Hunting High and Low for Vertical FDI

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Abstract: Recently the two dominant models of foreign direct investment (FDI), the horizontal and vertical models, have been synthesized into the knowledge capital (KK) model. Empirical tests, however, have found that the horizontal model cannot be rejected in favor of the KK model. This paper suggests that this is because the empirical specifications used do not allow the vertical aspects of FDI to manifest themselves. By extending the specification, I find evidence of vertical FDI. In particular, when I use the stock of FDI as my measure of FDI activity I can reject the horizontal model in favor of the KK model and identify countries for which FDI is dominated by vertical investment.

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1. Introduction

For the past twenty years, the horizontal and vertical models have dominated the research on foreign direct investment (FDI). In the horizontal model, which was originally formulated by Markusen (1984), a multinational enterprise produces in multiple countries to minimize the costs associated with trade and the creation of firm-specific assets. In the vertical model, developed by Helpman (1984), FDI occurs to take advantage of factor price differences between countries. Recent work by Markusen, Venables, Konan, and Zhang (MVKZ, 1996) and Markusen (1997) has combined these two motivations for FDI into a unified approach called the Knowledge Capital (KK) model. According to Markusen and Maskus (1999) among others, one of the key methods for distinguishing between the horizontal and vertical motivations for FDI is to analyze the relationship between countries' relative factor endowments and FDI. In particular, the literature has focused on countries' relative supplies of skilled labor.[1] According to the theory, horizontal FDI is greatest when countries have similar endowments since this supports production of the MNE's good in both countries. Vertical investment, however, is greatest when countries have very different endowments since that creates large differences in factor prices. When these are combined in the KK model, Carr, Markusen, and Maskus (CMM, 2001) indicate that total FDI (horizontal and vertical combined) is increasing in the skill difference, defined as the parent's relative endowment of skilled labor minus the host's relative endowment of skilled labor.

CMM confirm this pattern using data on in- and outbound U.S. FDI. Blonigen, Davies, and Head (BDH, 2002), however, use the CMM empirical specification and data but allow for different signs on either side of equal relative endowments, that is, on either side of zero skill differences. In contrast to the CMM results, they find that FDI is not always positively related to the skill difference as posited by CMM. In particular, while they do find the predicted positive relationship when the host is skill abundant, when the parent is skill abundant, they find that FDI decreases in the skill difference, not increases. They find the same pattern in both an expanded U.S. sample and in OECD data. This negative relationship is confirmed in the empirical analysis of Markusen and Maskus (1999) and Markusen and Maskus (2001). Because of their results, BDH and Markusen and Maskus (1999) indicate that the horizontal model cannot be rejected in favor

[1] See for example, Markusen and Venables (2000) who couch the horizontal model in these terms.

of the KK model. Overall, as Braconier, Norb@ck, and Urban (2002) discuss, there is very little existing evidence for vertical FDI even in the so-called "gravity" tests of FDI. Are we then to take the combined empirical work to mean that the KK model is wrong? Certainly not, since the KK model nests the horizontal motivation for FDI. Why then should we use the KK model, which is far more complex than the horizontal model? The answer to this is that the KK model also allows for vertical FDI. However, if there is no evidence of vertical FDI in the data, why should we bother? Alternatively, why are we not finding evidence for vertical FDI?

This paper addresses this final question. I propose that the reason we have not yet found vertical FDI in the empirical work on the KK model is that researchers are not using an empirical specification that gives vertical FDI a chance to show itself. In developing the CMM (2001) empirical framework, they rely on simulations that indicate that, all else equal, FDI should be strictly increasing in the skill difference. This presupposes, however, that increasing vertical FDI more than compensates for any decline in horizontal FDI. While this is certainly possible, the results of Markusen and Maskus (1999) and BDH (2002) show that it is not in fact true. I therefore propose a more general specification of the KK model that allows for non-monotonicities on both sides of zero skill differences. In my results I find that when the parent is skill abundant, but only slightly so, FDI is decreasing in the skill difference. This is consistent with horizontal FDI dominating in this region. As the skill difference rises, this relationship reverses itself and FDI is increasing in the skill difference. This is consistent vertical FDI dominating investment when the parent is very skill abundant. I find the same patterns using CMM's (2001) U.S. data as well as BDH's (2002) expanded U.S. and OECD data. Thus, by using a more general empirical specification, I am able to control for the switching between horizontal and vertical investment in my estimation, which was a primary goal of the KK model in the first place. As a result, unlike earlier authors, I am able to reject the horizontal model of FDI in favor of the KK model even when using their same data sets. This result is strongest when using the stock of FDI as the measure of FDI activity (as was done in the BDH OECD data) and when using this measure, I can construct a list of parent and host countries for vertically dominated FDI.

The remainder of the paper is as follows. In Section 2, I briefly discuss the three models of FDI and how they relate to skill differences. This section also contains a discussion of the existing estimates of

the KK model and why they may be too restrictive with respect to the emergence of vertical FDI. Section 3 describes my alternative empirical specification and my data. Section 4 presents my estimates as well as a list of the countries for which FDI is vertically dominated. Section 5 concludes.

