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Choice of foreign R&D entry mode and impact on firm performance: A firm-level analysis for Switzerland and Austria

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Choice of Foreign R&D Entry Mode and Impact on Firm Performance: A Firm-level Analysis for Switzerland and Austria

Heinz Hollenstein and Martin Berger

Abstract
The study seeks to identify the determinants of a firm's foreign entry mode choice and the impact of mode selection on firm performance for the specific case of R&D – a topic so far not investigated in entry mode research. Separate estimates of a Heckman selection model for Austria and Switzerland, based on comparable firm-level data and variable specification, show for both countries that the OLI model is well-suited to explain not only the propensity to investing abroad in R&D but also the respective choice between equity-based and non-equity governance modes. Moreover, it turns out, but only for Swiss companies, that foreign R&D raises (domestic) firm performance with a larger impact in case of equity-based governance. The differences between the two countries primarily reflect the much higher degree of R&D internationalisation of Switzerland.

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1 Introduction

Internationalisation of R&D strongly advanced over the last twenty years. In parallel, it became increasingly attractive to choose non-equity rather than equity-based modes of governance (Hagedoorn 1996; Dunning and Lundan 2008). Against this background it is surprising that the extensive entry mode research did not provide any econometric analysis dealing with mode choice in the *specific case of foreign R&D* (for reviews of this literature see Sarkar and Cavusgil (1996); Datta *et al.* (2002); Zhao *et al.* (2004); Brouthers and Hennart (2007); Morschett *et al.* (2010)).

This gap needs to be filled as the results of research dealing with the foreign mode selection *in general* cannot be carried over unseen to the case of R&D. For example, "insufficient IPR protection in host countries" may be more important as a determinant of entry mode choice in case of R&D than for international activity as a whole. Similarly, specific motivations to investing abroad in R&D such as "knowledge-seeking motives" are probably relevant to a higher extent in case of R&D than for foreign activities in general. Furthermore, as foreign R&D engagements often aim at getting access to completely new technological fields, they involve higher risks and uncertainties than FDI in general, implying that firms tend to prefer non-equity governance modes (Teece 1992; Narula and Zanfei 2005).

Against this background we aim, firstly, at identifying the *determinants* of a firm's choice between equity-based and non-equity governance modes of foreign R&D, with the explanation of the overall propensity to investing abroad in R&D as starting point. Secondly, we analyse the *impact* of foreign R&D on a parent firm's domestic performance, presuming that this effect differs between the two types of governance and is probably larger in case of equity-based modes of control.

The *equity-based governance mode*, as defined in this paper, covers wholly-owned foreign affiliates *and* majority or (substantial) minority equity-based joint ventures (JVs). The *non-equity mode* pertains to (long-lasting) R&D co-operation with foreign partners without capital participation. Firms with ventures of both types are assigned to the first category. In case of the equity-based mode, we had preferred to further distinguish between wholly-owned affiliates and partial ownership (JVs). However, as the number of JVs in the sample is quite low, econometric estimates based on such a more differentiated three-level mode variable would not be reliable. Finally, notice that complete out-contracting of R&D activities to a foreign company or university/government lab is not considered as foreign R&D.

A special feature of the paper is its *comparative* approach. We perform model estimates *separately* for Switzerland and Austria[1] using cross-section firm-level data stemming from similar surveys we conducted in the whole business sector of the two countries in 2010. Switzerland and Austria are interesting cases for a comparison of drivers and performance effects of foreign R&D and its governance as they strongly differ in terms of the level of FDI in general, and even more so with respect to foreign R&D, with the Swiss economy much more internationalised than the Austrian one (OECD 2008, 2009). For example, the share of patents based on foreign R&D in total patents amounts to about 20% in case of Austria, whereas it is 57% in Switzerland, a proportion that is higher than in (practically) all EU countries, Japan and the USA (OECD Patent Statistics; data for 2007). The empirical analysis shows that the differences between Austria and Switzerland with respect to the determinants of the foreign R&D mode choice and its impact on firm performance indeed reflect, to a substantial extent, the disparities between the two countries in terms of the degree of internationalisation, what underlines the relevance of a comparative approach.

More specifically, the empirical analysis of the foreign R&D mode choice is based on a model (*model A*) consisting of two equations, the first one serving to identify the factors determining the general decision to invest abroad in R&D ("*propensity equation*"), the second one to explain a firm's choice between the two governance modes we distinguish in the analysis *("mode equation*"). The propensity equation, in addition to its significance of its own, serves to correct a (potential) selection bias in the mode equation due to the use of a truncated sample (only firms with foreign R&D). Theoretical framework of the empirical analysis of model A is the OLI paradigm (Dunning 2000). Previous work showed that the OLI model, as postulated, is well-suited to explaining the propensity of foreign R&D as well as the foreign mode choice in case of foreign activity *in general* (see our assessment of the empirical literature in subsection 2.2). In the present analysis, we show that the *mode choice in case of foreign R&D* also can be explained by the OLI approach – and that for the Austrian as well as the Swiss economy.

