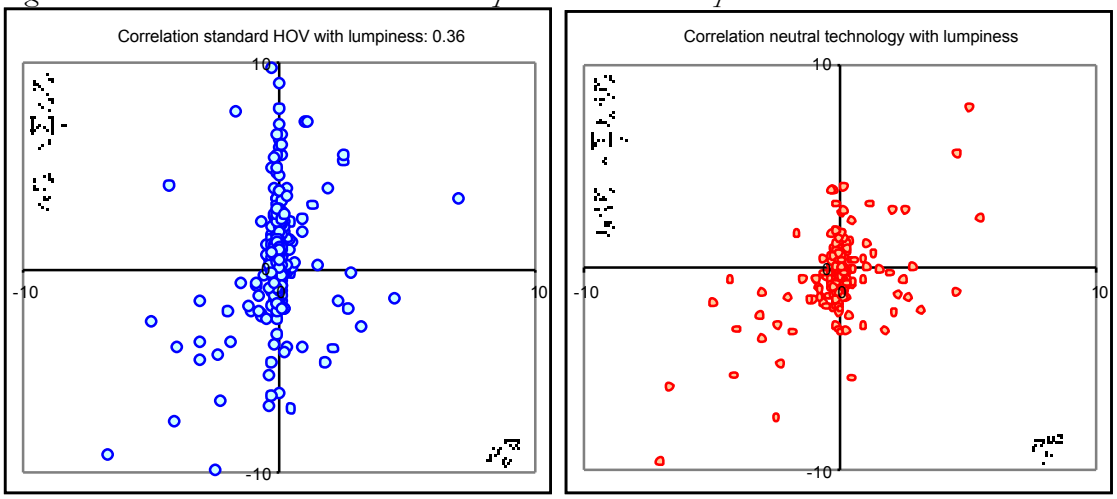
[10] Data is from the World Development Indicators for 1983; for Yugoslavia, we calculated a population-weighted average degree of urbanization based on the separate parts of Serbia, Croatia, Bosnia Herzegovina, Macedonia, Slovenia, and Montenegro.

relative to the US level; that is, if β_c is country c's degree of urbanization, then the measure of factor f's lumpiness γ_{fc} is 1 for immobile factors and β_c / β_{US} for the mobile factors. Combining the standard HOV model with this measure of lumpiness as in equation (5) increases the correlation coefficient from 0.28 to 0.363. Combining lumpiness with neutral technology differences as in equation (6) increases the correlation coefficient further to 0.564. The latter estimate does not provide an increase over the simple neutral technology difference estimate, but it is clear that lumpiness itself goes a long way in explaining the missing trade puzzle.[11] Our findings on lumpiness are illustrated in Figure 6.

(5) $$F_{fc}^{US} = \gamma_{fc} V_{fc} - s_c \sum_j \gamma_{fj} V_{fj}$$

(6) $$F_{fc}^{US} = \gamma_{fc} \delta_c V_{fc} - s_c \sum_j \gamma_{fj} \delta_j V_{fj}$$

Figure 6 Correlations between observations and predictions under lumpiness



5. Conclusions

The solutions to the missing trade puzzle have concentrated on technology differences (neutral and non-neutral) between countries and on home-bias in demand. Evidently, the increasing importance of cities (more than half the world population now lives in cities) is a good proxy for the degree to which factors of production are unevenly distributed across space. Using the degree of urbanization as an indicator, we show that lumpiness measured at

[11] We analyzed all possibilities of mobile and immobile factors in the latter case, which led to similar fits in most cases and the best fit if agricultural labour was the only mobile factor of production.

the city scale may at least partially explain the missing trade puzzle. At this stage, further research is dearly needed, an issue we are working on right now (this paper is incomplete).

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