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Capital Ideas: Modelling and Measuring Factors in the Knowledge Capital Model

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Abstract

One of the main challenges when analyzing multinational firms (MNEs) is that this group is comprised of a rich variety of firms engaged in a spectrum of activity. In response to the separate models describing one type of MNE or another, the Knowledge Capital model was developed in order to provide a unified framework. Although this did yield many empirically supported insights, it nonetheless had difficulty explaining to co-existence of FDI and trade among similar countries, a particular issue given that most FDI and trade takes place between such nations. While this can be resolved by adding in additional factor – capital – this raises several questions on how best to match the expanded theory to the data. In this paper, we provide an overview of the development of this literature, illustrate some of the difficulties in mapping the models to data, and provide several suggestions for future research including a need to model capital markets and taxation.

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1. Introduction

It is not an overreach to say that to understand the modern, global economy it is necessary to have an understanding of multinational enterprises (MNEs). Given their size and scope, foreign direct investment (FDI) is intricately linked to trade, innovation, employment, and more. That said, the economic research on FDI has largely been fractured because the term "multinational firm" represents several different types of activities, including market-seeking horizontal FDI and factor-seeking vertical FDI. This has led to an active empirical debate about which motive for FDI dominates, a discussion that has yielded a firm answer of "it depends" (see Davies and Markusen (2021a, 2021b) for more discussion). The empirical results then prompted a return to theory which resulted in the Knowledge Capital (KK) model developed by Markusen (2002) in which different MNE structures arise as a function of underlying parameters, with the focus largely on factor endowments.

While many of the KK model's predictions on the volume and structure of MNE activity were supported empirically, others were not.[1] In particular, the KK model did not tend to predict that both horizontal and national (non-MNE) firms would coexist when countries were of similar size, something in clear contradiction of the data. In an effort to resolve this conundrum, Bergstrand and Egger (2007, 2010, 2013) expanded the original two-factor version of the KK model into one of three factors. By adding physical capital to the original models high- and low-skilled labor endowments, their work expanded the co-existence of horizontal and national firms, bringing added realism to the model's predictions. The goal of the current paper is to discuss this innovation further, both in terms of its theoretical workings and how those insights might be taken to data. In particular, our goal is to highlight measurement of capital, what that means relative to the theory, and thus directions for future work on the research describing when FDI occurs and what firm structures it represents.

In the next section, we provide a brief overview of the development of the literature on

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[1] See, for example, Carr, Markusen, and Maskus (2001), Blonigen, Davies, and Head (2003), and Davies (2007). For more detailed coverage of the existing literature, we suggest Antràs and Yeaple (2014), Davies and Markusen (2021a, 2021b), and Kox (2023).

FDI. Although this review is by no means comprehensive, the goal is to provide a foundation for the KK model which is described in Section 3. In particular, we wish to highlight how the discussion of the KK model developed from what came before it. This then helps to explain some of the choices made by Bergstrand and Egger when introducing a third factor of production, a developed discussed in Section 4. With that in hand, Section 5 turns to how one might measure capital and how that relates to the way it is modeled in the theory. ~~In particular,~~ Specifically, this highlights the need to add an international capital market subject to taxation to the theory. Finally, we conclude in Section 6 by offering suggestions on potential avenues for future research.

2. The Evolution of the Theory of FDI

In the early years of international economics as a field of study – a time early even by the standards of the more senior coauthor of the current contribution – MNEs and FDI received very little discussion in the microeconomics trade literature. On the whole, we believe that it is fair to say that FDI was rostered primarily in the open-economy macroeconomics literature. In this setting, FDI was merely a manifestation of capital flows motivated by differences in the returns to capital across countries. As a result, the international trade literature tended to model capital as a homogenous factor of production which, if internationally mobile, moves from capital-abundant countries (where due to the fixed supply of other factors, the rate of return was low) to capital-scarce ones.

This view of FDI as a simple capital flow, however, has a number of limitations which created issues for the research on FDI for several decades. First, there was no distinction between portfolio investment and FDI. This ignores a key distinction between FDI and portfolio investment, namely, that FDI explicitly provides a degree of control to the investor over the overseas activity whereas portfolio investment does not. This distinction is at the heart of the business literature's early attempts to describe FDI using the "eclectic paradigm" (Dunning, 1979, 2001). Furthermore, for an investment to count in official FDI statistics, a sufficiently

large share of equity must be provided by a single foreign individual.[2] Thus, conflating portfolio and FDI flows misses a key aspect of what makes FDI different from other capital movements and speaks to the need to ensure that the theory aligns with the data (and vice versa, a topic we take up in Section 5).

Second, if FDI is driven by differences in the return on capital, the macro approach would predict that FDI should flow from developed to developing countries. In addition, as discussed by Mundell (1957), the Heckscher-Ohlin model – essentially the only model of international trade at the time – would predict that this capital flow would substitute for trade in goods.[3] These predictions, however, were clearly contradicted the available data. During the 1960s to the 1980s, most trade *and* FDI took place between large, wealthy countries (with the US the largest home and host for FDI). Although more MNEs are now found in developing countries, this pattern persists (Davies, Desbordes, and Ray, 2018). Thus, the capital flow approach to FDI does not explain either the predominance of FDI between capital-abundant countries or the positive correlation between trade and MNE investment.

Third, equating FDI with capital flows creates an unconscious bias in how the data are used. For example, the yearly World Investment Report (UNCTAD) implicitly focused on investments in property, plant and equipment (PPE) for its measure of FDI. This creates a significant bias that tilts the FDI measures towards physical capital-intensive industries and ignores the substantial flow of the services of intangible assets from parents to affiliates. In particular, this tends to ignore the role multinationals play in the development of intellectual property. Given that Bircan, Javorcik, and Pauly (2021) find that MNEs account for a sizable share of global patents, this is an important oversight.

Fourth, thinking of FDI as a passive capital flow entirely ignores the questions of what multinationals actually do and what makes them different from purely national firms. Attempts to answer these queries form the genesis of what most economists would consider the modern approach to FDI, an approach that is defined by its focus on why firms choose to become MNEs.

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2 Legally, the minimum ownership for an investment to count as a controlled investment is typically around 10% with that threshold varying somewhat across countries. In practice, however, most foreign-controlled firms tend to be majority owned with many ownership shares above 90% (see Davies, Desbordes, and Ray, 2018).
3 Twenty-six years later, Markusen (1983) noted that Mundell had used an extremely special case and showed instead a wide variety of cases in which factor movements and trade are complements.

The basis for this modern treatment of the MNE derives from Dunning's (1979) eclectic paradigm in which three conditions – ownership, location, and internalization (OLI) – are necessary for FDI to make arise. The first of these posits the existence of a "proprietary asset", that is, something that makes one firm distinct from others. This can take the form of a brand, process, technology, management technique, or other characteristic that gives one firm an edge relative to others. As a result, most modern models include firm-level fixed costs which reflect the creation of this proprietary asset, a process that is typically considered skilled labor intensive relative to production. A second implication of the proprietary asset for theory is that it implies a degree of market power. This then calls for models that feature less-than-perfect competition, with monopolistic competition often the chosen approach.

