THE ROLE OF OPERATIONAL FLEXIBILITY IN THE EXPANSION OF INTERNATIONAL PRODUCTION NETWORKS

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Volatile factor cost developments urge manufacturing firms to increase production efficiency by building up facilities in multiple countries. Differing from previous work that examines the quality of individual locations for investment, the study evaluates the net present value, the growth option value, and the operational flexibility value of the existing production network to predict the establishment of a new site. The results on a sample of 352 German manufacturing firms suggest that the direction, uncertainty, and diversity of labor cost movements in the extant locations influence the propensity to set up a new production subsidiary. Analyzing the international production network after the expansion shows that the new location increases the value of the network regarding these dimensions. Copyright © 2012 John Wiley & Sons, Ltd.

INTRODUCTION

According to the traditional theories of internationalization (Johanson and Vahlne, 1977; Dunning, 1988), research on international production has mainly centered on the question of whether multinational corporations (MNCs) establish production subsidiaries in foreign markets. Typical motives of expanding production to foreign markets are reducing transaction and transportation costs, adapting products to local tastes, or circumventing trade barriers (Dunning and Lundan, 2008). However, if a foreign direct investment is supposed to increase the efficiency of the entire production system rather than to improve the access to a particular market, the decision maker’s scope widens from the potential target location to the whole set of production locations maintained by the firm. Having established an international production system in several locations, the set of production subsidiaries provides the opportunity to capitalize on developments in certain countries and to exploit interdependencies between multiple locations. This paper seeks to explain the decision to establish a new production subsidiary as a consequence of adverse environmental changes in the locations of the existing production network and to demonstrate that MNCs choose new locations that compensate for these deficiencies.

In the management literature, several studies investigate the effects of prior international investments on the establishment of new foreign subsidiaries. However, they are not specific to production subsidiaries. Chang and Rosenzweig (2001) find that a firm’s competitive advantage and degree of diversification as well as its cultural distance to the host country influence the entry mode of subsequent investments (greenfield vs. joint venture or acquisition). After Davidson (1980), Kogut and Chang (1996) show that MNCs tend
to invest in countries they have entered before. Chang (1995) as well as Delios and Henisz (2003) reveal that experience from other foreign countries increases the probability of further foreign direct investments. Tan and Vertinsky (1996) analyze the timing of subsequent market entries and identify network economies as one of multiple theoretical explanations for the positive influence of prior entries. The authors mention the opportunity to shift production among plants in different locations. However, they do not elaborate this argument and do not provide empirical evidence of network effects between foreign subsidiaries.

In the field of economics, studies on the international location of production activities have a tradition since the work of Adam Smith and David Ricardo. Recent studies stress that MNCs take advantage of factor cost differentials between countries by realizing a cost-minimizing geographic organization of their production (Antràs and Helpman, 2004; Blinder, 2006; Grossman and Rossi-Hansberg, 2008). Equilibrium-based models assume that the factor-cost differentials between countries are permanent. However, international factor cost differentials such as wage rates may change rapidly and would require an ongoing optimization process of relocating production from countries with rising factor costs to countries with falling factor costs. When firms are not fast enough to follow factor cost fluctuations by synchronized investments and divestments, they will struggle to achieve an optimal dispersion of activities in their production networks. Nevertheless, MNCs can exploit the primary advantage of multinational firms over national firms, which is the flexibility to quickly transfer resources, rather than investments, across borders (Kogut, 1983). While there is a rich body of economic studies on the wealth effects of locating investments for production activities abroad (Ben-David, 1996; Arndt, 1998; Feenstra, 1998; Glass and Saggi, 2001; Bernard et al., 2003), economic work on network effects between foreign production subsidiaries is rare, apart from exceptions such as Ernst and Kim (2002).

The theory of real options is a useful tool to study portfolios of diversified investments (Vassolo, Anand, and Folta, 2004). In particular, the view of real options can account for network effects between the elements of an investment portfolio (Anand, Oriani, and Vassolo, 2007). Option-based analyses of international production networks focus on the concept of operational flexibility. Kogut and Kulatilaka (1994) demonstrate by stochastic programming that MNCs benefit from maintaining production sites in two countries when there is uncertainty of exchange rate movements. Optimization models for production planning propose numerical solutions for international production configuration under uncertainty (de Meza and van der Ploeg, 1987; Huchzermeier and Cohen, 1996; Dasu and Li, 1997). Empirical studies support the evidence that MNCs make use of operational flexibility by altering their production configuration according to exchange rate fluctuations (Rangan, 1998), due to labor cost changes (Belderbos and Zou, 2007), or at times of economic crisis (Chung et al., 2010). Another stream of research shows that operational flexibility creates firm value (Allen and Pantzalis, 1996; Tang and Tikoo, 1999; Lee and Makhija, 2009). The goal of this paper is to add to this stream of research by examining the value of operational flexibility as a factor of international expansion decisions. Thereby, we complement prior knowledge on the internationalization of production, which has thus far been dominated by market-related motives of investment.

The remainder of the paper is structured as follows: building on real-options reasoning, the theory section develops a model that incorporates the net present value of the existing production network, its value of the option to expand within the extant locations, and the value of the flexibility to react to local factor cost changes. We hypothesize (a) that international production networks with unsatisfactory value will be complemented by a new location, and (b) that the new location increases the value of the network. The third section describes the empirical research design; the fourth section presents the results. A discussion of the findings, including the limitations of this analysis as well as implications for management and future research, conclude the study.