2. The Theory and Evidence on FDI

In this section I briefly review the motivations for the horizontal and vertical models of FDI and how they combine with one another in the KK model. In particular, I focus on the role of skill or relative factor endowment differences since, as noted by Markusen and Maskus (1999) this provides the best way to distinguish between the models. My discussion is intentionally non-technical. I choose this approach because the models themselves are extremely complex and a full treatment of them requires an entire book (such as Markusen, 2002). Instead, by focusing on the overall ideas behind the various models and using these as guiding principles, I hope make it as clear as possible why the current empirical specifications may be too restrictive for finding vertical FDI and why my chosen alternative side improves upon the existing work. I conclude this section with a review of the relevant empirical literature.

Before discussing each of the models in particular, let me set up a framework for their unified treatment. Consider a two country, two good, two factor world. Label the two countries home and foreign. Note that this is a different label than parent and host, which refer to the citizenship of a particular MNE. The two factors are skilled and unskilled labor. One good, which can be produced by MNEs, has a two-stage production process. In the first stage, the MNE must undertake some headquartering activity. This is intended to represent the development of blueprints, technologies, and the like. The second stage is the actual physical production of the good. The headquartering and production stages can be geographically separated. A MNE's parent country is given by the location of its headquartering activity. In a horizontal MNE, production takes place in both countries while headquartering takes place in only the parent country. In a vertical MNE, production occurs only in the host while headquartering is again done only in the parent. A national firm does both activities in the same country. In addition to this sector, there is a second, numeraire sector. Factor intensities are such that headquartering is the most skill intensive activity while production of the numeraire is the least skill intensive.

2.1 The Horizontal Model

The first presentation of the horizontal model is Markusen (1984). In its original version, the two countries are identical and Markusen compares the equilibria with one MNE to that with two national firms. In the horizontal model, a MNE firm has two advantages over a national firm. The first advantage arises because headquartering is a joint input, that is, it can be used in multiple production locations, including those in other countries, without additional cost. Thus, if two national firms were producing the same amount as the single horizontal MNE, their average headquartering costs would be twice as great. The second advantage of the MNE is that by servicing a market through local production, it avoids trade costs.[2] In determining the relationship between the skill difference and horizontal FDI, the key is to recall that the skill-intensive production of the MNE's good takes place in both countries. As one country becomes skill abundant relative to the other, it gains a comparative advantage in both headquartering and the production of the MNE's good. Thus, the MNE has an incentive to shift production and citizenship towards the skill abundant country. Therefore, as the skill differences rises, FDI goes down since the MNE produces less in the host.

More recent versions of the horizontal model, such as Markusen and Venables (1998) and Markusen and Venables (2000), treat the MNE sector as one with differentiated products and multiple MNEs. These models are particularly useful because bilateral FDI flows arise in equilibrium and therefore come closer to observed patterns of investment. To determine the effect of relative skill endowments on FDI in these models, again begin with identical countries and zero skill differences. Now let the home country become slightly more skill abundant relative to the foreign country. This corresponds to a rise in the skill difference for MNEs from home (a positive skill difference for home's outbound FDI) and a drop in the skill difference for MNEs from foreign (a negative skill difference for foreign's outbound FDI). Just as in the simpler version of the model, home's outbound FDI drops because the foreign country becomes a less attractive location for production of its MNEs' products. Thus, for skill differences above zero, there is a negative relationship between the skill difference and horizontal FDI. In the foreign country, this shift in

[2] In fact, in its original version, the horizontal firm structure only strictly dominates a national monopolist under positive trade costs.

relative endowments means that it is no longer as attractive a location for either the production of the MNE's good or the headquartering activity. Because of this drop in foreign's headquartering activity, foreign's outbound FDI also drops. Thus, as the difference between foreign's relative skill endowment and home's relative skill endowment becomes negative, foreign's outbound FDI decreases. Turning this around, as the skill difference rises, i.e. it moves closer to zero, foreign FDI goes up. Thus, for skill differences below zero, there is a positive relationship between the skill difference and horizontal FDI. As a result, horizontal FDI is greatest when countries are similar in relative skill endowments. This relationship is shown in Figure 1. Finally please note that there are also effects from the relative size of the two countries on FDI. However, since Markusen and Maskus (1999) point to the skill difference as the best method of differentiating among the models, I focus on this variable.

2.2 The Vertical Model

The vertical model finds its genesis in Helpman (1984). In its original form, the model is described by a standard Hecksher-Ohlin model with the exception that the factors used in the production of the MNE's good can be combined across borders. This again represents that the skilled labor used in the headquartering activity can be geographically separated from the production activity. Here, there are no trade costs. As is typical in the Hecksher-Ohlin model, when the factor endowments of the two countries lie within the factor price equalization (FPE) set, the integrated world equilibrium can be achieved through trade in goods. Furthermore, there is no need for a MNE since there is no advantage to this structure relative to a national firm structure. If, however, factor endowments are outside the FPE set, this is not true. The integrated world equilibrium can be restored in one of two ways. First, trade in factors can be permitted, implying that factors will relocate until the relative endowments are in the FPE set. Alternatively, we can allow for trade in headquarter services, that is, a trade in the service of the factor rather than the actual relocation of the factor. Since this implies production in one location with its headquarters in another, this is the creation of vertical FDI. In this equilibrium, the skill abundant country specializes in headquartering activity while the skill deficient country specializes in the production of both goods. This yields three anticipated patterns of vertical FDI. First, vertical FDI only exists when factor endowments lie outside of the FPE set, i.e. only when the skill difference between the parent and host countries is sufficiently greater than

zero. Naturally, in many cases the FPE set can be empty (for details see Bhagwati, Panagariya, and Srinivasan, 1998). Second, only the skill abundant country can be a parent country for vertical FDI. Third, as endowments move further from the FPE set, trade in headquartering services increases, implying that vertical FDI is increasing in the skill difference between the parent and the host. This is shown in Figure 2, where the initial point V will be at zero if the FPE set is empty.