Internalization, the third component of the eclectic paradigm, says that there must be a reason for the firm to do an activity itself rather than outsource it to a contractor or licensee. This then directly relates to the control aspect of FDI which differentiates it from portfolio investment. Internalization, now more frequently referred to as vertical integration, is modeled in the modern literature as a tension between the high-powered incentives coming with outsourcing versus the agency problems outsourcing creates. There are two quite different ways to model the latter. Ethier and Markusen (1996) model the agency problem by assuming that (knowledge-based) assets are non-excludable from foreign workers or firms. Alternatively, Antràs (2003) assumes that physical capital is fully excludable based on ownership, but outsourcing creates an ex-post hold-up problems. These two approaches are combined in an integrated setting by Chen, Horstmann and Markusen (2012) with the empirical evidence of Kukharskyy (2020) finding strong support for this unified approach. As this issue is not our focus, we set further discussion on this point aside.

The meat of the OLI sandwich – location – has arguably been the largest point of discussion on what drives FDI within the economics literature. The location requirements means that, in order for the MNE to exist, there needs to be a reason for the firm to produce in different countries, i.e. for the "multi" in multinational to make sense. In the economics literature, two different motives have been put forth for this location motivation.

The first builds from the macro approach and relies on factor price differences (Helpman, 1984). Here, production is fragmented, with activities of differing factor intensities being

allocated to various locations according to differences in the local factor prices (which are themselves driven by differences in factor endowments). In particular, this approach has tended to focus on the issue of differences in the relative endowment of (immobile) skilled labor across countries.[4] Given that the firm fixed costs (the creation of the proprietary asset) are a skill intensive activity, this – and MNE's headquarters and nationality – will be done in the skill-abundant country. These skill-intensive services in the home country are then combined with unskilled labor in the host country to produce a final good which is sold locally and in the home country. Thus, FDI is supported by intra-firm trade in intermediate goods and services and leads to trade in final goods. Vertical FDI is therefore very much linked to the idea of a global supply chain. Note that, as with the capital view of FDI which preceded it, the vertical MNE is the result of factor prices differences across countries: if factor prices were the same across borders, then there is no rationale for fragmenting the firm across countries.

In contrast to the vertical MNE which expands overseas to gain access to immobile inputs, the second approach motivates overseas investment as gaining access to consumers (Markusen, 1984). When trade costs are substantial, the firm has an incentive to replicate its production process across countries using a local production facility – a plant – in each market. This firm structure then allows the firm to replace costly trade with local production, a substitution very much at odds with a vertical MNEs investment and trade pattern. Thus, in addition to the firm fixed cost (which is now a joint input that can be used in a non-rivalrous way across plants), this "horizontal" MNE also has a plant-level fixed cost. As a result, the horizontal MNE faces a tradeoff between being proximate to consumers and additional plant-level fixed costs which urge it to concentrate its activity in one factory, a tension labeled the proximity-concentration hypothesis by Brainard (1997).

These two models then predict two very different underlying motivations for why FDI happens and thus what factors should drive it. At the most simple level, on the one hand there is factor-cost driven vertical FDI which is characterized by fragmentation of the production process. This type of investment should flow from a skill-abundant country to a skill-deficient one and yield a pattern in which FDI and trade are complements. On the other hand, horizontal

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4 Note the assumption of internationally immobile factor endowments here, something in direct contrast to the capital flow approach to FDI.

FDI is characterized by replication of the production process and is driven by access to consumers. Since similar activities are carried out in each plant, this will be most reasonable when factor prices are likewise similar, implying that horizonal FDI will be most viable between countries with similar relative endowments. Finally, since the purpose of FDI is to eliminate costly trade within the firm, this would suggest FDI and trade are substitutes for the horizontal firm.

Following the development of these two alternatives, the natural question became whether the data supports vertical or horizontal FDI. Early contributions in this vein include Brainard (1997) who tests the proximity-concentration tradeoff and finds evidence consistent with more FDI when trade costs are high but less when plant-level fixed costs are larger. This then provides early support for horizontal FDI. Since that contribution, a number of other papers have emerged to offer support for the horizontal model (see Davies and Markusen (2021a; 2021b) for both evidence and a review of the existing literature). This is dominance of horizontal FDI is not difficult to understand since, even as investment in hosts such as China and India has risen, FDI flows between the developed countries remains the bulk of global investment (Davies, Desbordes, and Ray, 2018). Furthermore, extensions of the baseline horizontal model have proven quite useful in explaining additional features of the FDI data. For example, the export platform model, developed by Ekholm, Forslid and Markusen (2007) and empirically supported by Blonigen, et al. (2008), extends the horizontal model by allowing for exports from one host country to other nearby countries. Likewise, the heterogeneous firms approach to FDI pioneered by Helpman, Melitz, and Yeaple (2004) predicts that the most productive firms will export the most and therefore gain the most from proximity to overseas consumers. This then implies that the most productive firms will choose to be horizontal multinationals.

This debate about whether FDI is horizontal *or* vertical, however, is a largely misguided one. While it may be true that the US has more investment in highly developed countries such as the UK, Germany, France, and Canada, it nevertheless has significant investment activity in China, India, Mexico, and Brazil. This pattern in which a country invests in both high skill- and low skill-abundant countries is seen routinely across the globe. Further, when examining affiliate sales, while a greater share of output is destined for the home market, even in low-income countries a significant volume of output is sold locally. As such, the data predicts that FDI is not

horizontal or vertical, but rather that the data finds varying degrees of support for both. This points to a need for a unified treatment in which one MNE structure or the other can arise as a function of the underlying characteristics of the countries in question. Further, this unified model should incorporate both firm-level fixed costs (and thus imperfect competition) as well as plant-level fixed costs (to reflect the proximity-concentration tradeoff). This need then led to the next wave of theory – the knowledge-capital model of FDI.

3. The Baseline Knowledge Capital Model

The canonical KK model formally developed in Markusen (2002) sought to construct a single setting in which, depending on the underlying exogenous parameters, different MNE structures would arise endogenously. A body of work has arisen from this baseline that includes various extensions, including services trade (Markusen and Strand, 2009), heterogeneous firms (Antràs and Yeaple, 2014), human capital accumulation (Wang, 2022), and private-public development of proprietary assets (Kox, 2023). It is beyond the scope of this paper to present either a detailed theory analysis or comprehensive empirical review and these would be redundant given the well-established literature in any case. Instead, our goal is to provide sufficient detail so as to appreciate the contributions of Bergstrand and Egger (2007, 2010, 2013) and highlight our points regarding potentially fruitful avenues for further development. Further, in our discussion below, we will sidestep some of the more complicating (if rich) assumptions in the various versions of the baseline KK model.