In *model B* we analyse whether a parent firm achieves a higher performance as a result of its foreign R&D activities, and, what is at the core of our interest, whether this effect, as postulated, differs between the two governance modes. To this end we specify two performance equations, the one with innovation output, the other with labour productivity as dependent variable. In both equations we insert as explanatory variables the *propensity* and, alternatively (and at the core of our interest), the *mode* of foreign R&D. In both equations, we control for the standard factors determining, respectively,

[1] Estimates based on an *overall* sample of Swiss and Austrian companies are not adequate as this approach would not allow to detecting differences among the two countries with respect to the (individual) determinants of R&D mode choice; country-specificities would only be reflected in the estimates for a country dummy.

innovation output (model B1) and productivity (model B2). In model B1 and B2, we account throughout for a potential endogeneity of the propensity and the mode variable. Our empirical analysis showed, but only for Swiss companies, that foreign R&D, as hypothesised, raises (domestic) firm performance (what is in line with previous work; see subsection 3.2) and, what is new, that this effect, as postulated, is larger in case of an equity-based governance mode. The latter result underlines the economic significance (in terms of firm performance) of differentiating between equity-based and non-equity governance of foreign R&D.

The study complements previous research in several respects. Firstly, we analyse a firm's foreign mode choice and its impact on firm performance not only for foreign activity in general but *specifically for R&D*, what, to the best of our knowledge, has not been done to date. Secondly, we apply a *comparative* approach in order to identify the robustness of the explanatory patterns and the significance of the degree of internationalisation for explaining differences between the two countries included in this study. Thirdly, we account for *two econometric problems* hardly ever addressed in entry mode research: selectivity in explaining the mode choice, endogeneity of the entry mode variable in the performance equations.

The paper is organised as follows: In Section 2 and 3, we present the conceptual framework of model A and B, the hypotheses to be tested and an assessment of the results of the related empirical literature. In Section 4, we provide for the two countries some information on the database and the incidence of foreign R&D. Section 5 deals with the specification of the two empirical models and with some econometric problems. In Section 6 we present the empirical results, which, finally, are assessed with special reference to the cross-country comparison.

2 Model A: Determinants of propensity and governance mode foreign R&D

2.1 Conceptual framework and hypotheses

Since Hymer (1976) the theory of international investment of firms is based on the assumption of imperfect markets. In these conditions firm-specific capabilities yield a competitive edge independently of the economic attractiveness of different locations ("new trade theory", see, e.g., Helpman 1984). Moreover, "transaction cost theory" hypothesises that a firm engages in FDI whenever the costs of setting up and running a transnational organisation of activities are lower than those of external market transactions (Rugman 1981; Hennart 1982; Buckley and Casson 1985; Williamson 1985). In addition, there are many partial hypotheses explaining specific aspects of internationalisation that are rooted in management science, evolutionary economics, industrial organisation, etc. (Dunning 2000).

As early as in the 1970s, Dunning argued that no single approach is able to explain a firm's international activities. He proposed an eclectic theory of international production, the well-known OLI paradigm, which he further developed over the years to account for changing features of the international economy and new theoretical approaches. In its most recent version (Dunning and Lundan 2008) it applies not only to international production but also to R&D. Besides, it emphasises more explicitly the strategic aspects of internationalisation drawing on the "resource-based" (Wernerfelt 1984) or "dynamic capability" (Teece *et al.* 1997) view of the firm, or the concept of the "knowledge-based company" (Kogut and Zander 1993). Accordingly, foreign R&D is conceived as a means to augment a firm's competencies and capabilities. Besides, the OLI paradigm now clearly considers the network character of international activities reflecting the increasing attractiveness of partnerships and alliances compared to hierarchical governance modes.

We posit that the *OLI paradigm* is an appropriate theoretical framework for explaining foreign R&D *propensity* (yes/no decision) and the respective *mode choice* (equity-based vs. non-equity governance). Previous work more or less confirms this approach in case of R&D propensity (see subsection 2.2.1). The OLI model also is quite successful in explaining mode selection *in general* (see subsection 2.2.2). We use model A for testing the hypothesis that the OLI model also is able to explain the mode choice in the *specific case of R&*D, what, as argued in the introductory section, cannot be taken for granted.

The OLI model basically accounts for three groups of variables: *"Ownership-specific (O)* advantages" refer to firm-specific capabilities that make a company superior to local competitors. These advantages mainly arise from the availability of firm-specific knowledge, human capital, managerial skills, property rights, marketing outlets, access to finance and international experience. *"Location-specific (L) advantages"* are representing potential gains a firm can realise by optimising its activities along the value chain across locations. In the present context, this type of advantage primarily roots in differences between foreign and domestic locations with respect to factors that favour or impede knowledge creation. To mention are, in particular, locational characteristics such as the general regulatory framework, protection of IPRs, knowledge infrastructure, availability of R&D personnel and cultural proximity. *"Internalisation (I) advantages"* can be realised by escaping from market relations, primarily by setting up foreign subsidiaries but, to a lesser extent, also by engaging in *equity*-based co-operations (JVs) with foreign partners. In this way, transaction costs on imperfect markets can be reduced and appropriability problems mitigated.