2.3 The Knowledge Capital Model

The beauty of the knowledge capital model is that it combines both the horizontal motive for investment (minimizing trade and headquartering costs) with the vertical motive (exploiting factor price differences). Unfortunately, this comes at the cost of extreme complexity. As a result, most of the work on the KK model derives its insights from the output of simulations. As shown in the figures of MVKZ (1996) and Markusen (1997), horizontal FDI is most active when countries are similar in relative factor endowments while vertical FDI is most prominent when relative endowments differ. In particular, looking at panel three of MVKZ's Figure 1 where trade costs are reasonably large, no vertical MNEs are present when the countries have similar relative endowments and sizes. As we move from the center of the box towards its North-West or South-East corners, that is, as we hold relative size the same but increase the skill difference, we move from a region in which all MNEs are horizontal to one in which all MNEs are vertical with a mixed region in between. Thus, as we move from a skill difference of zero towards positive infinity, this indicates that we would expect to move from a region wherein all FDI from the skill abundant country is horizontal to one in which both horizontal and vertical FDI coexist to one in which only vertical FDI occurs. For the skill deficient country, which only has outbound horizontal FDI, movement away from equal relative endowments decreases its outbound FDI as before.

What does this then imply about the relationship between total FDI, that is horizontal and vertical FDI combined, and skill differences? This is the same as asking what can happen when I combine my Figures 1 and 2 into a Figure 3. Since near a zero skill difference horizontal FDI describes the majority of investment, we find a negative relationship between the absolute value of the skill difference and total FDI (although naturally the slope need not be the same on either side). As we move further into the positive skill differences, vertical FDI begins to pick up. Eventually, vertical FDI dominates the investment and we find a

positive relationship between the skill difference and total FDI. This implies that the KK model predicts a very non-monotonic relationship between skill differences and FDI. Specifically, as we move from a negative skill difference towards a large positive skill difference, we expect FDI to increase, then decrease, then increase again.

This is not, however, what CMM (2001) suggest. In their graphs, they illustrate a positive monotonic relationship between the skill difference and FDI for both skill deficient and skill abundant parents, that is, they predict a relationship that is upward sloping across all skill differences as illustrated by the dashed line in Figure 3. Because of this, they predict that the estimated coefficient for the skill difference should be positive, regardless of whether the parent country is skill abundant or not. For this to be true it is necessary that any reductions in horizontal investment be more than compensated by increases in vertical investment. This places two requirements on the figures. First, V, the point at which vertical FDI initially appears, must be equal to zero. This in turn implies that for extremely small endowment differences, some firms find the vertical structure superior to the national structure. For this to be true the FPE set must be empty for all differing relative factor endowments and that headquartering costs be the same for vertical and national firms. While there exist plenty of situations in which we expect FPE to fail, including the non-competitive MNE sector of MVKZ (1996), it is not clear what stance those authors take on the relative headquartering costs between national and vertical firms. On page 6, in Assumption (a) they indicate that vertical and national firms have the same fixed costs (which represent the headquartering costs). However, on the following page, they state that the vertical firm's fixed costs are one percent higher than the national firm's fixed cost. In any case, if V is equal to zero, one can argue that this violates the spirit of Helpman's original version in which vertical FDI only occurred if the skill difference is relatively large. Second, the change in vertical investment must be larger than the opposite of the change in horizontal investment for all skill differences greater than V. This requires that the slope of the line in Figure 2 must be greater than the opposite of the slope of the relationship in Figure 1 everywhere to the right of V. Alternatively, it is possible that the graphs presented in CMM (2001) do in fact have a dip similar to that in Figure 3 but, given the parameters they chose, it is just too small to see. In any case, a more general interpretation of the KK model

includes those that exhibit a far more non-monotonic relationship between skill differences and FDI than CMM indicate.

2.4 Empirical Evidence

As discussed above, several studies have used variants of the KK model to create an empirical framework for studying FDI. Of these, CMM (2001) is perhaps the best known and rightly so because it offers the first theory-driven empirical specification for FDI. As discussed above, to estimate the relationship between endowments and FDI, the authors use the skill difference between the parent and the host. In addition because their simulations show that this relationship is impacted by country size differences and trade costs, they interact the skill difference with other variables. They find that, as they hypothesized, the coefficient on skill difference is positive and significant. Note that this does not imply that the total marginal effect of skill difference on FDI is positive because of the interaction terms. In fact, they estimate a negative total marginal effect of skill differences on FDI even though the direct effect is positive and significant. Markusen and Maskus (2001) use a comparable specification but restrict attention to only U.S. outbound FDI. In contrast to the prediction of CMM, they find both negative direct and marginal effects from skill differences. The authors attribute this to the extreme size of the U.S. which restricts their observations to one corner of the simulated diagrams. BDH (2002) explores this idea further and instead link this negative relationship between FDI and skill differences to the fact that the U.S. is almost always the skill abundant country. Because of this, the outbound data used by Markusen and Maskus (2001) is always to the right of zero skill differences. Furthermore, BDH claim that the CMM empirical specification is not general enough to test the KK model because it does not allow for different slopes on either side of zero as called for by the horizontal model. When they allow for different marginal effects of skill differences on either side of zero, they find a pattern similar to Figure 1 and state that the horizontal model cannot be rejected in favor of the KK model. They find this result in the data used by CMM (2001), Markusen and Maskus (2001), an expanded U.S. data set, and an OECD data set covers a broader range of the simulated figures. Markusen and Maskus (1999), who use the CMM (2001) data and dummy variable interactions to allow for different coefficients on either side of zero, also suggest that the horizontal model cannot be rejected in favor of the KK model.