The KK model was deliberately designed to be close to the traditional two country, two good, two factor Heckscher-Ohlin model, and indeed reduces to that if multinationals are not allowed. In particular, this approach was used because it places this unified model as close as possible to the horizontal MNE-only model of Markusen (1984) and the vertical MNE-only model of Helpman (1984). In this setup, there are two countries and two immobile factors of production, skilled and unskilled labor. These factors are used in two sectors, X and Y. Y is the numeraire sector and is characterized by constant returns to scale, zero trade costs, and perfect competition. Further, it is often assumed to use unskilled labor exclusively, an assumption which then fixes the unskilled wage rate.

In contrast, the X sector – the one in which MNEs may arise – is one of increasing returns

and differentiated products. This increasing returns is the result of fixed costs at both the firm (headquarters) and plant levels. In particular, the firm fixed costs reflect the creation of knowledge-based proprietary assets and are presumed to be produced using only skilled labor, making firm fixed costs the most skill intensive activity in the model. Their importance thus motivates the name "Knowledge Capital". As in the Markusen (1984) approach, these are presumed to be geographically separable from production, non-rivalrous in the firm, and excludable outside of the firm. Note that the first of these implies that, although skilled labor is internationally immobile, the propriety asset it creates is not. Given the differentiated products in the sector, imperfect competition characterizes the market (with monopolistic competition a typical assumption). Finally, trade in this differentiated good incurs the traditional iceberg transport cost.

Within the X sector, there exist three possible firm structures.[5] First, national firms (NEs) have their headquarters and a single plant in the same country. These firms may then sell their good in the other country via exports. Vertical multinationals (VMNEs) likewise have a single plant, however, their headquarters and plant are in different countries. They then serve their home country via trade. Thus, as in the Helpman (1984) model, vertical FDI and intra-firm trade are complements. Finally, horizontal MNEs (HMNEs) have their headquarters in only their home country but have two plants, one in each of the two countries. In contrast to the NE and VMNE structures, HMNEs do not trade since the purpose of opening the second plant is to serve those local customers without incurring trade costs. The *raison d'etre* of the KK model is that the types of firms which (co)exist in equilibrium can be traced back to fundamentals of the model. In particular, the focus has been on relative endowments, relative sizes, and trade costs.

Although we point the reader to the above cited work for proofs and details, the main predictions and intuitions are as follows. First, as predicted by the proximity-concentration tradeoff, if trade costs are high relative to plant fixed costs, then HMNEs will tend to emerge in order to produce for local sales. This outcome, has three important features to it. First, FDI will tend to flow in both directions – meaning that both countries will be home and host for FDI –

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5 Note that export platform FDI, where a single plant in one host country is used to serve consumers in the other non-home country, is generally ignored as a possibility. Ekholm, Forslid, and Markusen (2007) provide a thorough theoretical treatment of export platform investment with Blonigen, Davies, Waddell, and Naughton (2008) providing supporting empirical evidence.

since trade costs are presumed comparable in both directions (something which can certainly be relaxed, particularly if there are policy-induced trade barriers). This matches the empirical evidence which shows that the largest hosts of FDI are also the largest sources of it. Second, HMNEs will be most prevalent between countries with similar relative endowments. This is because HMNEs replicate production processes across countries, something that makes the most economic sense when factor prices are comparable across locations. Third, HMNEs will be most common between countries of similar size. If the sizes are highly unbalanced, then the smaller country may not have the resources needed to support the demand for plant level fixed costs.

Conversely, vertical FDI will tend to arise when relative factor endowments differ. In this setting, VMNEs take advantage of the low price of skilled workers in one country and the low price of unskilled workers in the other. This, combined with the assumption on the skill intensity of headquarter services, results in vertical MNEs headquartered in the skill-abundant country who produce output in the unskilled-abundant country. Implicitly, the services of the knowledge asset are exported from the skill-abundant country to the unskilled-abundant country and output of X flows in the other direction. Vertical multinationals are also encouraged by low trade costs since this allows them to gain the most from exporting their output from their host to their home country.

Thus, the complementarity or substitutability of trade and investment depends on the type of MNE that occurs in equilibrium which itself will depend on relative factor endowments (and prices). Furthermore, the extent to which HMNEs crowd out NEs and thus trade will depend on the relative size of countries. In fact, when countries are of similar size, the returns to scale of HMNEs will fully crowd out NEs in equilibrium.[6] Although we think it fair to say that results using foreign-affiliate sales as the measure of FDI generally support the KK model's predictions on where horizontal or vertical FDI will be the predominant type of MNE, this latter result is in

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[6] This does not mean that HMNEs and NEs can never coexist in the canonical KK model. For example, if the two countries have the same relative endowments but differ greatly in size, then the limited resources in the small country make fixed costs expensive there. As such, some firms will choose to be NEs in the large country to serve its larger demand even as a handful of HMNEs are headquartered there and serve both markets locally. The smaller country, meanwhile, will have only HMNEs.

clear contradiction of the data.[7] This conundrum can additionally be seen in the fact that bilateral trade and FDI are positively correlated even between similar countries. In contrast, the KK model predicts either horizontal FDI and no trade when trade costs are high or trade and no FDI when they are low, a result reminiscent of Mundell (1957). Therefore, although the baseline KK model may be useful at describing FDI, it requires more to describe the overall industrial structure.

In the next section, we discuss how this issue was resolved by a series of contributions by Bergstrand and Egger (2007, 2010, 2013).

4. One Factor Fixes Two Problems

In contrast to the above-described two-country, two-factor, two-sector baseline version of the KK model (hereafter referred to as the 2KK model), Bergstrand and Egger (2007, 2010, 2013) made two departures by adding a third factor of production and a third country (hence our referring to their expanded version as the 3KK model). Other than this difference, the two models share many key features. First, the numeraire sector again uses only unskilled labor under constant returns to scale and perfect competition which fixes this factors price. Second, NEs, HMNEs, and VMNEs have firm fixed costs, plant fixed costs, and variable production costs. While production technologies are again the same for all three firm structures (and use all three factors), the fixed costs differ as described above according to where the headquarters and plant(s) are located. The main point of departure is instead how these fixed costs utilize the factors of production.

In both models, firm fixed costs requires only skilled labor from a firm's home country. Although skilled labor remains internationally immobile, its services are a joint input which can be used in the overseas affiliate. Plant fixed costs, however, are quite different. In the 2KK model, plants are constructed using both skilled labor and unskilled labor.[8] In the 3KK model,

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7 Antrás and Yeaple (2014), Davies (2008), Blonigen, Davies, and Head (2003), Markusen (2002) and Carr, Markusen and Maskus (2001) all provide evidence that is generally in line with the main predictions of the baseline KK model.