Some additional variables complement the basic ingredients of the OLI model. *Firm size*, in addition to being a general control variable, captures I-advantages (e.g. superiority in monitoring foreign activities) as well as size-related elements of O-advantages (e.g. privileged access to capital markets).

Furthermore, *competitive pressure* may induce a firm to extend its activities to foreign locations. Besides, specific strategic goals of foreign R&D *("motives")* represent L-advantages of host countries (knowledge-seeking motives) or a mix of O- and L-advantages (market-oriented motives).

The OLI model incorporates the "transaction cost approach" of explaining foreign *mode choice*. In this perspective, Anderson and Gatignon (1986) postulated six core determinants of choosing a high-control/equity-based rather than a low-control/co-operative governance mode. Four of them represent O- and I-advantages (proprietary knowledge; intangible knowledge; reputation-related assets; international experience), the other two reflect L-*dis*advantages of the host country arising from (firm-external) uncertainty and cultural distance.[2]

The hypotheses to be tested by use of model A are as follows:[3]

H1: The *propensity* of a firm to perform R&D at foreign locations is positively related to its O- and I-advantages and negatively to the L-*dis*advantages of host countries.

H2: A firm's preference for an equity-based rather than a non-equity governance mode is positively related to its O- and I-advantages and negatively to the L-*dis*advantages of host countries.

At this point we have to refer to the literature dealing with the decision of heterogeneous firms to become active abroad as exporters or by way of FDI (see the seminal papers of Melitz (2003) and Helpman *et al.* (2004)). The main proposition of this approach according to which only the most productive firms enter foreign markets by FDI, less productive ones export and the least productive companies exclusively serve domestic markets is widely supported by recent empirical work (for a review see Greenaway and Kneller (2007) or Wagner (2011)).[4] Based on the same approach Cieslik and Ryan (2009) showed that highly productive firms choose full ownership rather than JVs as a mode of FDI governance. Notwithstanding these results we do not insert productivity as an additional O-variable because the set of O-variables used in our model already accounts for productivity differences.[5] Adding the variable "productivity" would thus lead to biased estimates (multicollinearity). Moreover, the "heterogeneous firms approach", in the first instance, is used to explaining why firms choose FDI rather than exports (or the other way round) whereas in this paper

[2] A review of foreign entry mode research covering the OLI model, the transaction cost theory and other conceptual approaches is provided by Sarkar and Cavusgil (1996), Datta *et al.* (2002), Zhao *et al.* (2004), Brouthers and Hennart (2007) or Morschett *et al.* (2010).

[3] We formulate H1 and H2 in terms of locational *dis*advantages of host countries rather than advantages. In this way, we get a clear correspondence with the specification of the empirical model where locational variables are represented by *obstacles* to engaging abroad reflecting L-*dis*advantages of foreign locations.

[4] In case of services, the pecking order seems to be different as exporters tend to be more productive than firms entering foreign markets through FDI (see Wagner 2014).

[5] Regressing labour productivity on O-variables yields highly significant results.

the export strategy is not dealt with (among other things, because R&D is a service that is rarely exported).

2.2 Evidence from previous research related to H1 and H2

2.2.1 Propensity of foreign R&D

There are quite a few empirical studies which analysed the determinants of foreign R&D based on the OLI model. According to Arvanitis and Hollenstein (2007) all three components of the OLI model positively affect Swiss firms' foreign R&D propensity, with O- and I-advantages as dominant drivers. Rammer and Schmiele (2008) and Schmiele (2012) got similar results for Germany. Studies based on Japanese (or Japanese and Swedish) data, though not explicitly applying the OLI model, confirmed the relevance of OLI-related variables (Zejan 1990; Belderbos *et al.* 2009) or found evidence for O- and L-advantages (Odagiri and Yasuda 1996; Ito and Wakasugi 2007; Shimizutani and Todo 2008). Swedish studies (Hakanson and Nobel 1993; Andersson 1998) identified international experience (representing O-advantages) and pre-existence of production facilities as most important determinants of foreign R&D, what is in line with the "stages view of internationalisation" (Johanson and Vahlne 1977).

All in all, the evidence is quite consistent with *hypothesis H1*, although only part of the studies found that *all* components of the OLI model are driving foreign R&D.

2.2.2 Mode of Foreign R&D

To our knowledge, Brouthers *et al.* (2001) is the only study explaining the mode choice specifically for *foreign R&D*. However, because of the very small database of this OLI-based analysis it does not provide a reliable test of *hypothesis H2*.

