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# Why trucks jump: Offshoring and product characteristics ☆

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ABSTRACT

In this paper, we study the role of vertical product differentiation in the decision to allocate production between domestic and foreign plants. To do so, we examine the first wave of light-truck offshoring to Mexico that occurred due to substantially lower post-NAFTA trade barriers and a coincident increase in US demand for light trucks. In contrast to the typical assumption, but similar to many other industries, the need for additional capacity was accommodated by investment in both the US and Mexico for the same models of light trucks. Using a new dataset that details the extent of offshoring and domestic production within models, we document sharp differences in how capacity was utilized. Specifically, within models, we find that automakers offshored varieties which tend to be older in design vintage, lower scale, and less complex to produce. In contrast, we find that varieties "inshored" to newer capacity in the US exhibit the opposite characteristics. This highlights the important role of vertical differentiation and the associated variation in production complexity for the sorting of production across borders. A product with a large degree of vertical differentiation may provide scope for a firm to maximize profits by "inshoring" the more complex varieties while offshoring the less complex versions.


## 1. Introduction

It is well-known that multinationals are big, productive, and by definition operate multiple plants within and across multiple locations. However, a fact often lost in the multi-plant nature of multinationals is that many firms produce the same basic product across locations with very different production characteristics. Moreover, these plants serve the same markets.[1] For example, the Fender guitar company produces the "Stratocaster" – a very specific style of electric guitar – in California and Mexico. Whirlpool produces refrigerators in Arkansas (until recently), Iowa, and Mexico. Indeed, this behavior extends beyond manufacturing trade, where some tele-radiology firms headquartered in the US own assets in Sydney, Barcelona, Tel Aviv, and Bangalore to perform radiological services for US hospitals (Levy and Goelman, 2005). What causes a firm to source a very similar product across multiple plants, and once these plants are operational, how do multinationals allocate output across these plants?

A natural industry in which to study these decisions is the US automobile industry. Like the industries described above, it is characterized by large multinationals that source many models of products across a number of plants globally. However, in terms of sheer scale few sectors match the US automotive industry, comprising a large share of overall trade (Hellerstein and Villas-Boas, 2010) and in some cases, driving a large share of trade growth following trade agreements.[2] Furthermore, due to comprehensive registration requirements, excellent data exists to study the production sourcing decisions of these firms, and in particular, the location of final assembly. In this paper, we focus on the offshoring decisions of light-duty trucks within this industry over the period 1990–2000. In particular, we present new facts for large multi-plant firms, and study how these firms allocate the final assembly of light-duty trucks across similarly capable plants based in very different locations.

What does theory suggest should drive the sourcing decisions of multinationals? Theory tends to emphasize production characteristics such as factor intensity as determinants of the location of production. Following this logic, to serve US and Canadian consumers, it may be

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[1] This feature distinguishes these investments from platform FDI which can have a horizontal dimension.

[2] For example, after NAFTA, the US auto industry was responsible for 25% overall trade growth (Hufbauer and Schott, 2005).

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optimal to build complex, high-tech products within the US–Canadian market, where capital and automation are relatively cheap, and low-quality, low-tech, and standardized varieties in Mexico where unskilled production labor is relatively cheap (Vernon, 1966; Feenstra and Hanson, 1997; Antràs, 2005; Keller and Yeaple, 2012).[3] On the other hand, if consumers in Mexico demand the same low-quality products (as in Verhoogen, 2008; Fajgelbaum et al., 2011) that are optimal to produce in Mexico for factor endowment reasons, then it is an empirical question as to whether any sorting of production across borders is due to local demand or relative factor endowments.

To study this issue, we use an extremely detailed dataset of light truck sales in the US and Canada, along with supplementary (though more aggregate) information on sales in Mexico. Studying the final assembly of light-duty trucks, which includes SUVs, pick-ups, and vans, has a number of advantages. First, final assembly represents a common point in the value-chain within and across firms, where a mix of workers and machines assembles large primary inputs, but potentially also adds a wide variety of other options to complete the finished product. Second, it is notable that the pre-NAFTA trade barriers were effectively prohibitive, so their removal provides scope for greatly expanded trade in light trucks. However, this is only part of the story. A rapid expansion of demand for light trucks – demand doubled in the US in the 1990s – provided a need for additional assembly capacity.[4] The combination of the elimination of trade barriers and a dramatic increase in demand makes low wage Mexico an attractive location for investment in light truck assembly capacity. However, similar to the examples cited above, any light truck model that was offshored post-NAFTA to Mexico was also inshored to new facilities in the US. This suggests that locations with very different labor costs are producing the same product from investments that are made at the same time. Is it possible to rationalize this behavior in terms of the theories developed in the existing literature or does this behavior point to new and unexplored factors?