8 Note that here, skilled labor is rivalrous, i.e. it cannot be used both for one plant's construction and another activity.

plants are created using physical capital.[9] In contrast to skilled and unskilled labor, capital is internationally mobile. However, by assumption, a country's outflowing capital is used only in constructing the plants it owns in the host(s). An alternative assumption would be to assume that a country's overseas plants are constructed using an input produced at domestically and exported at no cost, a point made in Bergstrand and Egger (2013). In this light, we see that this assumption makes capital's use in plant fixed costs similar to skilled labor's use in firm fixed costs. For the moment, we simply wish to highlight that this implies that capital markets are segmented from one another. Although this difference in which factor is used in plant construction may seem slight, it has profound implications for factor markets when FDI is allowed to take place.

Both models are in agreement that HMNEs and VMNEs will not, as a rule, coexist for the reasons outlined above. Where they differ is that, between two similarly endowed countries, the 3KK model will predict the existence of both HMNEs and NEs (and thus the coexistence of bilateral trade and FDI). The difference is due to how the emergence of HMNEs affects factor prices and therefore the number of NEs. To see this, consider a situation with similarly endowed countries and trade costs but where horizontal FDI is initially not permitted. In the 2KK model, when the first HMNE is permitted, this increases demand for skilled labor in the home country. Since unskilled wages are fixed, this unambiguously increases the cost for NE firms. As such, due to the scale economies of a HMNE over a NE, this encourages more NEs to switch to HMNE status, a process that continues until they NEs are crowded out. Further, with symmetric countries, this happens in both nations.[10] Thus, since HMNEs do not export, trade evaporates as FDI increases.

In the 3KK model, however, there is an important difference. When the first HMNE is permitted, this increases demand for capital, not skilled labor. As the demand for capital rises, this again forces a NE firm out of the market. However, now that exiting firm also releases skilled labor which the HMNE does not require. This then places downward pressure on skilled

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9 This can be extended to also use skilled labor, but so long as the skilled intensity of firm and plant fixed costs differ the same results emerge.

10 This is where the potential coexistence of HMNEs and NEs when countries differ significantly in size becomes clear. With a small overseas market, in the larger country, competitive pressures increase as more of its firms jump the trade barrier wall. This then reduces the desire for proximity which, when asymmetric market sizes are sufficiently large, can halt the desire for NEs to switch to HMNEs.

wages even as the rate of return on capital increases. Since NE firms are skill-intensive relative to the capital-hungry HMNEs, this creates a release valve that ensures that some NEs remain even as HMNEs come to dominate the equilibrium.

This difference also underpins the second major contribution of the 3KK model – the positive correlation between FDI and trade flows in the differentiated goods sector. Here is where the third country comes into play. In comparison to the third country, with three factors, it is possible for both the remaining countries to be relatively skilled labor and/or capital abundant. As the differentiated sector is intensive in both factors compared to the numeraire, this allows a situation in which they both specialize in production of the differentiated sector. Then, by virtue of the CES preferences and love for variety, the amount of trade will be greatest between them even as HMNE takes place primarily between those countries. Although the versions presented across their 2007, 2010, and 2013 contributions vary somewhat, all of Bergstrand and Egger's 3KK models provide similar results in this regard, enabling them to develop a gravity-type specification for FDI which mirrors that for trade.

5. Measuring Capital(s)

By introducing a third factor, Bergstrand and Egger were able to resolve two of problematic implications of the early version of the knowledge capital model. Clearly, whether that third factor is called capital – physical capital to use their precise terminology – or something else is not important for its implications for the theory. Why then use the term capital and what does this mean for estimation? We explore these issues in this section.

5.1 Capital in the Theory

The most obvious answer is that this choice reflects the intellectual history of multi-factor international trade theory. To our knowledge, every trade textbook begins its discussion of the the Hecksher-Ohlin model by naming the two factors capital and labor. Further, given that perhaps the most lauded attempt to resolve the Leontief (1953) Paradox is to consider both skilled and unskilled labor (see Brecher and Choudhri, 1982), it should perhaps be no surprise that the 3KK models use capital, skilled labor, and unskilled labor. If, however, we are going to focus on capital as the third factor, a critical issue for both empirical work and calibration efforts is how to measure it.

When initially explaining the idea of capital to neophyte economists, two differing concepts are offered. The first is to refer to the tangible, directly productive assets of a firm. As illustrative examples, economists often point to equipment, machinery, buildings, and the like. In the data, these are commonly rolled up into the abbreviation "PPE", that is, property, plant, and equipment. Indeed, as noted above, many measures of FDI focus on PPE. The second notion of capital is a monetary one, i.e. available funds that can be used to purchase inputs. This notion harkens back to the capital flow interpretation of FDI, albeit one with control remaining of central importance.

What then is the difference between these two meanings and what might that mean for efforts to link the 3KK model to the data? Our assertion is that the main difference is one of timing. When purchasing inputs to use in creating revenue-raising profits, there is an outflow of cash (buying inputs) and an inflow of cash (selling outputs). In a static model, these happen simultaneously, so that in essence the payment for inputs is funded by the selling of outputs.

In reality, there is a lag between buying inputs and selling outputs. This means that a firm must first raise monetary capital, either via retained earnings (unless it is a new startup), equity investment, and/or debt.[11] Then it is able to purchase inputs, produce outputs, and pay off whatever liabilities it initially incurred. After this, if there is money left over, this can be distributed to shareholders as dividends or reinvested into the firm, starting the process again. Since it seems reasonable that there is a longer time difference between when PPE is purchased – i.e. property obtained, a plant constructed, and equipment installed – and output is sold than between when workers are hired and sales begin, this is potentially why physical and monetary capital are often amalgamated into a single term "capital".

In a static model, none of this really matters as there is no time dimension. In practice, however, there are two issues where the distinction between physical and monetary capital matters in relation to the KK model. The first is with regards to factor specificity. In both the 2KK and 3KK models, only home skilled labor is used in firm fixed costs. Likewise, in the 3KK model, plant fixed costs require only home capital. Thus, there is imperfect substitutability in

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11 In the accounting literature, equity plus retained earnings is known as stockholder or shareholder equity and these plus borrowing equals total capital (or total capital employed). In order to maintain the distinction between this total capital and PPE, we will maintain the designations monetary and physical capital respectively.

plant construction across capital arising from different countries. This is difficult to reconcile with the some components of PPE (especially property) and perhaps even more so when thinking about fungible monetary capital. The second, and more obvious, way in which the distinction between physical and monetary capital matters is when translating from theory to empirics (or back again when using data to calibrate a model) since PPE, equity, debt, and retained earnings are all distinct variables in the data.

5.2 Capital in the Data

With the above issues in mind, we now turn to data on US outbound FDI (the foreign affiliates of US-owned MNEs) from the Bureau of Economic Analysis.[12] Disappointingly, some of the data we wish to use were no longer collected after 2008. However, since the points that we wish to make are unlikely to have evaporated since then, rather than create confusion by moving across time periods, we simply focus on the period for which the data are available. Furthermore, in our discussion, we focus just on US outbound investment via majority-owned non-bank affiliates.