**THEORETICAL DEVELOPMENT**

**Options to invest in assets vs. options to alter the use of assets**

Real options are the ability, but not the obligation, to take advantage of opportunities that would not have been possible without an earlier investment (Sharp, 1991). There are two types of such
options: the first are incremental, as they provide the firm with the opportunity to undertake profitable follow-up investments; the second originate from the flexibility to make use of investments that are already in place. Trigeorgis (1996: 11, 13) refers to incremental options as ‘options to expand,’ and to flexibility options as ‘options to switch use.’ Regarding foreign direct investment, Kogut and Kulatilaka (1994: 124) use the terms ‘within-country growth options’ and ‘across-country options.’ Adner and Levinthal (2004) recall the analogy of real options and financial options and claim that only options of the first type should be called real options, as only they are options on investment. McGrath, Ferrier, and Mendelow (2004) promote a more liberal understanding of real options and suggest that real options are all opportunities that create value. We follow the latter notion and distinguish options to invest in assets from options to alter the use of assets.

Options to invest in assets refer to flexibility in the dimension of time (McDonald and Siegel, 1986). Under uncertainty, having discretion about the timing of an irreversible investment is valuable (Dixit and Pindyck, 1994). Consequently, firms make small investments with the intention of possibly growing these investments in the future (Myers, 1977). MNCs establish foreign subsidiaries as growth options with limited investments and exercise these options by subsequent investments as uncertainty recedes (Fisch, 2008b). Firms can increase the flexibility of timing by diversifying investment across multiple assets. In a portfolio of growth options, the options may be mutually exclusive, that is, one opportunity will be chosen in favor of others (Anand et al., 2007). A portfolio of competing growth options provides switching options on the difference between the related growth option values (Oriani and Sobrero, 2008).

Options to alter the use of assets refer to flexibility in the dimension of utilization (Kogut, 1983). Under uncertainty, having discretion about the utilization of a real investment is valuable. Firms can increase the flexibility of capacity utilization by diversifying investment across locations in different countries. A portfolio of production subsidiaries provides operational flexibility by the opportunity to shift production capacity from locations with rising input costs to locations with falling input costs (Kogut, 1985). Local input costs can be influenced by exchange rate movements (Kogut and Kulatilaka, 1994; Huchzermeier and Cohen, 1996). MNCs exploit the opportunities of operational flexibility under uncertain macroeconomic conditions by adjusting the inputs of local production (Rangan, 1998) or the headcount of local workforce (Belderbos and Zou, 2007).

Value of an international production network

As multinationality increases the flexibility of firms, international diversification is likely to create option value. Tong and Reuer (2007) stress the benefits of real options provided by a multiplicity of host countries. The value potential of international diversification can be approximated by a firm’s number of host countries (Tallman and Li, 1996; Reuer and Leiblein, 2000). However, the number of host countries does not capture the location quality of the countries concerned. To determine the value of an international production network, we consider it as a portfolio of investments that generate cash flows and provide options to invest in assets as well as options to alter the use of assets.

Vassolo and colleagues (2004) write the value $V$ of a portfolio of $n$ investments as the sum of their net present values $C_i$ plus the sum of their growth option values $G_i$ plus a portfolio effect $PE$:

$$V = \sum_{i=1}^{n} C_i + \sum_{i=1}^{n} G_i + PE. \quad (1)$$

MNCs benefit from arbitrage opportunities presented by the dynamic cost differences of locally sourced inputs that are not priced on world markets, above all labor (Kogut, 1985). By choosing a suitable degree of automation, production can be profitable in high-wage countries as well as in low-wage countries (Mucchielli and Saucier, 1997). We assume that the MNC establishes a manufacturing technology that allows for efficient production at the wage level of location $i$ and that changing the degree of automation is costly. As long as the MNC is committed to the technologies chosen for manufacturing in each location, the net present value $C$ of the international network will depend on the growth of labor costs in its locations.

Manufacturing plants carry the option to expand production by subsequent investments (Trigeorgis, 1996). Such investments can be committed in order to enhance manufacturing extant products or to start manufacturing other products in this...
location, which will increase the operational flexibility potential of the network without entering new locations. Holding back investment to enlarge foreign subsidiaries can pay off in the presence of uncertainty (Fisch, 2008b). On the one hand, the example of Eastern Europe shows that low-wage countries may become high-wage countries within a few years. On the other hand, the example of Western Europe shows that political and economic changes can lead to a reduction of wages. Low labor costs provide the firm with the opportunity to grow, as the firm achieves a greater market share through lower input costs. Uncertain input costs include the chance that the future change in labor costs will be favorable. Therefore, the growth option value $G$ of the international production network depends on the uncertainty of labor costs in its locations.

The portfolio effect $PE$ between diversified investments can be negative due to a sub-additivity property or positive due to a super-additivity property of the growth option values in the portfolio (Vassolo et al., 2004). Sub-additivity results from the interdependence of growth options. When several growth options are mutually exclusive, as they provide access to the same opportunities, the investor holds a portfolio of competing growth options. The value of the single growth options is lower because, ceteris paribus, each option will have a lower probability to be exercised. The investor can choose between these options; the value of the opportunity to switch decreases as the correlation of the underlying assets increases (Anand et al., 2007). This is the case if firms develop alternative technologies for new products (Oriani and Sobrero, 2008). Regarding international production networks, the options to invest in assets are not mutually exclusive, since subsidiaries in different countries provide access to different growth opportunities (Tong et al., 2008). Therefore, the portfolio effect of an international production network will be nonnegative.