However, just as BDH suggests that the CMM specification is too restrictive to adequately test the KK model, the BDH or Markusen and Maskus (1999) specifications are too restrictive as well because they do not allow for non-monotonicities in skill differences when the parent is skill abundant. In other words, just as a straight line is not sufficient to estimate the relationship in Figure 1, straight lines on either side of zero are not sufficient to estimate the relationship in Figure 3. Therefore, I estimate a more general version of the empirical specification suggested by CMM (2001) using both the U.S. data of CMM and the expanded U.S. and OECD data of BDH (2002). When I do so, I find evidence that does allow me to reject the horizontal model in favor of the KK model.[3]

3. Data and Empirical Specification

Before describing the data, let me discuss the basic CMM specification:

$$FDI_{ij} = f(SUMGDP_{ij}, GDPDIFSQ_{ij}, SKDIFF_{ij}, SKDIFF_{ij}* GDPDIFF_{ij}, (SKDIFF_{ij})^2*T\_COST_j, DISTANCE_{ij}, T\_COST_i, T\_COST_j, F\_COST_j)$$

The dependent variable, FDI_{ij} is a measure of FDI activity from a parent country (i) to a host country (j). The first two independent variables are SUMGDP defined as the sum of the two countries' real gross domestic products (GDPs) and GDPDIFSQ defined as the squared difference between the two countries' real GDP. These are intended to capture country size effects, with an expected positive correlation between SUMGDP and FDI_{ij} and an expected negative correlation between GDPDIFSQ and FDI_{ij}. The third term is my variable of interest, the skill difference between the parent and the host. The next two terms interact this with GDP differences and trade costs. This is intended to capture some of the observations CMM make when varying these parameters in their simulations. Distance ($DISTANCE_{ij}$) is included to proxy for transport and other trade costs. T_COST_i and T_COST_j represent additional barriers to trade for the parent and the host respectively. Finally, F_COST_j proxies for the barriers to setting up an MNE in the host. I

[3] An alternative explanation for the lack of vertical FDI evidence is that the proxies for relative skill endowments are poor. Braconier, Norb@ck, and Urban (2002) use wage differences instead of the job categories of CMM or the education of BDH. They find that this measure tends to be more significant than the others and is indicative of greater vertical FDI. They do not, however, use the higher order specification I suggest and therefore are unable to adequately test the KK model.

modify this basic specification by introducing $SKDIFF2_{ij}$ and $SKDIFF3_{ij}$ which are the squares and cubes of the "plain" skill difference between the parent and host countries.

I use the same data as CMM (2001) and BDH (2002). This provides me with three sets of data, two for FDI with the U.S. and one for FDI with the OECD. While I refer the interested reader to those papers for details on the data, I must point out some important differences between these three data sets. CMM use bilateral FDI data with the U.S. over the period 1986-1994. For their measure of a country's relative skill endowment, they use the percentage of workers employed in either the 0/1 (professional, technical, and kindred workers) or 2 (administrative workers) job categories as reported by the International Labor Organization. For their U.S. data, BDH use U.S. inbound FDI from 1984 to 1992 and U.S. outbound FDI from 1983 to 1992. Their sample covers a broader collection of partner countries because they use different skill, trade, and investment proxies. In particular, this data set uses a country's mean years of education as reported by Barro and Lee (1996) as a proxy for skill. Both of these data sets measure FDI activity as the sales by foreign affiliates. These data are provided by the Bureau of Economic Analysis. The OECD data set is an unbalanced panel from 1982 to 1992. This set also uses the mean years of education as the skill proxy. Unlike the other two data sets, it uses the stock of foreign direct investment as the measure of FDI. This information was obtained from the OECD's *International Direct Investment Statistics Yearbook*.

4. Results

Tables 1, 2, and 3 present OLS results using CMM's U.S. data, BDH's expanded U.S. data, and BDH's OECD data respectively. The first column of each table replicates their OLS results.[4] In all three data sets, the estimated coefficient on the plain skill difference is positive as anticipated by CMM. The second column introduces the squared skill difference to the standard specification. For the CMM and the OECD data, I find that both the plan skill difference's coefficient is again significantly positive while the squared skill difference coefficient is significantly negative. In the BDH expanded U.S. data, the squared

[4] In unreported results, I also used their Tobit and Weighted Least Squares procedures and found qualitatively similar results. These additional estimates are available upon request.

term is insignificant. Roughly, this implies that when the host is skill abundant, FDI is increasing in the skill difference while when the parent is skill abundant, FDI is decreasing in the skill difference. This is consistent with Markusen and Maskus (1999) and BDH (2002).