Therefore, we report some results of the extensive research dealing with foreign entry mode *in general*. Given the vast number of such studies, we confine the literature review to contributions that *explicitly* use the OLI paradigm as a framework of analysis. It turns out that the majority of these studies confirms the adequacy of the OLI model for determining the selection of alternative equity-based modes (Erramilli *et al*. 1997; Tatoglu and Glaister 1998; Nakos and Brouthers 2002; Tsai and Cheng 2002) as well as the choice between equity- and non-equity governance arrangements (Agarwal and Ramaswami 1992; Nakos and Brouthers 2002). Although these results may not be carried over unseen to the specific case of R&D (see the introductory section), they, at least, do not prevent right from the start an OLI-based explanation of the foreign R&D mode choice.

3. Model B: Impact of foreign R&D propensity and governance on firm performance

3.1 Approach and hypotheses

Model B seeks to identify the impact of foreign R&D and the respective mode choice on a parent firm's domestic performance in terms of innovation output (model B1) and productivity (model B2).

In *model B1*, a firm's *innovation output* is explained by foreign R&D propensity and, *alternatively*, foreign R&D mode, which are the two variables we are interested in. To get reliable estimates of their effect we also have to account for a) the standard variables of the resource-based approach of explaining innovative activity (physical and human capital), b) other core variables of an innovation function (appropriaability of knowledge, market conditions) and c) some general structural firm characteristics (firm size, firm age, industry affiliation). In this approach, foreign R&D is considered as an additional element of a firm's resource base.

In *model B2*, we estimate a production function with *labour productivity* as dependent variable. We again use foreign R&D or, *alternatively,* foreign R&D mode as the two explanatory variables of interest. To ensure unbiased estimates of the respective coefficients we control for a) the classical production factors (physical and human capital), b) knowledge capital created by a parent firm's domestic R&D and c) the same structural firm characteristics we use in model B1. In model B2, foreign R&D is regarded as a specific production factor complementing the three production inputs mentioned in a) and b).

Foreign R&D (*propensity*) as it raises a firm's knowledge base and/or market position should be positively related to innovation output and productivity. The impact of the *mode* choice, however, is not so evident. We argue that the performance effect of foreign R&D activities are higher in case of an equity-based governance as in these circumstances they are integrated in the innovation and production process of the parent company more strongly than in a non-equity framework of control. The decisive role of the within-group integration is emphasised, for example, by Ambos *et al*. (2006). More specific aspects are put forward in the literature dealing with factors influencing the transfer of knowledge (which is particular relevant for knowledge-seeking foreign R&D activities). Problems in this respect are easier to keep under control if intra-group (technology-related) information flows are adequately organised and managed (Rabbiosi 2011), the foreign unit is strongly embedded in the local innovation system (Frost 2001) and if the capacity to absorbing external knowledge of the parent firm (Penner-Hahn and Shaver 2005) and its foreign unit is high (Minbaeva et al. 2003). As these conditions are easier to fulfil under an equity-based governance mode, we expect that the effect of foreign R&D on firm performance is particularly high in case of this type of control.

Furthermore, the advantage of an equity-based over a non-equity governance mode might be larger with respect to productivity than innovation performance. We argue that market-oriented foreign R&D, which mostly rests on equity-based governance, primarily raises a firm's productivity (scale effects due to the extension of foreign markets based on product adaptation to local needs by means of foreign R&D) rather than its innovation output (for evidence, see Arvanitis and Hollenstein 2011). It is the other way round in case of knowledge-seeking foreign R&D, which, at least in the short run, extends a firm's knowledge base rather than its productivity. This type of foreign R&D which often aims to get access to a completely new field of technology tends to involve high risks and uncertainties and is thus frequently performed in the framework of non-equity governance (Teece 1992). However, since market-oriented motives of foreign R&D (still) dominate (see, e.g., Criscuolo et al. 2005), we expect that the performance differential between equity-based and non-equity governance is larger with regard to productivity than innovation performance.

Against this background we formulate the following *hypotheses* (model B):

H3: *Foreign R&D* raises a parent firm's performance in terms of innovation output (H3a) as well as labour productivity (H3b).

H4: The positive effect on firm performance is larger in case of an equity-based than a non-equity mode of *governance,* independent on whether performance refers to innovation (H4a) or productivity (H4b). The performance differential between the two modes is larger in case of productivity than innovation (H4c).

3.2 Evidence from previous research related to H3 and H4

3.2.1 Impact on innovation output

Previous studies dealing with the impact of foreign R&D on a parent firm's innovation output yielded quite consistent results. Peters and Schmiele (2010) showed that German firms investing abroad in R&D are particularly innovative. Other researchers also obtained a positive innovation effect which, however, was only due to specific types of foreign R&D. For example, Iwasa and Odagiri (2004) found that "research-oriented" foreign R&D raises the patent output of Japanese companies, but the same was not true for "application-oriented" R&D. Similarly, Piscitello and Rabbiosi (2007) got a positive effect on the innovativeness of Italian parent firms only in case of "competence-creating" foreign R&D. Arvanitis and Hollenstein (2011) showed for Swiss companies that knowledge-seeking foreign R&D positively affect a parent company's sales of innovative products, whereas market- or efficiency-oriented R&D do not have such an effect. Ambos *et al.* (2006) found for European multinationals that R&D investments of foreign subsidiaries have a positive impact on the parent

firms' innovativeness, but only if the foreign units are highly integrated into the innovation network of the whole company.