A portfolio of real options is super-additive when there are synergies between the related assets. Such synergies originate from commonality of resources, redeployment of existing capabilities to new endeavors, economies of scope, and sharing of experiences (Vassolo et al., 2004). International production networks have an additional source of synergy: MNCs can exploit temporary labor cost differentials by increasing the capacity utilization of plants in countries with falling input costs and decreasing the capacity utilization of plants in countries with rising input costs (Kogut and Kulatilaka, 1994). Due to super-additivity between its locations, the portfolio effect $PE$ of an international production network based on operational flexibility tends to be positive. The value of operational flexibility $F$ depends on the diversity of labor cost developments in its locations. We summarize that the value of an international production network consists of three components: a net present value $C$, a growth option value $G$, and an operational flexibility value $F$, and simplify equation (1) as

$$V = C + G + F.$$  \hfill (2)

While the continuous factors of value—the labor costs in the network’s locations—are mostly exogenous to the actions of an MNC, the MNC can influence the value of the international production network by modifying its structure of locations. In our hypotheses, we propose that firms with a falling network value strive to complement the existing production network by a new location. Furthermore, we propose that firms prefer countries as new locations that improve the direction, uncertainty, and diversity of labor cost movements in the network.

Hypotheses

We assume that a firm has established an international network of production subsidiaries for various reasons, including the access to skilled or cheap labor. The production network is exposed to labor cost developments in various countries, which affect the efficiency of production. Productivity can be influenced by the MNC through technology and training, thus cost-efficient production is also possible in high-wage countries (Mucchielli and Saucier, 1997). However, at an attained level of productivity, increasing labor costs erode the net present value $C$ of the production network. If cost savings in the existing locations do not suffice to recover production efficiency, the MNC is prone to consider different locations as complements and maybe—in the long run—as substitutes for those locations (Belderbos and Zou, 2006). Accordingly, we assume that rising labor costs in the existing locations will encourage MNCs to complement their international production networks by a new affiliate.
Hypothesis 1a: Growth of labor costs in the existing network of production subsidiaries increases the propensity to establish a new production subsidiary.

To achieve efficiency, the MNC will choose a production technology that is suitable for the wage level of the new location. Since educated workers are essential for flexible production networks in which tasks are quickly shifted to other factories (Pull, 2008; Geishecker, Goerg, and Munch, 2010), an appropriate location need not have a low level of labor costs. However, the location should not feature a rising tendency of labor costs, as the goal of network expansion is to decelerate the rise in labor costs of the production network. Regarding the net present value of the production network, we predict that

Hypothesis 1b: The location chosen for a new production subsidiary contributes to reducing the growth of labor costs in the network of production subsidiaries.

Uncertainties in the development of labor costs within an international network of production facilities make the design of cost-minimizing production processes difficult (de Meza and van der Ploeg, 1987). Labor cost volatility leads to an extra discount on the cash flows that are going to be generated by the production sites and decreases the net present value C. However, the locations of the existing network of production subsidiaries may also embody options to expand. The value of such options rises by uncertainty (Amram and Kulatilaka, 1999). At high levels of uncertainty, growth options are extremely valuable (Kester, 1984). Therefore, the positive value effect of labor cost volatility on the growth option value G will exceed the negative effect on the net present value C when labor cost volatility is high. Altogether, uncertain wage developments will urge MNCs to complement their international production network by a new site only at low levels of uncertainty. Under high levels of uncertainty, the future potential of the existing network to grow in locations with favorable environmental conditions will be great enough to compensate for the discount on future cash flows due to uncertainty.

Hypothesis 2a: Uncertainty of labor costs in the existing network of production subsidiaries has an inverted U-shaped influence on the propensity to establish a new production subsidiary.

The inverted U-shaped influence of uncertainty suggests that the volatility of wages in the existing network is not an unambiguous factor of network expansion. MNCs that consider expanding their international production networks will, again, have to weigh the net present value effect against the growth option value effect of expansion. MNCs benefit from stable conditions in their production locations and may, therefore, prefer locations with constant labor costs. However, as uncertainty includes future events that are better than expected, uncertainty may also attract foreign direct investment (Fisch, 2008a). The upside potential of investment rises with uncertainty (Amram and Kulatilaka, 1999). To cope with the downside potential of uncertainty, MNCs can establish foreign subsidiaries in uncertain environments with little investment and enlarge them later when uncertainty recedes (Fisch, 2008b). Thus, the MNC will rather accept the challenges of unpredictable labor costs and choose a location that strengthens the growth option value G of the network.

Hypothesis 2b: The location chosen for a new production subsidiary contributes to increasing the uncertainty of labor costs in the network of production subsidiaries.

In addition to the positive side of uncertain labor costs, MNCs can balance the international movements of labor costs through shifting value-adding activities to other locations (Miller, 1992). When production costs are uncertain, it is valuable to have an across-country option to shift production (Kogut and Kulatilaka, 1994). The opportunity to quickly relocate production capacity from countries with rising labor costs to countries with falling labor costs substantiates a super-additive portfolio effect (Vassolo et al., 2004). The value of operational flexibility F under uncertain labor cost developments increases by the labor cost differentials across the established production locations. Chung et al. (2010) confirm that MNCs shift production internationally only if macroeconomic conditions among subsidiary locations do not change in parallel. When the operational flexibility value of the production network is high as labor cost developments in its locations are
dive, the MNC is likely to maintain the present network and respond to adverse events by shifting production across countries. Thus, we expect that

Hypothesis 3a: Under uncertainty of labor costs, the diversity of labor cost developments in the existing network of production subsidiaries reduces the propensity to establish a new production subsidiary.

The major advantage of spreading operations over multiple countries is the flexibility to transfer resources across borders (Kogut, 1983). If the ability of the existing production network to outbalance international labor cost movements by production shifting is unsatisfactory because the labor cost differentials between its locations are too small (Belderbos and Zou, 2009; Chung et al., 2010), the network does not provide the full value potential of a portfolio of diversified assets (Anand et al., 2007). As a consequence, the MNC may consider establishing a new production site. In order to increase the operational flexibility value $F$ of the production network (Sharp, 1991), it will place the site in a location featuring a labor cost development that is different from the existing locations.