If I were to stop at this point as Markusen and Maskus (1999) or BDH (2002) did, I would be unable reject the horizontal model in favor of the KK model. However, as discussed above, introducing this squared term is not enough to give the vertical FDI a chance to reveal itself in the KK model. Thus, the third column of the three tables includes both a squared and a cubed skill difference in the CMM specification. If the description of the KK model in Figure 3 is correct, we might expect the plain and cubed skill difference to have positive coefficients while the squared skill difference has a negative coefficient. Unfortunately, the data does not exhibit strong evidence for this. I only find the expected pattern of signs in the OECD data, where the plain skill difference coefficient is insignificant. In the CMM data, although the plain and squared skill differences perform as expected, the cubed term is insignificant and has the wrong sign. Finally, in the BDH U.S. data, while all three skill differences are significant, only the plain skill difference has the anticipated sign. Furthermore, I find that introducing the squared or cubed terms does little in terms of improving my R^2s. This is admittedly somewhat disappointing for my story since it indicates that even with my expanded specification, there is little evidence for vertical FDI.

As an alternative to this cubed specification, I estimated the expanded CMM specification after separating my observations into those with positive skill differences and those with negative skill differences. I refer to these subsamples as the positive and negative subsets. Since the negative subset should include only horizontal FDI while the positive subset includes both horizontal and vertical FDI, I anticipate that this split will allow the estimation procedure to better capture the vertical forces at work. Note that for the CMM and the BDH U.S. data, this implies that I am more or less splitting my observations into U.S. outbound (positive skill differences) and U.S. inbound (negative skill differences) data sets. If the KK model described by Figure 3 is a reasonable description of the data, I expect that for the direct marginal effect of a rise in skill differences should be positive for the negative subset. For the positive subset, I expect that the direct marginal effect of skill differences will switch from negative to positive as the skill difference

rises. Therefore, for the positive subset, I expect that the plain skill difference will be negative while the squared skill difference will be positive.

The fourth column of Tables 1 through 3 presents OLS estimates when using the negative skill difference observations. In the CMM and BDH U.S. data, the significant coefficients imply that FDI is strictly increasing in the skill difference. The OECD data finds that FDI is increasing for skill differences below 1.5, that is when average years of education in the parent is 1.5 years less than in the host. In this subsample, this implies that for the majority of observations, FDI is increasing in the skill difference.[5] Combining this information indicates that in the negative subset, FDI does seem to be increasing in the skill difference. In other words, as the skill difference rises towards zero, implying a movement towards equal relative skill endowments, FDI rises as the horizontal and KK models predict. Furthermore, for the BDH expanded U.S. sample and the OECD data, restricting attention to the negative subset dramatically improves the models fit of the data.

This does not, however, imply that we can differentiate between the horizontal and KK models since to the left of zero skill differences these two models are the same. To deal with this question, it is necessary to consider the positive subset where vertical FDI can occur in the KK model but not in the horizontal model. Therefore, in the final column of Tables 1 through 3, I present OLS estimates when using the positive skill difference subset. In each case, as expected, I find that the plain skill difference has a negative coefficient while the squared skill difference has a positive coefficient.[6] For the BDH U.S. and the OECD data, both of these coefficients are also significant, while in the CMM data, only the plain skill difference is significant. Since the BDH U.S. data's alternate trade and investment cost measures permit the inclusion of more developing countries (those we would expect to receive vertical FDI), this difference in

[5] The mean skill difference in this subsample is –1.64 while the standard deviation is 1.22.

[6] One interesting implication of the estimated upturn in FDI for large skill differences is that it may help to explain why the existing literature continually finds a positive coefficient for skill differences when using all observations and only the plain skill difference. If the data corresponded to Figure 1, one might expect that a negative estimated coefficient is as likely as a positive one. However, if the data looks more like Figure 3, this second upward-sloping section might tip the scales in favor of finding a positive coefficient.

significance levels is not surprising.[7] Furthermore, for the BDH U.S. data and the OECD data, restricting the data to skill abundant parents greatly improves the fit of the model. These coefficients are those predicted by the KK model but still do not imply I can reject the horizontal model in favor of the KK model, since it is unclear whether FDI is simply asymptoting towards zero or whether it actually swings back up as in Figure 3. In other words, do these estimates imply a simple tapering off of horizontal FDI or do they actually suggest a rise in vertical investment?

To get at this issue, I calculated the estimated inflection points from these three regressions. For the CMM data, the inflection point is .501, that is FDI only starts to rise again when the percentage of workers employed in skilled jobs in the parent is 50 percent points higher than in the host. Since the maximum difference in this subsample is only 27.7 percentage points, there are in fact no country pairs in the CMM database that actually exhibit the positive slope that characterizes vertically dominated FDI. In the BDH U.S. data, I find a similar result since the inflection point is at an eighteen year difference in mean years of education whereas the maximum value for this difference is only 9.5 years. Thus, on the basis of these two data sets, I am still unable to reject the horizontal model in favor of the vertical model. The OECD data, however, tells a different story. Here, the estimated inflection point is a difference in mean education of 3.9 years compared to an average and maximum difference of 2.88 and 8.1. Thus, while the average country pair in the OECD sample is dominated by horizontal FDI, there are country pairs that are dominated by vertical investment. Thus, for the OECD sample, I can reject the horizontal model in favor of the KK model.