5.2.1 Proxies for Capital

To begin with, Figure 1 plots three measures of "capital" in the foreign affiliates of US MNEs. The first is net PPE, i.e. the value of property, plants, and equipment in the US foreign affiliates. This then is closest to the idea of physical capital that can be created from the available data. The second is monetary capital calculated as the sum retained earnings and total external financing which itself is comprised of parent equity, other US funding (including borrowing), host funding (including both local equity and borrowing), third country funding (which again includes both borrowing and equity).[13] The third measure of capital is total assets which, in addition to PPE includes intangible assets, cash, inventories, receivables (including lending to others), and equity investments. From this, three differences are observed.
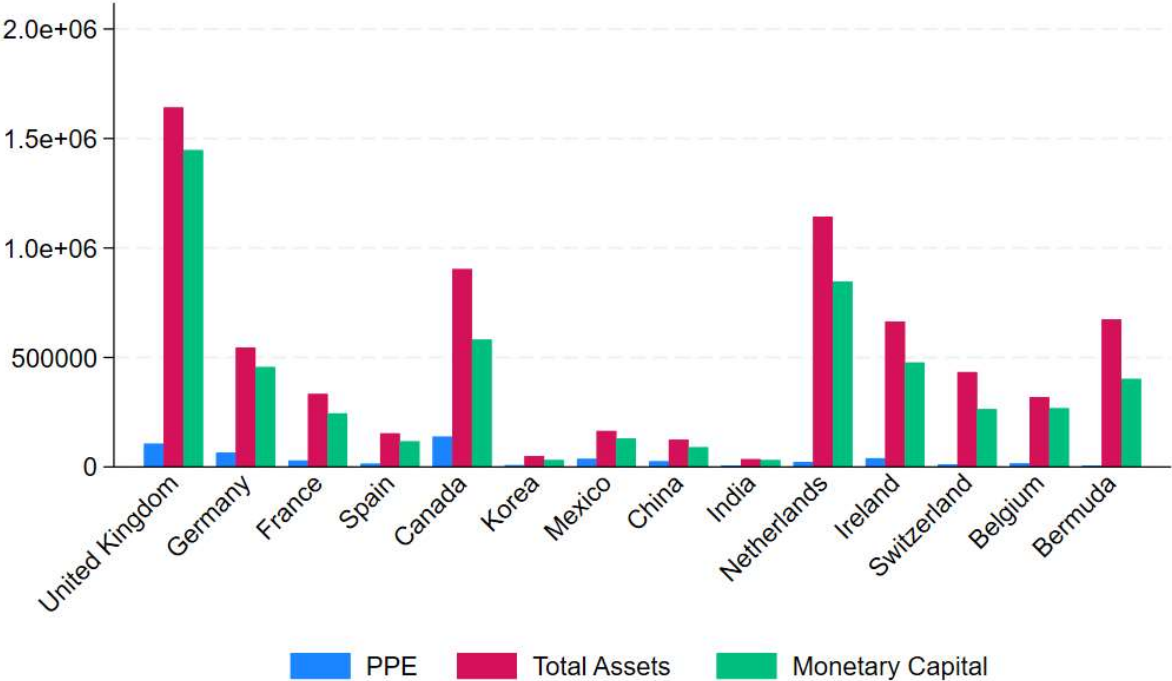

Figure 1: Capital Measures
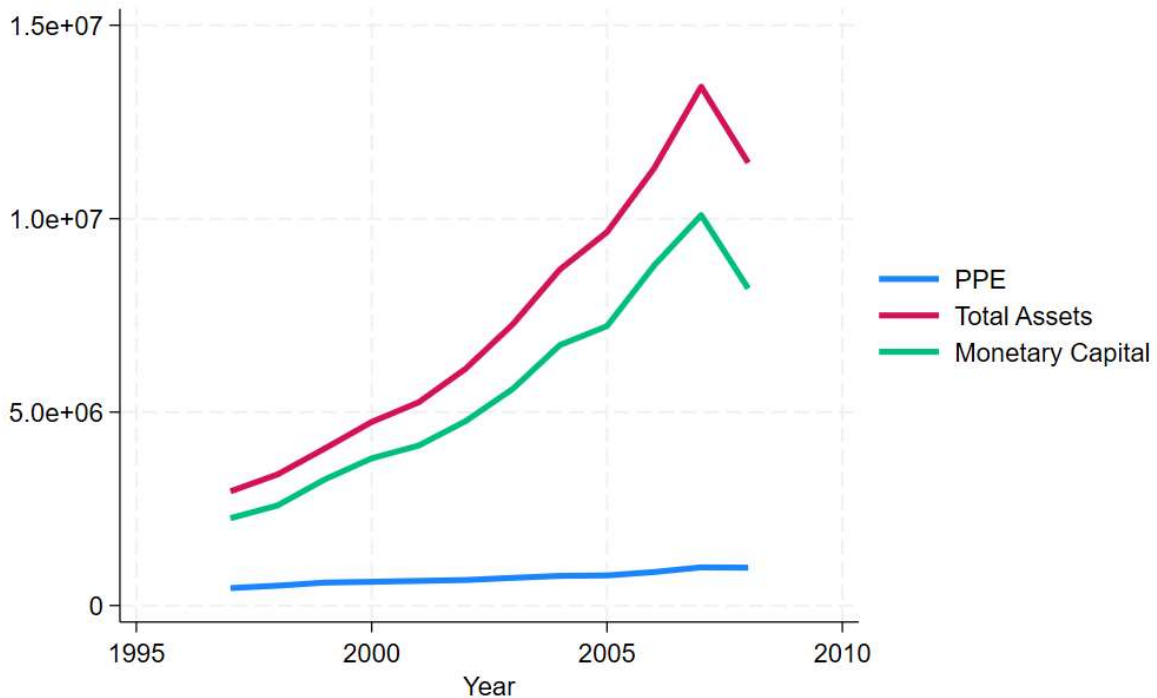
Notes: Capital measures in nominal millions of US dollars and represent the data for the foreign affiliates of US-owned MNEs.

First, as is clearly seen, PPE is much smaller when compared to the other two measures. In particular, this points to the importance of intangible assets which appear in total assets but not PPE. A second important factor included in total assets but not PPE is lending – including that to the parent. As is well established intra-firm debt is one method used by MNEs to shift profits to tax havens (see Egger, et al., 2010). The difference between total assets and monetary

capital, meanwhile, is much smaller. Second, there has been massive growth in total assets and monetary capital which has not been reflected in PPE. Again, this may be the result of the documented increases in profit shifting via intellectual property and intra-firm debt (see Tørsløv, Weir, and Zucman, 2023). Third, both total assets and monetary capital experienced a sharp decline following the global economic crisis of 2007-2008. PPE meanwhile holds nearly constant. Thus, PPE is likely to be far less volatile.