Hypothesis 3b: The location chosen for a new production subsidiary contributes to increasing the diversity of labor cost developments in the network of production subsidiaries.

EMPIRICAL METHODS

Data

Sample selection

With an emphasis on labor costs, we need to account for two effects that arise from labor cost differentials between countries. First, firms make investments to exploit different levels of labor costs, for example, through locating part of their production activities in low-cost countries. Second, with a suitable allocation of production activities across multiple countries, firms can exploit temporary changes in labor costs and may complement their production networks by new sites in order to increase operational flexibility. The latter effect is the focus of our study. Hence, to investigate network effects between international production locations, our study requires a sample of firms with international production networks that have been established for primary reasons of foreign direct investment, for example, access to cheap labor. We find such firms in industrialized countries with high levels of labor costs.

Germany has been one of the countries with the highest labor costs in the world for decades. In spite of two immigration waves from Turkey and Southern European countries such as Italy and Yugoslavia in the 1970s and gaining access to a new potential of workers from East Germany and Eastern Europe by the end of the 1980s, manufacturing wages have stayed at a high level. The high level of labor costs can be attributed to the dominant manufacturing sector in Germany, which has a growing need for workforce due to the rising international demand for German-engineered products. Other reasons are strong labor unions and Germany’s welfare system that leads to high nonwage labor costs. As German firms faced high labor costs early, they were among the pioneers in international production (Dunning, 1979). After Germany’s large MNCs, even small and medium-sized manufacturing firms have built up foreign production units. Every fourth German firm from the manufacturing sector invested in foreign production facilities during the last decade (Kinkel and Maloca, 2009).

The effect of high labor costs in the home country on the propensity to establish production subsidiaries abroad is likely to decay as firms enter their first foreign production locations. As the international production network grows, its value potential of operational flexibility rises. To study the role of operational flexibility in the expansion of international production networks, we use a sample of German manufacturing firms with foreign direct investments.

Sampling process

The Central Bank of Germany maintains a database that comprises anonymous information about all foreign direct investment objects of German parent firms—including the German parent firms held by foreign investors—above a balance sheet total of currently € 3 million. The reports include balance sheets and the stock of foreign direct investment, and other characteristics of the foreign subsidiaries such as sales volume and the number of employees. They are available as panel data on a yearly
basis. The investors and investment objects in the database are classified by industry codes. As sales subsidiaries are classified as trading companies, we can filter out the production affiliates of manufacturing firms.

Production shifting causes a considerable effort in adapting an MNC’s value chain and involves additional transportation and coordination costs. A smaller distance facilitates earning the benefits of operational flexibility (Rugman and Verbeke, 2004). For this reason, Belderbos and Zou (2007) raised data on production subsidiaries in nine countries in Southeast Asia, which is the most relevant geographical region for production activities of Japanese firms. In our data of German firms, foreign production shows a strong concentration in the European region (67%). The rest of foreign production is distributed over the North American Fair Trade Agreement countries (12%), East Asia (12%), and other countries in the world (9%). We acknowledge that subsidiaries in different continents are part of the international production system, but we assume that they are far less interrelated than production sites within the same region. To study the effects of operational flexibility on network expansion, we limit the analysis to the most relevant production region for German firms, which is Europe. Due to the euro as a common currency and its influence on the currencies of European countries outside the euro zone, exchange rate fluctuations play a minor role in the European region (European Central Bank, 2007). However, there is a remarkable diversity of labor cost developments.

The study focuses on expansions of international production networks. As the subsidiaries have been assigned to investors by consistent identification numbers since 1996, we could identify new subsidiaries from 1997 on. Starting in 2002, the Central Bank data provide more detailed information about the investors, which we need to predict network expansions. However, we can use entries before 2002 to measure the period between a previous network expansion and the network expansion we try to predict. As we closed the dataset with definite figures from 2006 and preliminary figures from 2007, we were able to observe establishments of new production affiliates with complete investor data in the period between 2002 and 2007. Investment objects with a return on sales below −1,000 percent or above 1,000 percent were excluded from the analysis as outliers. To avoid a bias from in-country firm restructuring, we ignored establishments of subsidiaries that compensated for subsidiary closures in the same country and year. In order to treat new investments without prejudice, we did not eliminate the establishments of sites in those countries that had been chosen as production locations by the MNC beforehand. We finally obtained a panel of 352 investors.

Besides the firm-level data of the German Central Bank we included country-level data in our analysis. The macroeconomic data were obtained from the World Bank. Data on national labor costs were taken from statistical reports of the International Labour Organization (ILO).

Measures

Dependent variable

The dependent variable new subsidiary takes the value of 1 in the year in which an investor establishes a new production subsidiary abroad, and 0 otherwise. Within the period between 2002 and 2007, 245 of the 352 investors established a new subsidiary. After the expansion, the MNC may consider closing existing sites, as they are no longer needed to ensure flexibility. However, the analysis of withdrawal from foreign locations is beyond the scope of this study.

Independent variables

We expect to find an impact of changing factor prices in the existing production locations on the decision to make an additional investment. Data on national wages were taken from ILO’s Key Indicators of the Labour Market (KILM) databank, fifth edition (2007). To calculate labor cost growth, we use the real manufacturing wage index as a basis, which is the nominal wages index corrected for changes in purchasing power measured by the consumer price index (100 × nominal wage index/consumer price index). As national labor unions justify higher wages by wage increases in other industries and regions, we assume that wage growth rates within a country are similar across industries and regions. We subtract the wage index of the previous year from the wage index of the present year and calculate the mean across all existing production locations of the MNC in a year.