What is driving this difference between the OECD estimates and those for the U.S.? One culprit is that the two U.S. data sets are almost entirely comprised of U.S. outbound investment. Since the U.S. is so much larger than other countries, it is possible that these estimates cover only a limited section of the parameter space analyzed by the KK theories. In particular, looking at the figures of MVKZ (1996) or Markusen (1997), when one country is much larger than the other, we might expect little FDI to occur regardless of the relative skill endowments. Alternatively, this difference could be driven by the differing

[7] Regardless of the data set used, the other control variables have roughly the same signs and significance levels for the positive and negative skill difference subsamples.

measures of FDI activity since the OECD data sets uses the stock of FDI while the other two data sets use the sales of foreign affiliates. To test this possibility, I repeat the inflection point exercise using the positive subsample of the BDH expanded U.S. data but using the stock of FDI instead of affiliate sales. These estimates are found in Table 4. As with the sales measure, the plain skill difference has a negative, significant coefficient while the squared skill difference has a positive, significant coefficient. Unlike the sales data, however, the estimated inflection point is at a difference of 3.38 years, which is below the average difference of 4.7 years. This indicates that country pairs dominated by vertical FDI can be isolated when using the U.S. stock data but not the U.S. sales data. Since the stock data is more complete than the sales data, the final two columns of Table 4 re-estimate the equation using only those observations for which both stock and sales information was available. Using the stock results from column two, the estimated inflection point is at a 4.7 year difference. The sales data, however, estimates the inflection point to be at a difference of 16.4 years. This indicates that the KK empirical specification finds evidence of vertical FDI when the measure of FDI activity is the stock of investment but not when it is the sales by overseas affiliates.

What might cause this difference between the sales and stock measures? One possibility is that the stock captures the accumulated changes in investment up to the current period while sales reflect the current output of those decisions. If there are short-run fluctuations that impact a MNE's choices in a given year but not its long-run strategy, then we might expect the stock to better reflect long-run trends such as long-term factor price differences. Alternatively, the answer may lie with the incentives a MNE has to manipulate its international finances. In particular, if one of the primary purposes of vertical FDI is to export back to the parent, an MNE might have an incentive to distort its sales figures in order to engage in transfer pricing and avoid taxation or other costs. Since this might not affect a firm's stock decision but only the income it reports to the government, this could create the difference I observe. While these possibilities are intriguing, they lie outside the scope of this paper and I leave them to future research.

Finally, Table 5 presents a list of the countries with skill differences above the inflection points calculated from the stock regressions. Not surprisingly, the host countries are primarily developing countries while the parents are the large, developed countries (recall that the U.S. is always the parent country in the BDH U.S. data). Two hosts are rather unexpected: Australia and Switzerland. While these

countries certainly seem skilled anecdotally, the BDH data lists both of them as having fewer than seven average years of schooling. Since this is quite probably a data error, I have repeated the regressions omitting these two nations. This had little impact on my results and I was still able to reject the horizontal model in favor of the KK model when using FDI stocks.

5. Conclusions

The purpose of this paper has been to shed some light on the empirical debate between the horizontal and knowledge capital models. By returning to the original theories, I have found that the specifications used in this debate may not be sufficient to adequately compare the two models. In particular, while the horizontal model may be adequately described by a linear relationship between FDI and skill differences on either side of zero, the KK model requires a richer empirical specification. By using an alternative framework, I am able to isolate country pairs for which FDI seems to be dominated by vertical investment as opposed to horizontal investment. Unlike previous work, this result permits me to reject the horizontal model of FDI in favor of the more comprehensive KK model when measuring FDI activity by the stock of FDI. While there are still several unanswered questions surrounding these models, in particular why vertical FDI is found in FDI stocks but not in affiliate sales, I hope that these results serve as a resolution for some of the current discussion and as well as a departure point for further investigation.

Figures

Figure 1:
Horizontal FDI from Parent i to Host j

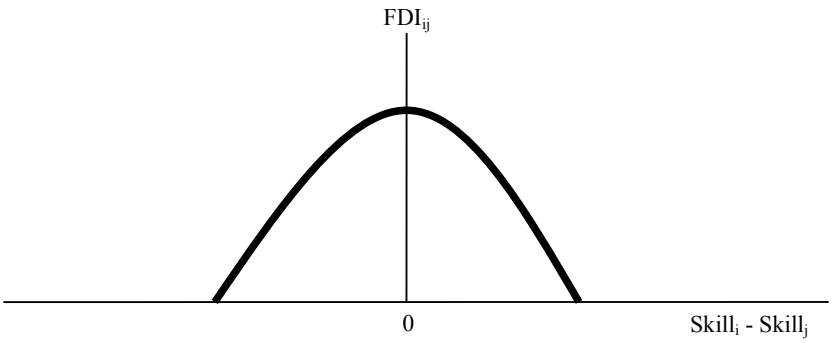

Figure 2:
Vertical FDI from Parent i to Host j

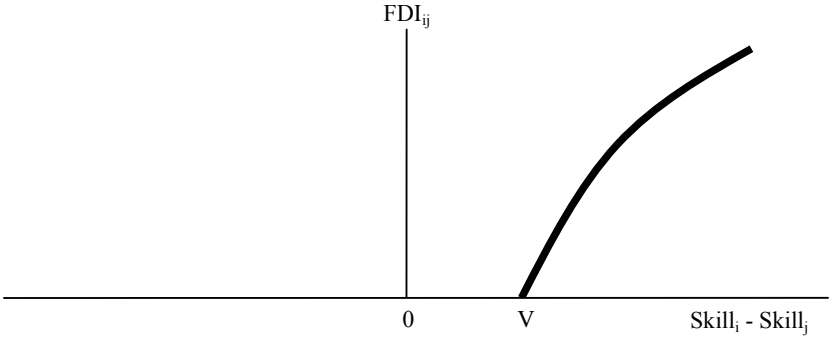

Figure 3:
Total FDI from Parent i to Host j (KK)