All in all, the evidence is in line with *hypothesis H3a*, although the majority of studies found a positive innovation effect only for knowledge-related types of *foreign R&D*.

Finally, we notice that, to the best of our knowledge, there is no empirical research dealing with the innovation effect of the choice between equity-based and non-equity foreign *R&D governance* (*hypothesis H4a*).

3.2.2 Impact on productivity

Previous research with respect to the impact of foreign R&D on a parent firm's productivity (growth) yielded somewhat ambiguous results. Higon *et al.* (2011) obtained a positive output effect of foreign R&D in case of UK multinationals. Other studies also found a positive effect which, however, was due only to specific categories of foreign R&D. For example, Todo and Shimizutani (2008) showed for Japanese companies that overseas R&D aiming at the acquisition of knowledge raised the growth of total factor productivity (TFP), but the same was not the case for R&D focusing on the adaptation of products to foreign market needs. In the Swiss case, in contrast to Japan, the overall positive impact on labour productivity was the result of market- and efficiency-seeking foreign R&D, whereas knowledge-seeking R&D did not have such an effect (Arvanitis and Hollenstein 2011). Another study for Switzerland (Ben Hamida and Piscitello 2013) did not find a positive relationship between total foreign R&D and productivity growth, but they obtained such an effect if only knowledge-seeking R&D was considered. Griffith *et al.* (2006) identified positive effects on TFP growth in case of UK multinationals that invested in technology-sourcing R&D at US locations. In contrast to these studies, Fors (1997) using Swedish data did not find any significant productivity effects.

To sum up, the majority of empirical studies indeed obtained the expected positive productivity effect, which, however, was primarily due to specific categories of foreign R&D. Nevertheless, the findings are largely in line with *hypothesis H3b*.

Brouthers *et al.* (2001), to our knowledge, is the only analysis of the impact of foreign *mode choice* on firm performance for the specific case of R&D. However, the study does not provide a valid test of *hypothesis H4b* as it relied on sixteen observations only.

4. Data and Incidence of Foreign R&D

In the *Swiss* case, the firm data stem from a survey conducted in 2010 by the KOF Swiss Economic Institute[6] among a random sample of 4533 firms (5 or more employees) drawn from the official enterprise census of 2008. The sample covers the whole business sector and is stratified by 29 industries and 3 firm size classes. Valid information was provided by 1921 companies (response rate: 42%). In the reference period 2006-2008, 659 of the responding firms invested in R&D, of which 152 (23%) did so also abroad with 70% of them relying on equity-based governance. After deleting observations with missing values for one or more variables of the model we got a final sample of 415 to 525 *R&D performing firms*, the precise number of observations depending on the specific equation to be estimated. In models referring only to companies which, *additionally*, undertook *R&D abroad* the number of observations is in the range of 100 to 110, again depending on the specific equation to be estimated.[7]

In the same year, a similar survey was conducted in the Austrian business sector. In contrast to Switzerland, the questionnaire[8] was not addressed to a representative sample of firms but to all companies whose innovation activities were supported by the Austrian Research Promotion Agency (FFG) at least once in the period 2005-2009. The questionnaire was sent to 5702 firms, of which 410 provided the required information. The low response rate (7%) is partly due to the fact that the subsidised innovation projects in many instances were based on engineering, consultancy and similar activities rather than on R&D. As this is the case for about 50% of all innovative firms (Statistik Austria 2012) the response rate *effectively* may be in the order of 14%. As the proportion of R&D performing firms according to the official R&D census is about the same (16%) we conclude that the low response rate does not imply *per se* a strongly biased sample. This might hold true the more as the size and industry composition of our dataset and that of the official R&D statistics are very similar. To get a sample comparable to the Swiss one, we excluded the firms with less than five employees ending up with a dataset of 284 R&D performing companies, of which 140 (49%) did so also abroad with 43% of them relying on equity-based governance. The final dataset (after deletion of observations with missing values) comprises, depending on the specific equation to be estimated, 200 to 237 *R&D performing firms*. In models referring only to the companies which, *additionally*, undertook *R&D abroad* the number of observations lies in the range of 95 to 107 observations. All in all, we conclude

[6] The questionnaire of the Swiss survey can be downloaded from http://www.kof.ethz.ch/de/umfragen/strukturumfragen/andere-umfragen/internat2010/.

[7] "Some information on the access to the data by external researcher is found in the appendix."

[8] The Austrian questionnaire is available on http://www.joanneum.at/uploads/tx_publicationlibrary/RR59_02.pdf.

that the Austrian sample, though not of the same quality as the Swiss one, also allows reliable estimates.