We also draw on the ILO real manufacturing wage index to measure uncertainty of labor costs.
In the same way as earlier studies that incorporate uncertainty by the volatility of a macroeconomic indicator (Campa, 2004; Folta and O’Brien, 2004), we use an autoregressive conditional heteroskedastic (ARCH) process (Engle, 1982) to estimate the degree to which the current wage index could not be expected looking at the past development. To obtain a measure of the uncertainty of labor costs in the entire portfolio, we compute the mean volatility across all locations in a year.

The variable _diversity of labor cost developments_ shall reflect the heterogeneity of contemporary labor cost developments across the locations of the production network. We calculate the variance in real manufacturing wage growth of the current set of host countries within a year. Since the decision to enlarge the extant network takes time to be implemented, all variables including the controls are lagged by one year, that is, we classify network expansions as reactions to these variables when they occur at least one year later.

**Control variables**

The opportunity to shift production internationally requires manufacturing to be spread over multiple locations (Allen and Pantzalis, 1996; Tang and Tikoo, 1999; Tong and Reuer, 2007). However, additional subsidiaries boost the cost of coordination (Gomes and Ramaswamy, 1999; Berry, 2006). Operational flexibility increases as the international production network grows but yields decreasing marginal returns to network size (Chung, Lu, and Beamanis, 2008). Therefore, we control for the influence of international diversification on the propensity to expand the network by the logarithm of host countries (_logNOC_).

Market growth is a predominant location factor in market-seeking investment decisions (Buckley, Devinney, and Louviere, 2007). The study in hand focuses on efficiency-related motives of investment, where local market growth may be less important. However, as we cannot distinguish efficiency-seeking from market-seeking production subsidiaries in the anonymous dataset, we control for market-related motives of investment: weak market growth in the given locations could be a motive for investing in a different location. We operationalize _market growth_ by the mean gross domestic product growth rate in the extant host countries.

Previous research suggests that the geographic situation of a country influences a firm’s decision to invest (Brush, Maritan, and Karnani, 1999; Nachum, Zaheer, and Gross, 2008). Accordingly, the geographic distribution of the existing network may be crucial for the establishment of new production sites. Similar to Bouquet and Birkinshaw (2008) as well as Ojala and Tyrväinen (2007), we calculate the mean capital-to-capital distance of the existing locations to the home country Germany as a measure of _geographic distance_. Flores and Aguilera (2007) point to a negative influence of cultural distance on the likelihood to invest in a new foreign market. Cultural differences of the existing network may also be influential for the probability to establish a new production subsidiary. We operationalize _cultural distance_ using the cultural indices of Hofstede (1980). Chang and Rosenzweig (2001) further developed the index measure of Kogut and Singh (1988) by extracting a root of the squared cultural differences. Accordingly, we first calculate the square root of the sum of squared differences between the four cultural dimensions of the respective host countries and Germany, divided by four, and then compute the mean across all existing locations.

New sites may be established due to capacity limitations of the existing production locations as the firm grows. To separate the effects of growth from cost and flexibility considerations, we control for the _employment growth rate_ within the existing production network. Since company size may foster (Tan and Vertinsky, 1996) or suppress (Chan, Makino, and Isobe, 2006) international expansion, we control for _size_ by the total number of employees working for the existing production network. As the patterns of expansion may differ depending on the nature of the related products and processes, we also control for network labor _productivity_, measured by the sales earned per worker. MNCs owned by private individuals or families exhibit internationalization strategies that are different from other ownership types (Zahra, 2003; George, Wiklund, and Zahra, 2005). Ownership may, therefore, affect the international production configuration. We include the dummy variable _ownership_, which has the value 1 if the firm is held by a domestic private individual or family, and 0 otherwise. Time dummies account for overall effects that may impact on the establishment of new production subsidiaries in the individual years.
RESULTS

Propensity to establish a new foreign production subsidiary due to a low value of the existing production network

Descriptive statistics of the sample are presented in Table 1. Due to confidentiality policies, minimum and maximum values of firm-level variables need to refer to the average of the highest and lowest three observations. The correlation matrix reveals that the variables are mostly independent of each other. There is a correlation between uncertainty of labor costs and market growth that indicates that economies that feature strong growth rates are less predictable. This finding seems plausible regarding the macroeconomic developments in Eastern Europe. The positive correlation between logNOC (number of host countries) and size (number of employees in those locations) is obvious as well. The variance inflation factors (VIF) still indicate an acceptable level of multicolinearity; the mean VIF is 1.25.

To test Hypotheses 1a, 2a, and 3a, we examine the propensity to establish a new production subsidiary abroad. As the data are right-censored, we use hazard rate models. The hazard rate is defined as the probability that an event occurs in a given time interval divided by the length of that interval. After exploring the dataset with semi-parametric hazard rate models (Cox, 1972) we estimated more efficient, parametric Weibull models. They are presented in Table 2. All regressions feature a significant Weibull parameter p > 2 indicating a progressively increasing baseline hazard, which reflects a rising probability of establishing a new foreign production subsidiary in the course of time. This finding corresponds to Kogut’s (1983) understanding of foreign direct investment as a sequential process of reinvesting earnings in foreign markets.