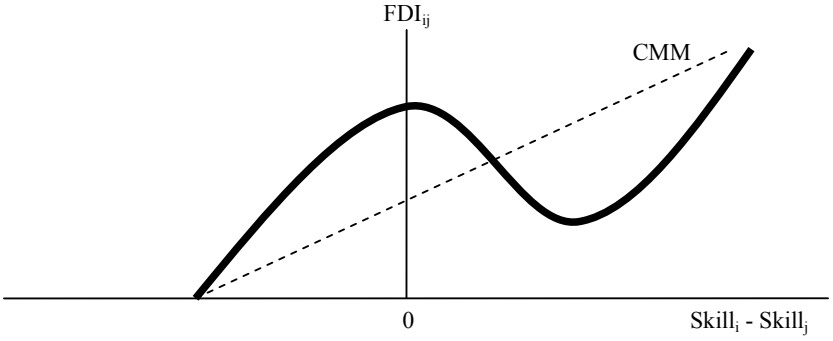

Table 1: Regressions Using CMM Data

Dependent Variable: Affiliate Sales of Country i's firms located in Country j					
Skill Differences Included:	All	All	All	Negative Only	Positive Only
$SUMGDP_{ij}$	10.803*** (5.86)	10.881*** (5.98)	10.895*** (5.91)	12.914*** (4.21)	9.220*** (3.93)
$GDPDIFSQ_{ij}$	-0.001*** (6.28)	-0.001*** (6.32)	-0.001*** (6.34)	-0.001*** (3.25)	-0.001*** (5.93)
$SKDIFF_{ij}$	33,742.912*** (3.92)	30,735.766*** (3.49)	43,097.824** (2.42)	242,581.713*** (3.02)	-96,384.845** (2.05)
$SKDIFF2_{ij}$		-286,595.371** (2.20)	-327,133.820*** (2.67)	629,991.803 (0.89)	96,241.221 (0.41)
$SKDIFF3_{ij}$			-393,477.780 (0.96)		
$SKDIFF_{ij}$* $GDPDIFF_{ij}$	-6.337** (2.56)	-4.559** (2.07)	-4.574** (2.08)	-10.871* (1.76)	5.436** (2.59)
F_COST_j	-516.594*** (4.31)	-483.191*** (3.98)	-505.623*** (3.95)	-1,225.108 (1.46)	-516.391*** (3.89)
T_COST_j	119.244 (1.09)	-17.263 (0.12)	-23.100 (0.16)	73.257 (0.11)	64.470 (0.61)
$(SKDIFF_{ij})^2$*T_COST_j	605.231 (0.40)	6,208.207** (2.02)	7,696.372** (2.52)	10,917.558 (0.54)	3,001.912 (1.16)
T_COST_i	-93.669 (1.23)	-70.036 (0.89)	-84.227 (1.04)	-78.240 (0.70)	-430.261* (1.81)
$DISTANCE_{ij}$	-1.822*** (6.73)	-1.828*** (6.76)	-1.834*** (6.79)	-2.192*** (4.48)	-1.589*** (6.53)
Constant	16,630.411 (1.09)	19,401.593 (1.26)	20,560.348 (1.35)	37,873.309 (1.00)	47,205.232** (2.53)
Observations	509	509	509	203	306
R-squared	0.48	0.48	0.48	0.47	0.55

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Regressions Using BDH U.S. Data

Dependent Variable: Affiliate Sales of Country i's firms located in Country j					
Skill Differences Included:	All	All	All	Negative Only	Positive Only
$SUMGDP_{ij}$	34.37902*** (8,98)	34.3332*** (9.03)	34.04002*** (8.96)	35.94687*** (6.05)	25.1461*** (6.56)
$GDPDIFSQ_{ij}$	-0.003*** (8.06)	-0.003*** (8.04)	-0.003*** (7.36)	-0.013*** (13.93)	-0.006*** (5.42)
$SKDIFF_{ij}$	1,855.800*** (4.91)	1,807.699*** (4.34)	3,348.055*** (5.58)	86,686.565*** (16.15)	-34,167.209*** (5.21)
$SKDIFF2_{ij}$		97.849 (0.47)	443.411* (1.70)	-13,197.570*** (4.73)	951.714** (2.43)
$SKDIFF3_{ij}$			-30.405*** (3.83)		
$SKDIFF_{ij}$* $GDPDIFF_{ij}$	-0.242 (1.31)	-0.339 (1.07)	-0.550 (1.46)	17.096*** (13.16)	5.697*** (3.35)
F_COST_j	-763.696*** (6.50)	-759.093*** (6.32)	-801.059*** (6.49)	876.666 (0.84)	-539.930*** (3.84)
T_COST_j	68.868** (2.57)	82.898** (2.11)	176.296*** (3.81)	-1,710.492*** (6.89)	38.114 (0.87)
$(SKDIFF_{ij})^2$*T_COST_j	-5.179*** (4.38)	-6.034*** (2.82)	-9.713*** (4.13)	179.258*** (5.21)	-3.857 (1.58)
T_COST_i	18.312 (1.15)	19.497 (1.20)	0.680 (0.04)	-36.143*** (4.40)	-112.554 (0.50)
$DISTANCE_{ij}$	-3.094*** (7.52)	-3.108*** (7.54)	-3.162*** (7.81)	-1.217*** (4.28)	-3.922*** (5.30)
Constant	-26,121.563* (1.75)	-26,937.219* (1.75)	-29,101.800* (1.89)	231,026.477*** (7.63)	99,606.799** (2.30)
Observations	778	778	778	397	381
R-squared	0.53	0.53	0.54	0.83	0.63