Table 1 shows the industry and size composition of the firms that invested in R&D only at home and of those which, additionally, did so abroad. It also indicates, by industry and firm size, the relevance of foreign R&D in total and by governance mode. We identify four major differences between the two countries: Firstly (see cols. 5 and 6 vs. 1 and 2; upper part of the table), the share of knowledge-intensive service firms is significantly larger in the Austrian dataset, and that is true for firms investing in R&D only at home as well as for those also active abroad; in the Swiss case, high-tech manufacturing stands out, particularly with respect to the firms undertaking R&D also abroad. Secondly (cols. 5 and 6 vs. 1 and 2; lower part), the share of small firms performing R&D (whether only at home or also abroad) is very high in Austria, whereas in Switzerland larger firms are more prominent: medium-sized companies with regard to "domestic R&D only", large companies among the firms active in R&D also abroad. Thirdly (col. 4 vs. 8), in the Swiss economy, equity-based governance modes of foreign R&D are more prevalent than non-equity arrangements, whereas it is the other way round in Austria. Finally (col. 7 vs. 3), the number of firms with foreign R&D as a percentage of *all* R&D performing companies is larger in the Austrian than in the Swiss sample. This observation, though somewhat surprising at first sight, is not inconsistent with the fact that outward FDI *flows* of Switzerland are much higher than those of Austria (see Section 1) because Swiss firms engaged abroad in R&D are larger and more frequently equity-based than their Austrian counterparts (see above).

Table 1 (about here)

We complete the data section by indicating that many variables used in model estimation are dummies (yes/no; high/low). The *high/low* dummies pertain to specific *obstacles* and *motives* to investing abroad in R&D as well as to *coordination costs*. These variables originally were measured on a 5-point Likert scale reflecting a firm's *qualitative* judgments of the relevance of specific factors for deciding on internationalisation. For model estimation, the ordinal measures of relevance, ranging from "very high" (5) to "very low" (1), were throughout converted into dummies with value 1 (originally 4 or 5) and zero (originally 1, 2 or 3); for details see the specification of model A (Table 2 in subsection 5.1).

5. Specification of the empirical models and estimation procedure

5.1 Specification of model A: Determinants of foreign R&D

5.1.1 Dependent variables

Model A is made up by two probit equations. The "propensity equation" determines the likelihood of a firm to invest in foreign R&D (RDFOR). The "mode equation" explains, given a firm is active abroad in R&D, why it chooses an equity-based rather than a non-equity governance mode (MODE: value 1 for equity-based mode; zero otherwise). The mode equation may yield biased estimates as it can be estimated only for firms with foreign R&D. To account for this problem we use a two-stage Heckman selection model (Heckman 1979).

5.1.2 Independent variables

RDFOR and MODE are explained by three sets of variables capturing O-, L- and I-advantages which are complemented by some general controls (industry affiliation, etc.). The *mode* equation, additionally, contains variables representing motives of foreign R&D and experience gained from export/FDI transactions with specific foreign regions (no data for firms without foreign R&D). In the *propensity* equation we inserted two variables to ensure the identification of the Heckman model, that is "export intensity" (X1, X2) and "degree of competition" (COMP); for justification of the two variables, see subsection 5.3.1.

In the following we discuss the specification of the explanatory part of the model. Exact definition and measurement of the variables as well as sign expectations are shown in Table 2.

Table 2 (about here)

O-advantages: O-advantages of parent companies are expected to be positively related to RDFOR and MODE. We consider R&D (LRDS) and human capital intensity (LHC) as variables capturing strategic asset availability. We also account for physical capital intensity (LCL) as machinery may contain a firm-specific element as well. Besides, we insert dummies standing for the use of patents (PAT) and brands/copyrights (BRANDCOPY); these variables, in addition to capturing firm-specific assets, represent specific instruments of protecting a firm's knowledge.

International experience, as emphasised by the stages view of internationalisation, is an important factor determining foreign activities (*O-advantage*). In the RDFOR equation, we use as explanatory variable a measure of "*basic international experience*" ("export intensity": dummies X1 and X2, reflecting different levels of export shares; see below, subsection 5.3). In the MODE equation, however, we apply a more "demanding" measure of experience. More specifically, we presume that

"*extended international experience*" in terms of complexity (FDI in addition to exports; transactions with distant and not only nearby regions) creates larger O-advantages than basic experience, thus raising the likelihood of selecting an equity-based mode of control. To capture the extended experience effect we include dummies for a firm's presence by means of FDI/exports in regions of different distance: Asian countries (ASIA), Eastern Europe (EAST), North America/Mexico (NAFTA) and "Rest of the world" (ROW) with EU/EFTA as reference region. The dummies should be positively associated with MODE as almost all firms are active in EU/EFTA; the largest coefficient is expected for ASIA.

L-disadvantages: The model contains four dummy variables (high/low) reflecting a firm's assessment of the relevance of specific obstacles to investing abroad in R&D. As these stand for *dis*advantages of foreign countries, they should be negatively related to RDFOR. The L-*dis*advantages of host locations we considered are "insufficient protection of intellectual property rights" (IPR), "lack of R&D personnel" (STAFF), "restrictive regulatory environment" (REGUL) and "cultural distance between foreign and domestic locations" (CULTDIST). We also expect a negative relationship between the L-variables and MODE as equity-based foreign activities are more risky and require larger resource commitments than non-equity engagements (Anderson and Gatignon 1986).