Model 1 is the base model comprising the control variables. It features a log likelihood of −223.74. Ownership exerts a negative influence on the propensity to establish a new production subsidiary, which may be ascribed to a greater risk aversion of family owners. Market growth in the existing locations decreases the urge to establish a new production affiliate due to market-related motives for production locations, which have been put forward by previous studies. The variables geographic distance and cultural distance are positively associated with an enlargement of the network in some of the models. However, employment growth, size, and productivity do not seem to have an influence on network expansion. The number of host countries covered by the international production network drives expansion at a decreasing rate (logNOC). As diversity of labor cost developments is mostly insignificant, it does not seem to have a direct impact on the decision to enter a new location.

Model 2 incorporates the variable labor cost growth to test Hypothesis 1a. It shows a significant, positive coefficient. The log likelihood rises significantly to −218.34. As predicted by Hypothesis 1a, rising labor costs within the existing network seem to increase the propensity to establish a new production subsidiary. Also, the linear term of uncertainty of labor costs (Model 3) reveals a positive influence on network expansion. In Model 4, the squared term of uncertainty of labor costs produces a significant negative coefficient, while the linear effect stays significantly positive. The maximum of the parabola is at 625, which is well within the range of uncertainty of labor costs [0.52...1,040]. Both adding the linear and the squared term significantly increases the log likelihood. The data support Hypothesis 2a that the influence of uncertainty of labor costs on the propensity to enter a new production location is inverted U-shaped due to the balance of net present value and the growth option value of the existing network. In Model 5, uncertainty of labor cost is interacted with diversity of labor cost developments in order to test Hypothesis 3a. To calculate the interaction term, both variables were centered. The log likelihood is significantly higher (−214.91) than in Model 3. The negative coefficient supports our prediction: as the diversity of labor costs in the existing network of production subsidiaries creates operational flexibility that is valuable under uncertainty, it diminishes the influence of uncertainty on the propensity to establish a new production subsidiary. All influences remain stable in the complete Model 6.

Value improvement of the production network through establishment of a new production subsidiary

Our previous analysis centered on the value of the existing production network while ignoring the quality of the new locations. We now address the question of whether the 245 MNCs that decided to expand their networks selected locations that
Table 1. Descriptive statistics, correlation matrix, and variance inflation factors

<table>
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<tr>
<th>Variable</th>
<th>Mean</th>
<th>StdDev</th>
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<th>Max</th>
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<td>Labor cost growth</td>
<td>1.73</td>
<td>3.62</td>
<td>-10.20</td>
<td>22.2</td>
<td>0.05</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1.20</td>
</tr>
<tr>
<td>LogNOC</td>
<td>0.79</td>
<td>0.57</td>
<td>0.00</td>
<td>12.2</td>
<td>-0.04</td>
<td>0.15**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.34</td>
</tr>
<tr>
<td>Diversity of labor cost developments</td>
<td>9.61</td>
<td>35.00</td>
<td>0.00</td>
<td>537.9</td>
<td>0.23**</td>
<td>0.31***</td>
<td>0.25***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.27</td>
</tr>
<tr>
<td>Market growth</td>
<td>2.66</td>
<td>1.80</td>
<td>-1.96</td>
<td>13.5</td>
<td>-0.16**</td>
<td>-0.01</td>
<td>0.09*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.20</td>
</tr>
<tr>
<td>Geographic distance</td>
<td>943.15</td>
<td>476.58</td>
<td>279.76</td>
<td>3,879.9</td>
<td>-0.01</td>
<td>0.08</td>
<td>0.08</td>
<td>0.11**</td>
<td>0.19***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural distance</td>
<td>51.83</td>
<td>12.24</td>
<td>24.72</td>
<td>93.5</td>
<td>-0.07</td>
<td>0.16***</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.09*</td>
<td>0.18***</td>
<td>1.00</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment growth</td>
<td>0.19</td>
<td>1.35</td>
<td>-0.89</td>
<td>12.2</td>
<td>0.03</td>
<td>-0.08</td>
<td>-0.03</td>
<td>0.05</td>
<td>-0.02</td>
<td>-0.05</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Size</td>
<td>831.41</td>
<td>2,006.37</td>
<td>2.67</td>
<td>16,558</td>
<td>-0.06</td>
<td>0.04</td>
<td>0.42***</td>
<td>0.06</td>
<td>0.01</td>
<td>-0.03</td>
<td>0.04</td>
<td>-0.05</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>459.4</td>
<td>2,335.7</td>
<td>17.28</td>
<td>20,964</td>
<td>-0.02</td>
<td>0.03</td>
<td>0.08</td>
<td>-0.003</td>
<td>-0.04</td>
<td>0.13</td>
<td>-0.13**</td>
<td>0.00</td>
<td>-0.04</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td>0.34</td>
<td>0.475</td>
<td>0.00</td>
<td>1.00</td>
<td>0.13**</td>
<td>-0.08</td>
<td>0.16***</td>
<td>-0.10*</td>
<td>0.00</td>
<td>-0.02</td>
<td>0.07</td>
<td>0.05</td>
<td>0.17***</td>
<td>-0.05</td>
<td>1.00</td>
<td>1.09</td>
</tr>
</tbody>
</table>

352 observations; *** p < 0.01; ** p < 0.05; * p < 0.1.
increase the network’s net present value, growth option value, and flexibility value. Table 3 provides a country breakdown of the locations chosen for expansion. To ensure confidentiality, all numbers referring to three or less investments in a country are concealed.

In order to test Hypotheses 1b, 2b, and 3b, we introduce the variables change in labor cost growth, change in uncertainty of labor costs and change in diversity of labor cost developments. They indicate the absolute changes effected by the expansion. First, we use multivariate analysis of variance (MANOVA) to test whether there is an overall change in the variables that drive the value of the international production network. All test statistics suggest that the change is significant (Table 4).