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: Regressions Using BDH OECD Data

Dependent Variable: Stock of Country i's FDI in Country j					
Skill Differences Included:	All	All	All	Negative Only	Positive Only
$SUMGDP_{ij}$	9.278***	9.337***	9.249***	20.217***	5.068***
	(7.82)	(7.86)	(7.95)	(7.20)	(9.62)
$GDPDIFSQ_{ij}$	-0.001***	-0.001***	-0.001***	-0.003***	-0.000
	(3.19)	(3.36)	(3.10)	(5.63)	(0.39)
$SKDIFF_{ij}$	272.470***	347.253***	74.926	-3,010.887***	-851.198***
	(3.50)	(4.25)	(0.69)	(2.87)	(2.67)
$SKDIFF2_{ij}$		-80.219***	-169.480***	-1,000.293***	109.116*
		(3.63)	(5.09)	(4.30)	(1.95)
$SKDIFF3_{ij}$			26.523***		
			(3.39)		
$SKDIFF_{ij}$* $GDPDIFF_{ij}$	-0.693***	-0.623***	-0.688***	1.543***	-0.547***
	(6.19)	(5.54)	(5.37)	(6.00)	(3.77)
F_COST_j	-46.215***	-37.922**	-35.403**	320.992***	-88.696***
	(2.84)	(2.27)	(2.06)	(4.73)	(5.40)
T_COST_j	-4.144	-8.589***	-4.899*	-91.076***	0.210
	(1.48)	(2.88)	(1.71)	(3.36)	(0.10)
$(SKDIFF_{ij})^2$*T_COST_j	-1.380***	-0.805**	-1.416***	-30.363***	-0.321
	(4.46)	(2.56)	(3.18)	(6.73)	(1.48)
T_COST_i	-69.861***	-70.173***	-68.518***	-108.552***	-0.681
	(5.30)	(5.33)	(5.26)	(4.89)	(0.06)
$DISTANCE_{ij}$	-0.251***	-0.244***	-0.223***	0.039	-0.253***
	(6.23)	(6.11)	(5.45)	(0.36)	(5.66)
Constant	726.460	713.788	934.233	-19,115.539***	4,516.407***
	(0.63)	(0.62)	(0.84)	(5.50)	(6.64)
Observations	2460	2460	2460	671	1789
R-squared	0.37	0.37	0.37	0.62	0.32

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Regressions Using Positive Skill Difference BDH Data

Dependent Variable:	FDI Stock	FDI Stock	Affiliate Sales
$SUMGDP_{ij}$	5.288***	5.931***	25.476***
	(5.19)	(4.71)	(6.52)
$GDPDIFSQ_{ij}$	-0.000	-0.000	-0.006***
	(0.82)	(0.65)	(4.88)
$SKDIFF_{ij}$	-2,707.125*	-3,882.419*	-33,383.684***
	(1.76)	(1.78)	(4.91)
$SKDIFF2_{ij}$	400.067***	412.454**	1,016.407**
	(2.83)	(2.35)	(2.43)
$SKDIFF_{ij}$* $GDPDIFF_{ij}$	-0.278	-0.099	5.344***
	(0.57)	(0.15)	(2.90)
F_COST_j	-160.553***	-136.632**	-533.565***
	(3.27)	(2.28)	(3.78)
T_COST_j	42.425***	30.931*	44.084
	(2.80)	(1.71)	(0.92)
$(SKDIFF_{ij})^2$*T_COST_j	-2.309***	-1.951*	-4.152
	(2.94)	(1.92)	(1.53)
T_COST_i	207.007**	194.326**	-60.296
	(2.57)	(2.00)	(0.24)
$DISTANCE_{ij}$	-1.555***	-1.532***	-3.915***
	(6.11)	(5.18)	(5.22)
Constant	-4,596.907	-5,920.360	90,928.337*
	(0.36)	(0.37)	(1.96)
Observations	493	372	372
R-squared	0.39	0.40	0.63

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Parents and Hosts of Vertical FDI

Hosts (BDH U.S. Data):								
Australia	Brazil	Chile	China	Columbia	Ecuador	Egypt	India	Indonesia
Iran	Israel	Korea	Malaysia	Mexico	Morocco	Nigeria	Pakistan	Peru
Philippines	Singapore	Spain	Switzerland	Thailand	Turkey	Venezuela		
Hosts (OECD Data):								
Australia	Brazil	Chile	China	Columbia	Egypt	India	Indonesia	Israel
Italy	Korea	Malaysia	Mexico	Morocco	Nigeria	Philippines	Portugal	Singapore
Spain	Switzerland	Thailand	Turkey					
Parents (OECD Data):								
Austria	Canada	France	Germany	Japan	Korea	Norway	UK	USA

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