These differences make it very clear that how one chooses to measures capital will greatly influence the conclusions one draws from it. When using monetary capital and/or total assets, it will appear that MNEs are potentially becoming more capital-hungry over time while PPE might suggest a fairly stable intensity. Similarly, when using PPE, the capital use by MNEs may look quite resilient to shocks; not so when using the other measures. All of these issues will thus influence the calibration exercises of the 3KK model (and other models as well).

Figure 2: Capital Types by Host (2008)

In Figure 2, we focus just on the data for 2008, but break the global total down by country to consider some major hosts for US FDI. The most immediate lesson from this approach is the differing levels of capital in the different countries. In particular, the UK is the largest host by some margin, a somewhat unexpected finding. More interesting still is that other major hosts such as Germany, France, and Canda are matched or superseded by the tax haven countries on the right-hand side of the graph. The size of the tax haven investment then suggests why the UK may be so dominant. The work of van't Reit and Lajour (2018) finds that the UK is the world's major hub for treaty shopping, a practice in which conduit countries are used in order to mitigate taxes via a sequence of treaties. If a US firm initially invests in the UK in order to use that affiliate to invest elsewhere, including France or Germany, this would appear capital in the UK but not France or Germany (as only direct ownership is available). Thus, the high UK number may indicate significant tax motivated investment.

Figure 3: PPE and Monetary Capital Relative to Total Assets by Host (2008)
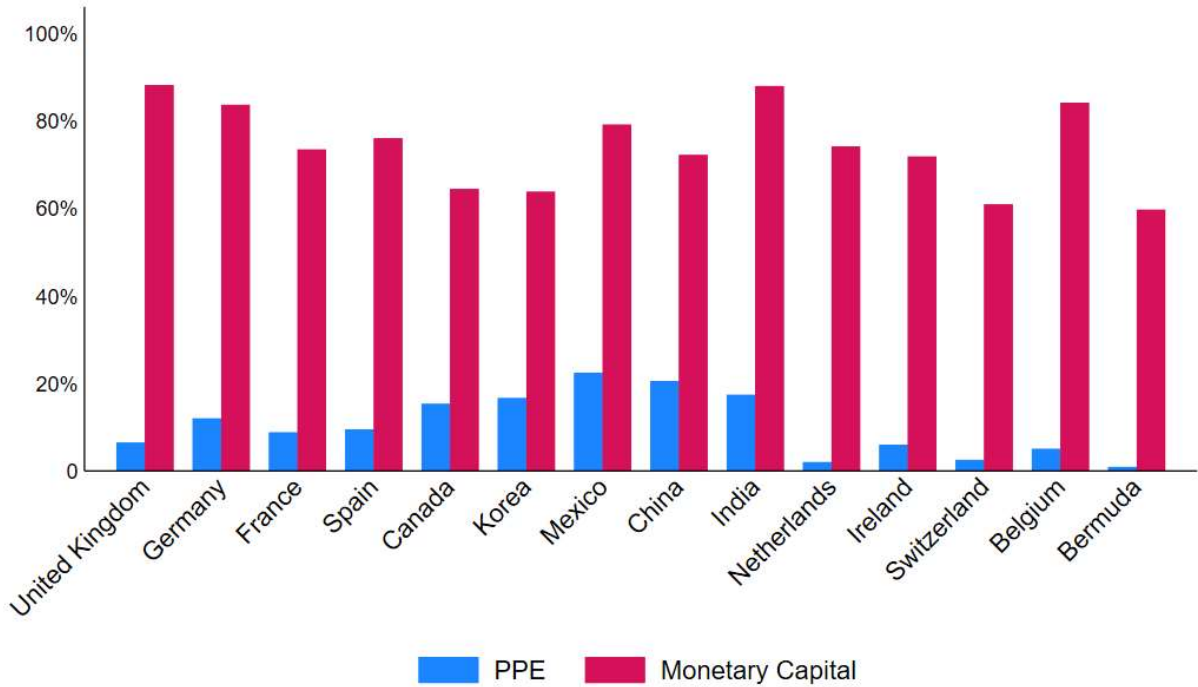
The second lesson from the cross-country comparison is more easily seen in Figure 3 where the foreign affiliates' PPE and monetary capital are normalized by total assets. This shows significant cross-country variation in the relative size of the capital measures. The PPE to total asset ratio is highest in relatively unskilled-labor intensive countries, namely Mexico, India, and China.[14] This suggests that the activity there may be fairly physical-capital intensive. An implication of this is that there may be a need for more than one differentiated goods sector in the KK models to allow for differing degrees of capital intensity. Conversely, the ratio of PPE to total assets is lowest in the tax havens (and to a lesser extent, the UK). If funds are routed through these not for production there but for production in a third country, such a pattern would be expected to emerge. The ratio of monetary capital to total assets also varies significantly across countries. Thus, the choice of capital measure is likely to give a very different picture

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14 By virtue of their relative unskilled labor abundance, this would suggest that these three countries tend to host vertical FDI. This does not, however, mean that they do not sell locally. In fact, the BEA data indicates that Chinese affiliate sales are primarily to Chinese consumers with only 10% of sales destined for the US (approximately the global average for US MNEs abroad). This highlights a common misunderstanding of vertical FDI: that it exports *all* of its affiliate output. Instead, VMNEs serve both home *and* host consumers from the host affiliate whereas a pure HMNE serves only host consumers from its affiliate. Thus, the issue is not how much vertical affiliates export but more about how little horizontal ones do.

depending on which of the countries are used in a calibration exercise. Further, it suggests that there may be a need to consider a model in which capital is routed through conduit countries for tax purposes.

5.2.2 Sources of Capital

In addition to what measure of capital to use, as noted above, the 3KK models make assumptions on the source of capital, namely, that it arises from the home country (for plant fixed costs) or the host (for production). To explore this, we decompose monetary capital according to its five sources: retained earnings, equity the US parent, other US sources, the host country, and third, non-host countries.[15]

We begin in Figure 4 by showing the share of monetary capital attributed to each of these. This shows that the majority of monetary capital in the foreign affiliate does not come from the US. Instead, debt and equity generated in the host is the major source of investment by some margin. What is equally interesting is how much funding comes from third countries, the share which is rising and surpasses the US share by 2002. This points to a much richer capital market than what is found in the 3KK model and suggests that there may be a need to expand it to include a global capital market.

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15 The BEA does not distinguish between debt and equity for many of these which is perhaps just as well as parent firms are often net debtors to their affiliates, particularly when intra-firm debt is used to avoid tax. Indeed, as discussed in Aykut, Sanghi, and Kosmidou (2017), such "roundtripping" FDI is a non-negligible amount of total investment.