Second, we employ one-tailed Student t tests to check whether the individual changes are significant (Table 5). The change in labor cost growth is negative. As we predicted in Hypothesis 1b, investors seem to establish a new foreign production subsidiary in a location that decreases the average labor cost growth rate in the locations of the country portfolio, improving the net present value of the network. By contrast, the change in uncertainty of labor costs is positive. According to Hypothesis 2b, investors appear to accept volatile wages in new locations, as they include the chance of falling labor costs and strengthen the growth option value of the network. Hypothesis 3b proposes that investors will choose a location that contributes to a greater diversity of labor cost developments and enhances the flexibility value of...
Table 3. Number of new production subsidiaries per host country

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of new subsidiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>11</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>confidential</td>
</tr>
<tr>
<td>Belgium</td>
<td>10</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>confidential</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>26</td>
</tr>
<tr>
<td>Denmark</td>
<td>confidential</td>
</tr>
<tr>
<td>Finland</td>
<td>confidential</td>
</tr>
<tr>
<td>France</td>
<td>28</td>
</tr>
<tr>
<td>Hungary</td>
<td>10</td>
</tr>
<tr>
<td>Ireland</td>
<td>confidential</td>
</tr>
<tr>
<td>Italy</td>
<td>21</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>confidential</td>
</tr>
<tr>
<td>Netherlands</td>
<td>8</td>
</tr>
<tr>
<td>Norway</td>
<td>5</td>
</tr>
<tr>
<td>Portugal</td>
<td>confidential</td>
</tr>
<tr>
<td>Russia</td>
<td>17</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>14</td>
</tr>
<tr>
<td>Spain</td>
<td>24</td>
</tr>
<tr>
<td>Sweden</td>
<td>6</td>
</tr>
<tr>
<td>Switzerland</td>
<td>14</td>
</tr>
<tr>
<td>Turkey</td>
<td>9</td>
</tr>
<tr>
<td>Ukraine</td>
<td>4</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>245</td>
</tr>
</tbody>
</table>

Table 4. MANOVA of absolute changes in the location characteristics of the international production network through establishment of a new production subsidiary

<table>
<thead>
<tr>
<th>MANOVA</th>
<th>Statistic</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilk’s lambda</td>
<td>0.9844</td>
<td>0.0533</td>
</tr>
<tr>
<td>Pillai’s trace</td>
<td>0.0156</td>
<td>0.0533</td>
</tr>
<tr>
<td>Lawley-hotelling trace</td>
<td>0.0156</td>
<td>0.0533</td>
</tr>
<tr>
<td>Roy’s largest root</td>
<td>0.0156</td>
<td>0.0533</td>
</tr>
</tbody>
</table>

Table 5. Student t tests of absolute changes in the location characteristics of the international production network through establishment of a new production subsidiary

<table>
<thead>
<tr>
<th>t test</th>
<th>Obs.</th>
<th>Mean</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in diversity of labor cost developments</td>
<td>245</td>
<td>2.9085</td>
<td>0.0543</td>
</tr>
<tr>
<td>Change in uncertainty of labor costs</td>
<td>245</td>
<td>13.143</td>
<td>0.0377</td>
</tr>
<tr>
<td>Change in labor cost growth</td>
<td>245</td>
<td>−0.5519</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

The prediction is supported by a positive change in diversity of labor cost developments.

DISCUSSION

Our analysis of international production networks of German firms suggests that the value of an existing set of locations is an important decision determinant for the establishment of a new production site. First, MNCs expand their networks if rising labor costs deteriorate the net present value of manufacturing sites in the extant locations. The locations chosen for new subsidiaries lower the average wage growth of the production network. Second, labor cost uncertainty in the existing network lowers the net present value, but it urges investors to enter new locations only at low levels of uncertainty. High levels of labor cost uncertainty keep MNCs from investing in new locations, as volatile labor costs drive the value of the option to expand production in the existing locations. Increasing the growth option value of the network appears to be a stronger motive in the selection of new locations than avoiding a risk premium on its net present value; the locations chosen for new subsidiaries increase the labor cost volatility of the production network. Third, MNCs seem to appreciate the value of an international production network to provide operational flexibility and tend to stay with production locations with uncertain labor costs if the diversity of volatile labor cost movements in those countries is high. To increase the flexibility value of the production network, MNCs choose new locations with labor cost developments that are different from the labor cost developments in the existing locations.

Our study makes three theoretical contributions. The first is to clarify the nature of production shifting as a real option. Real options include opportunities to invest in assets and opportunities to alter the use of assets (Sharp, 1991; Trigeorgis, 1996; Kogut and Kulatilaka, 1994). Portfolios of real options show sub-additivity due to switching options of committing irreversible investments in assets that are mutually exclusive (Anand et al., 2007; Girotra, Terwiesch, and Ulrich, 2007) and super-additivity due to options of realizing synergies through a coordinated use of assets (Vassolo et al., 2004). A major synergy in the use of internationally dispersed production units is shifting production from countries with rising input costs to countries with falling input costs (Kogut,
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DOI: 10.1002/smj

Belderbos and Zhou (2009) view international production shifting as a switching option and conclude that a correlation between the macroeconomic environmental changes in the locations of an international production network reduces the option value of the network. However, in the short time horizon of production shifting, investments in foreign production subsidiaries are not mutually exclusive. Exercising a switching option between mutually exclusive assets means striking a put option on one asset while striking a call option on another asset (Margrabe, 1978; Stulz, 1982). Abandoning one production site in favor of committing investments to another production site (Hurry, 1994) would confine the option to shift production. Furthermore, shifting production from one location to another location should not require irreversible investments, as they impede the exploitation of operational flexibility (Kogut, 1985). It seems that international production shifting relates to options to alter the use of assets rather than to switching options, which are options to invest in assets. Therefore, a correlation between the macroeconomic environmental changes in the locations of an international production network as observed by Belderbos and Zhou (2009) are more likely to reduce the positive super-additivity effect of the network than to increase the negative sub-additivity effect of the network. We show that the diversity of labor cost developments across the locations of an international production network strengthens the super-additivity effect of the network.