Among the L-variables, CULTDIST is a special case as *part* of the literature provides arguments suggesting, contrary to the other obstacle variables, a *positive* sign. With regard to RDFOR, it is pointed out that the penetration of culturally different target markets is easier if products are adapted to the specific needs by local R&D activities rather than by way of exporting. With respect to MODE it is argued, for example, that equity-based governance is superior to a non-equity mode in case a foreign unit, due to cultural differences, is not sufficiently able to absorb knowledge stemming from the parent company (Morschett *et al.* 2010). It is thus not surprising that the empirical evidence with respect to influence of cultural distance on mode choice is inconclusive (Tihanyi *et al*. 2005). Therefore, we do not postulate for CULTDIST *a priori* a specific sign.

I-advantages: To account for I-advantages, we use firm size (SIZE) and the costs of coordinating foreign and domestic R&D activities (COORD: high/low). SIZE stands for I-advantages reflecting the superiority of large firms in managing international R&D (positive relationship between SIZE and, respectively, RDFOR and MODE).[9] Besides, we presume that high coordination costs deter firms from investing abroad in R&D (negative correlation between COORD and RDFOR); in contrast, COORD and MODE should be positively related since, given a firm is active abroad in R&D, such costs can be

[9] We notice that SIZE also captures some not explicitly specified *size-dependent O-advantages* (e.g. access to the capital market).

reduced by selecting a high-control mode (Anderson and Gatignon 1986; Brouthers and Hennart 2007).

Motives of foreign R&D: The OLI model implies that MODE also is influenced by the motivation for investing abroad in R&D (no data for firms without foreign R&D). Recent studies dealing with entry mode choice *in general* found that market-oriented motives are positively associated with high-control governance (Tsai and Cheng 2002; Gil *et al.* 2006), but the results are contradictory in case of cost-reducing motives (Shan 1991; Shi *et al.* 2001; Gil *et al.* 2006). Our model accounts for market-oriented (RDMARK), cost-reducing (RDCOST) and knowledge-seeking (RDKNOW) motives of foreign R&D (dummies: high/low relevance). RDMARK should positively correlate with MODE (O-advantages of parent companies, L-advantages of host countries). In case of RDKNOW, we expect a negative sign as co-operative agreements are a flexible and efficient way of acquiring highly specific knowledge (Teece 1992; Narula and Zanfei 2005). Finally, we have no *a priori* sign expectation in case of RDCOST as the general entry mode literature is inconclusive in this respect.

Control variables: Foreign-owned companies (FOR) are less likely to invest abroad in R&D than domestic firms as they benefit from knowledge obtained from their parent company. If foreign-owned firms are active abroad in R&D they probably seek highly specific knowledge that most effectively may be accessed through R&D co-operations. We thus expect a negative sign of FOR in both equations. In contrast, firm age (LAGE) as an indicator of market experience should be positively related to RDFOR and MODE. Finally, we account for industry-specific effects depicting, for example, diverging business conditions in the reference period. Industry dummies also control for a potential "omitted variable bias".

5.2 Specification of model B: Impact of foreign R&D on firm performance

5.2.1 Innovation equation (model B1)

As dependent variable of the innovation equation we use the (logarithm of) "sales of new or significantly improved products per employee" (LINNL). RDFOR and MODE, for which we expect a positive sign, are the explanatory variables we are interested in. To get reliable estimates of the innovation effect of these two variables, we have to control for some standard variables used in the empirical literature for explaining a firm's innovation output: resource endowment (physical and human capital intensity: LCL, LHC), appropriability of knowledge (PAT, BRANDCOPY), market environment (market structure: COMP; intensity of price and non-price competition: IPC, INPC) and controls for firm size (SIZE), foreign ownership (FOR), firm age (LAGE) and industry affiliation. Based on the standard findings of empirical innovation research we expect a positive influence of

resource endowment, appropriability of knowledge, intensity of non-price competition and foreign ownership. A positive effect of price competition, if it actually exists, is expected to be small. There are no clear sign expectations with respect to firm size (as we only consider R&D performing companies), market structure and firm age. Exact variable definitions and sign expectations for model B are shown in Table 3.

Table 3 (about here)

5.2.2 Productivity equation (model B2)

As dependent variable of the productivity equation we use labour productivity (logarithm of value added per employee: LQL). Again RDFOR and MODE, for which we expect a positive sign, are the explanatory variables we are interested in. To get reliable estimates of the effect of RDFOR and MODE on productivity we control for the influence of the input factors of a standard production function (physical, human and knowledge capital: LCL, LHC and LRDL; positive sign). Besides, we insert the same general control variables we apply in the innovation equation. In accordance with the literature we expect a positive sign for variable FOR but have no *a priori* sign expectations for SIZE and LAGE (see Table 3).