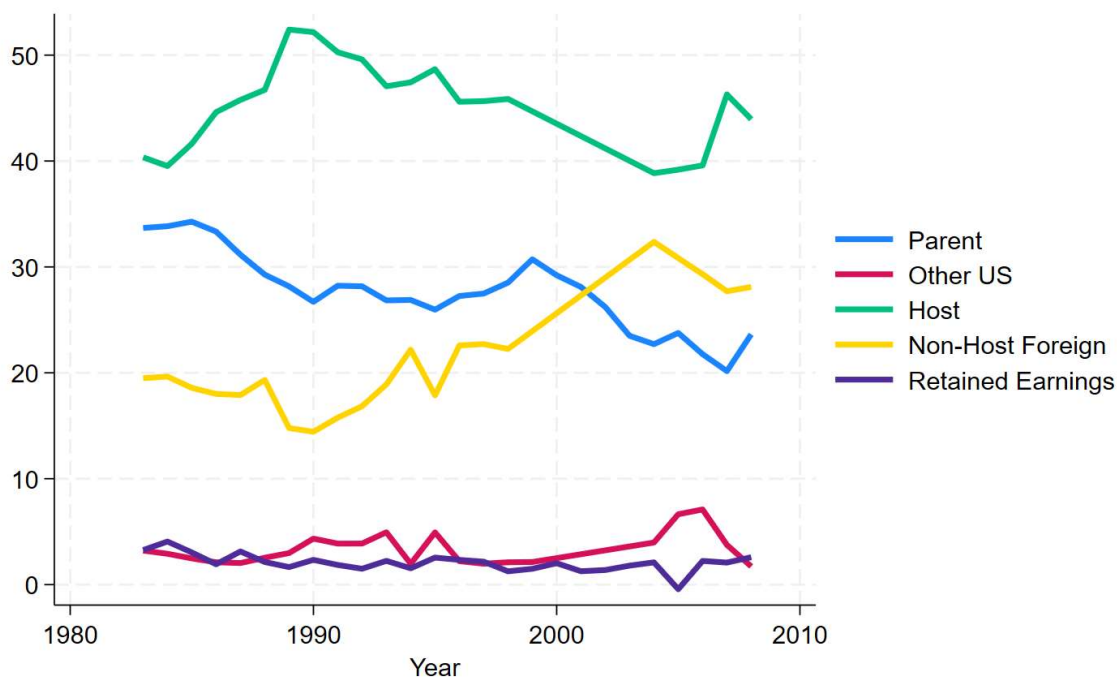**Figure 4: Composition of Monetary Capital**

Figure 4 also begs the question of why host-generated funds are so large in comparison to those coming from the US. The 3KK model would suggest that those funds are used solely in the production process. Although this might be reasonable in capital-intensive industries (again pointing to the potential biases when using PPE), Figures 1 to 3 make it clear that host monetary capital vastly outstrips PPE, suggesting something more than use in production alone. Going further, it is not difficult to imagine other reasons why host capital may be an imperfect substitute for home capital including expropriation/exchange rate risk, capital controls, and the functioning of financial markets. Further, based on the above results, one suspects tax may be an issue as well.

To delve deeper, in Figure 5, we illustrate the relative shares of these five sources across geographic regions using the data from 2008. From this, we see an overall negative correlation between the level of development and the share of funds coming from the US. This could suggest weak host financial markets (necessitating US funds) and/or risk (yielding a preference

to use local funds). That said, there does not appear to be a comparable negative correlation between development and the share coming from the host, suggesting that the financial market effect may be dominant. Excepting Africa (where the overall investment levels are small), there also seems to be a positive relationship between development and third country funding. Since the 3KK model predicts the most investment between large, wealthy countries, this again suggests that in order to mirror the bulk of global investment, there is a need to extend the model in the direction of a more complex, global capital market.

Figure 5: Composition of Monetary Capital by Region (2008)
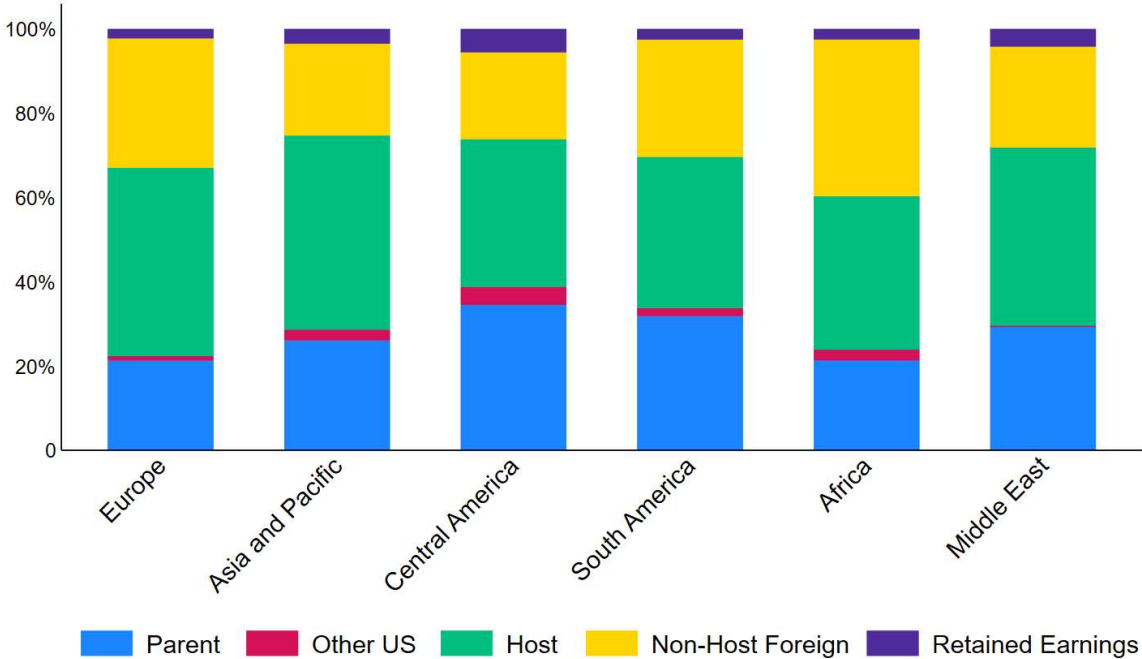
As a final exercise, in Figure 6 we repeat this for select major hosts of US investment. Again, we see significant variation, including the above-mentioned difference between advanced and developing economies. The other feature this approach reveals is a difference between the tax havens and other countries. As can be seen, the tax havens receive a significantly greater share of their monetary capital from third countries. In addition, many of them tend towards a higher share for retained earnings. In particular, given that in 2008 the US did not tax foreign

earned income until it was repatriated to the US, these patterns may indicate the use of tax haven affiliates as stores of wealth for tax purposes. Were the data available through 2020, it might be possible to test this following the reforms in the 2017 Tax Cuts and Jobs Act. In any case, it again suggests that there may be a role for taxes in future developments of the 3KK models.