As a second contribution, we extend the literatures on operational flexibility and sequential international entries. Several studies show that multinationality creates value by the potential of exploiting operational flexibility (Allen and Pantzalis, 1996; Tang and Tikoo, 1999; Lee and Makhija, 2009). We argue that a low operational flexibility value of an international production network urges investors to establish new production subsidiaries. The results suggest that, under uncertainty, the diversity of labor cost developments as an indicator of operational flexibility value is a predictor of the decision to expand the international production network. Furthermore, network expansion involves sequential entries to foreign countries. Previous studies find that earlier international entries exert an influence on later entries (Davidson, 1980; Kogut and Chang, 1996; Delios and Henisz, 2003). For the case of production subsidiaries, we further develop the idea of Tan and Vertinsky (1996) that network effects may constitute a causal relationship between prior investments and subsequent investments and analyze three components of network value. Our results show that MNCs enter new locations that complement the existing network in terms of net present value, growth option value, and operational flexibility value. The ability of a new location to improve the prerequisites of production shifting in the existing network establishes a causal link between earlier and later entries.

The third contribution of the study is to supplement the literature on location decisions for international production. The classic theories of internationalization assume that a foreign production subsidiary is established to serve the local market (Johanson and Vahlne, 1977; Dunning, 1988). Accordingly, extant research has centered on the characteristics of the host country chosen for production (Buckley et al., 2007; Desbordes, 2007; Flores and Aguilera, 2007). Foreign production subsidiaries that concentrate on serving local markets can work independently of one another. However, when environmental conditions in foreign countries are uncertain, investors need flexibility to react to unexpected events (Miller, 1992). By coordinating their foreign production subsidiaries, MNCs make the flexibility potential of geographical diversification useful. With a focus on labor cost developments, our study uses the concept of operational flexibility to argue that, under uncertainty, a network of interrelated production subsidiaries holds a value that is greater than the sum of the values of subsidiaries that operate independently of each other. If the value of one production subsidiary is associated with the value of other production subsidiaries, the quality of a host country to be chosen for a new production subsidiary also relates to the quality of the locations of the existing network. Therefore, decisions to expand production internationally need to respect the location factors of all host countries the firm has already entered. We examine labor cost developments as location factors of the existing production network to predict expansions to new locations and show that the location quality of the host country chosen for expansion fits the location quality of the existing host countries. The findings suggest that decisions of international expansion depend on the
firm’s present configuration of international production. As a consequence, the evaluation of the location quality of a country for production is path-dependent and company-specific. The finding that the location quality of host countries is company-specific leads to a strong implication for management. The more diversified the international production system of an MNC, the less applicable are uniform tools, for example, the Business Environment Risk Intelligence (BERI) index, to assess foreign locations. In the literature, factors that refer to individual locations dominate over flexibility considerations of the whole network as motives for locating production subsidiaries abroad. Managers should also pay attention to the operational flexibility contribution of additional facilities when expanding foreign production networks and choosing appropriate locations. Thus, a new production site ought to be evaluated by its strategic fit within the existing portfolio. There is also an important implication for economic policy. Host country governments that seek to attract foreign direct investments need to be aware that each investor evaluates the country’s appropriateness as a production location in its individual context. Positioning the own country against competing locations successfully requires having the country excel others concerning both general criteria and the distinct fit with the investor’s existing locations. The more developed the international production network of the investor, the more difficult and costly it can be to offer attractive conditions to the investor. The likely consequences are that governmental location marketing should be individualized for large investors and focused on those investors who can expect a contribution to operational flexibility from the new location.

The study has a number of limitations, some of which are due to missing information in the anonymous dataset. If we had more detailed information on the subsidiary level, we could verify that subsidiaries within the network deliver interchangeable output; that is, shifting of production capacity between subsidiaries is feasible. We would also be better able to differentiate between market-seeking and efficiency-seeking motives of foreign direct investment; the positive influence of market growth indicates that some of the production facilities also serve the local market. Furthermore, it would be possible to track outsourcing production capacity from contractors. Data restrictions made it difficult to investigate the influence of strategic motivations (for example, access to specific resources or the need to follow important customers) for the propensity to establish a new production subsidiary abroad. Neither were we able to distinguish greenfield investments from acquisitions (the latter of which can be instantly employed).

Future research can build on the findings of the study to advance the theory of international production. Given an empirical setting that is different from Europe, exchange rate movements may be an important determinant of a multinational production network’s operational flexibility value, for example, in the East Asian region where there is no common or dominant currency. Beyond that, studies using more fine-grained data such as management surveys may detect to what extent an MNC’s international production configuration allows for exploiting operational flexibility by shifting capacity as a reaction to changed micro- and macroeconomic conditions. Future research may also clarify the role of operational flexibility in closing down or relocating international production subsidiaries. Finally, it needs to be clarified how much MNCs benefit from international investment and divestment decisions that are based on operational flexibility.

ACKNOWLEDGEMENTS

Financial support from German Research Foundation (Deutsche Forschungsgemeinschaft) is gratefully acknowledged. We thank Heinz Herrmann, Yarema Okhrin, Jan-Michael Ross, our audience at the 2010 SMS conference in Rome/Italy, Editor Will Mitchell, and two anonymous reviewers for helpful comments.

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