To begin our analysis, we outline how *scale* and *vertical differentiation* motivate the production of a common light truck model across multiple plants. In terms of scale, as the market naturally grows, additional capacity is warranted. However, it may be easier to expand production at a new location rather than increase capacity at an old one, or spread production over multiple locations to minimize the down-side risk of local production disruptions. In both cases, increased scale of a model optimally leads to more plants tooled specifically for that model. In terms of vertical differentiation, a model with many different varieties should be optimally produced by plants with different characteristics. For example, a newer plant in the US may be more technologically advanced, which facilitates production of more sophisticated or non-standard varieties within a model. On the other hand, a plant in Mexico may be more labor intensive, and a facility at which less-sophisticated varieties are produced. Hence, models with a high degree of vertical differentiation could potentially be sourced across a heterogeneous set of plants. This provides scope for plants in both the US and Mexico to produce nominally the same "model", though the extent of vertical differentiation means that the actual characteristics of the vehicles produced are different.[5]

We find evidence for both predictions, and a particularly pronounced role for vertical differentiation, where within firm–year pairs, models with a greater mix of varieties, and higher scale, tend to be produced across more plants. Furthermore, when a model receives additional plants, it is associated with a reduction in the percentage of total varieties that are produced at the typical plant. Hence, greater differentiation is associated with more plants and more plants are associated with increased specialization at each plant. The question then becomes how plants are utilized conditional on being tooled for a specific model. If the role of vertical differentiation operates as suggested above, then we should see a clear segmentation of varieties within a model across plants as a function of their attributes. Indeed we find this to be the case. Specifically, we find that offshored varieties tend to be of older design vintage, less complex and lower scale. This is true both in comparison to established facilities and also new domestic plants. Within the US, we also find that newer plants tend to receive higher scale, more complex, and newer vintage varieties when compared to older plants. Overall, our results are consistent with the notion that vertical differentiation plays a role in sourcing of varieties across locations. Moreover, the patterns that we document for offshoring are in-line with the role of labor intensity in automobile production (low-scale, low complexity) and the role of product cycles (older design vintage) through the relative abundance of unskilled labor.

To test whether these patterns are related to supply motives for offshoring, or are driven by local demand considerations, we merge an auxiliary dataset of sales in Mexico at the model level and test whether these sorting patterns are more pronounced when Mexican demand is relatively low. If these sorting patterns are more pronounced when demand in Mexico is relatively high, then this suggests that local demand in Mexico is "pulling" the offshore production of varieties for the US that would also be produced in Mexico due to relative factor endowments. In contrast, if these sorting patterns are more pronounced when demand in Mexico is relatively low, this suggests that the supply characteristics of producing in Mexico are the main factor, not local demand for less-sophisticated varieties. Indeed, we find the latter is the case for all characteristics, where the pattern of offshoring is more pronounced when demand in Mexico is a very small share of total demand. Hence, we conclude that the supply characteristics of producing in Mexico are driving the patterns of offshoring, not demand characteristics. Furthermore, we also evaluate various measures of input quality, and show that while it appears physical quality and residual prices are lower for offshored varieties, these are not driving the main results described above.

The results in our paper add a new dimension to the understanding of production allocation decisions of large firms, and in particular, multinational firms. Similar to Hanson, Mataloni and Slaughter (2005), our primary analysis evaluates allocation decisions internationally conditional on the state of production facilities at a given point in time. However, we augment this perspective by emphasizing the role of product characteristics, especially vertical differentiation within a product line and the associated variation in production complexity. If a product is defined at a relatively aggregate level (such as a light truck model), then theory may suggest that highly differentiated products should not be produced in less developed locations due to their complexity. However, this ignores the fact that a product with significant within-; product differentiation can potentially have different quality varieties targeted to different plants, both inshore and offshore. At the finest level of detail, we find that highly complex and/or "new" varieties are in fact unlikely to be produced in Mexico, as theory would suggest.[6] While this makes a more basic (and obvious) point about getting the data "right", and is similar to Schott (2004) and Khandelwal (2010) where specialization occurs within products rather than across products, it makes a deeper point about the economics of production allocation decisions within multinationals. That is, while product differentiation can lead to more complexity, it can also provide

[3] Also see Helpman (1984), Grossman and Rossi-Hansberg (2008), and Baldwin and Robert-Nicoud (2010).

[4] For brevity, the US also includes Canada for the remainder of the paper.

[5] This is in spirit similar to Grossman and Rossi-Hansberg (2008), where given sufficient differentiation in tasks, inputs for a given product will be split by location. Otherwise, production will be located either all offshore or all inshore.

[6] This would suggest that models of vertical specialization such as Hummels et al. (2001) may be capturing trade in low-specialization varieties within industries. In terms of the magnification of trade shocks through this channel, if these different varieties have different elasticities, it is no longer clear how generalizable their results are to industries that are not offshored.