Figure 6: Composition of Monetary Capital by Country (2008)
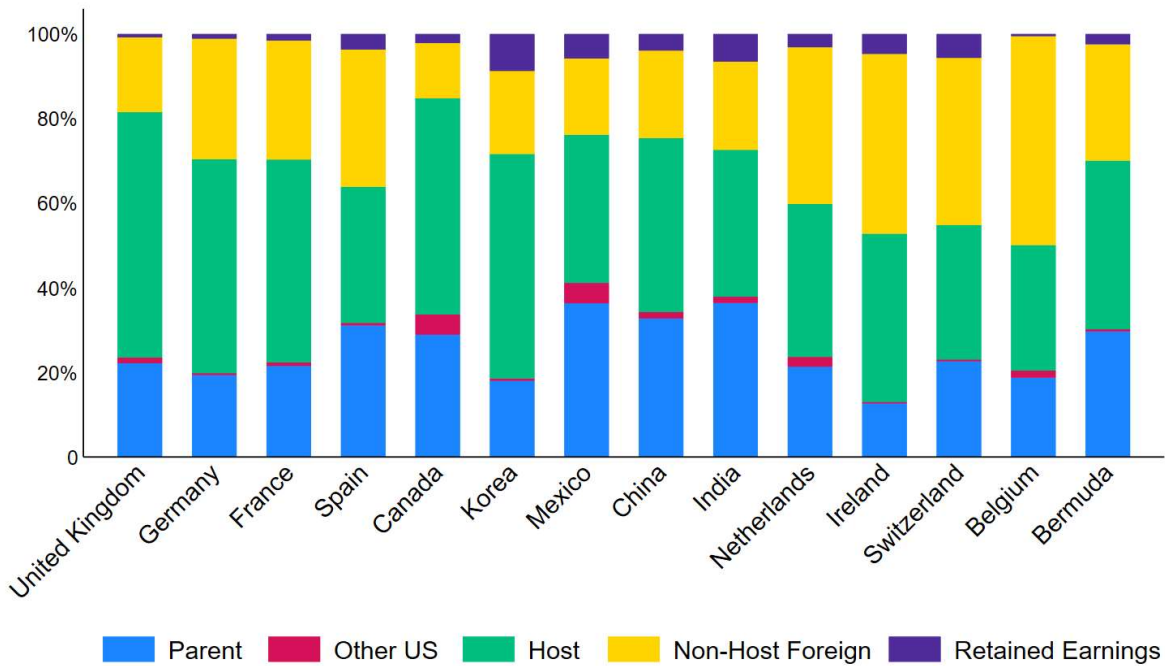
7. Conclusions and Suggestions for Future Research

From its (inaccurate) origins as an offshoot of capital flows through the recognition that multinationals take on a variety of forms, the literature on foreign direct investment has grown into a complex – and often contradictory – set of results and stylized facts. This has led to efforts to integrate the various rationales for why some firms become multinationals and what they actually do when they invest across borders. While the KK model and its extensions have provided a number of insights that have largely been bourn out by the data, there are a number of ways in which the KK model can be further extended to provide greater insights. While this is not to diminish the contributions of Kox (2023), Wang (2022), Antràs and Yeaple, (2014), and

many others, before concluding we wish to point out some of the potential gaps highlighted above.

First, the above analysis suggests the need for a much richer modelling of capital than what currently exists. This model should include an at least partially integrated global capital market. Following this first step, the results regarding tax havens points to the need for careful consideration of how "paper assets" may be influenced by tax policy and what this means for their international allocation relative to "real assets" and the available data. Similarly, our simple analysis of the data suggests that there may be important lessons to be learned from modelling financial frictions in local capital markets (or potentially moving towards an intertemporal model with capital accumulation). In doing so, it is important to keep in mind how the measure of capital – PPE, monetary, or something else – will likely introduce biases when the intensity of MNEs' industries varies across these (e.g. manufacturing versus services).

Second, although not our focus here, the KK models make it very clear that trade and FDI are intertwined in complex ways depending on the nature of MNEs in operation. Further, Bergstrand and Egger (2007) show that at a bilateral level this interaction is influenced by the characteristics of third countries. Together, these point to two potentially fruitful areas. First, since vertical FDI suggests intra-firm trade, there is a need for data separating intra-firm trade from inter-firm trade. While such data are occasionally accessible (see e.g. Clausing (2003) or Davies, et al. (2018)), these are exceptions and we hope that more such information becomes available. Within this is a need for better data on trade in intangible assets, particularly among affiliates within the same MNE group. While a body of work has grown around R&D and patents, the international business literature emphasizes that the concept of services of intangibles is much broader than just intellectual property. These services include management, marketing, finance, software and other systems, brand value, trained workforces and customer lists. The problem of course, is that these are very difficult to measure, largely escaping formal statistics. This then demands creative attempts to estimate intangible capital more broadly, with Chen, Los and Timmer (2018) and Ayyagari, Demirguc-Kunt and Maksimovic (2019) serving as inspirational examples.

Third, setting data availability aside, it is clear from the models that firms make interdependent decisions about producing abroad and importing/exporting. It is natural then to

look for an empirical specification that simultaneously estimates trade in finished goods, trade in intermediate inputs, and affiliate sales to the host market. There are a number of papers that analyze the relationship between the two, such as Bergstrand and Egger (2010), which make good progress. However, this work provides gravity equations that are estimated separately rather than in a unified specification. In particular, this approach should be able to better explain the concentration of FDI and trade among the high-income countries at the bilateral level, including identifying those factors which affect one, the other, or both.

Finally, although the KK models can provide a rationale for horizontal or vertical FDI to emerge, they still do not provide a convincing setting in which both happen simultaneously. As discussed in Davies and Markusen (2021a, 2021b), even in developing countries a significant share of affiliate sales are local, more than what might be expected. Further, anecdotal evidence suggests that intra-firm trade of intermediates is significant even when output is intended for local sales. This suggests that horizontal and vertical motivations co-exist, and quite likely do so even in the same firm. What advantages a model that incorporates both of those has yet to be seen, but since the horizontal/vertical distinction rests on international wage differences and trade costs, we suspect that such a model would yield significant insights into how policy restructures a MNE even if the measured amount of FDI does not change and that this restructuring may have significant factor market impacts.

In summary, the economist's understanding of why FDI takes place has come a very long way and developed into a large and meaningful area of study. This evolution has been helped along the way by a continuing back and forth between theory and empirics. The purpose of this paper has been to provide some insights into how and why this evolution of our thinking on FDI has developed into the Knowledge Capital model and its offshoots. In particular, we have sought to show some of the pitfalls and difficulties that matching these models to the data can cause. Nevertheless, we believe that the Knowledge Capital model is a useful framework for understanding the complicated, chimeric phenomenon of FDI and hope that our discussion sparks continued innovative research.

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