5.3 Methodological problems

5.3.1 Sample selection bias

MODE is measured only for firms that are active in R&D abroad, what, as already mentioned, may give rise to a selection bias in estimating the mode equation (model A). We accounted for this problem, never dealt with in entry mode research, by applying a two-stage Heckman correction (Heckman 1979). To identify the Heckman model we included in the propensity equation two variables not used in the mode equation, that is “export intensity” (dummies X1, X2) and “competitive environment” (COMP: number of principal competitors on the world market). We justify the use of these instruments by arguing, firstly, that some “basic international experience” (represented by X1, X2) suffices to explain the overall decision to locate R&D abroad (“propensity equation”), whereas, as mentioned in subsection 5.1.2, a firm may consider *equity*-based foreign R&D (“mode equation”) only if it has more advanced experience from international transactions. “Competitive environment” (COMP) is used as an instrument based on the view that foreign R&D is a means to escape intensive competition (for example, by choosing a first mover strategy), whereas COMP should not significantly influence the mode selection.

The estimates of the Heckman model showed that selectivity is not a real problem in our analysis. The identifying variables X1, X2 and COMP are statistically significant in the propensity equation, and the "inverse mills ratio" inserted in the mode equation is statistically *not* significant at any reasonable test level, neither in the Swiss nor the Austrian case. Therefore, it is justified to estimate the propensity and the mode equation of model A independently (two separate equations).

5.3.2 Endogeneity and causality

The estimates of model A and B are based on cross-section data, what is common practice in entry mode research.[10] Consequently, all explanatory variables are suspicious of being endogenous. Therefore, rather than making causal claims, we interpret the estimated coefficients as partial correlations what, however, does not preclude an evaluation of our hypotheses.[11]

A specific problem of cross-section estimation of model B refers to the direction of causality of foreign R&D and firm performance. As discussed in subsection 2.1, the literature dealing with the internationalisation of *heterogeneous* firms identified (lagged) productivity as the main factor determining why a company self-selects into FDI; accordingly, causality runs, contrary to our model B, from productivity to FDI. However, there also is evidence for the reverse causality running from FDI to productivity, even if it is controlled for self-selection (learning effects). This also holds true for R&D- and innovation-related FDI (see Pfaffermayr and Wolfmayr 2013). Against this background we estimated the two performance equations (model B1 and B2) accounting for a possible two-way relationship between RDFOR and MODE respectively and firm performance. We thus instrumented RDFOR and MODE in order to test for endogeneity of these variables by applying the procedure of Rivers and Vuong (1988).

For Austria, the test procedure did not yield any evidence for endogeneity of RDFOR and MODE, independent of whether innovation output or labour productivity was used as dependent variable. The coefficients of the residuals (predicted value of the instrumented variables minus value of the original variables) were not significant at the 10% test level. For Switzerland, we could reject endogeneity of RDFOR and MODE in all equations with the exception of RDFOR in the innovation equation. Given these results, we proceeded as follows: In the *one* case for which endogeneity could not be rejected, we performed a two-stage IV-Tobit estimation with the predicted value of RDFOR used as explanatory variable in the second stage equation (see Wooldridge 2002). This procedure yielded the final estimate of the coefficient of RDFOR in the innovation equation for Switzerland (Table 5, col. 1). If there was

[10] Exceptions are Barkema *et al*. (1996) as well as Chen and Chang (1996).
[11] To our knowledge, Shaver (1998) is the only entry mode study dealing with endogeneity.

no indication of endogeneity, we used the equations based on the original variables (Table 5, cols. 2 to 4 and Table 6, cols. 1 to 4).

6. Empirical results

6.1 Model A: Determinants of propensity and governance of foreign R&D

6.1.1 Propensity of foreign R&D

For *both countries*, all *categories* of OLI variables (with differences only for a few individual variables) contribute to explaining foreign R&D propensity (RDFOR). The findings (see Table 4, cols. 1 and 3) support thus *hypothesis H1* what is in line with previous work (see subsection 2.2.1).

For the majority of *O-variables* we obtained the expected positive sign: R&D and human capital intensity (LRDS, LHC), brands/copyrights (BRANDCOPY; Austria only), "basic international experience" (X1, X2).

We also found a significant effect for two variables representing *L-disadvantages* of host locations, that is "insufficient protection of property rights" (IPR) and "large cultural distance" (CULTDIST); the other two L-variables (regulatory restrictions, lack of R&D personnel) do not influence RDFOR. "Insufficient IPR protection" in target regions affects foreign R&D of Austrian and Swiss companies differently. In case of Austria, weak IPR regulation, in line with expectations, deters firms from investing abroad in R&D; the opposite is true for Swiss companies for which insufficient IPR protection at foreign locations obviously is not an impediment. This may be due to the fact that the majority of foreign R&D projects are extensions of manufacturing facilities (for evidence, see Pfaffermayr and Wolfmayr, 2013) which previously were established independent of the local R&D regime – a particularly relevant argument in case of highly internationalised countries such as Switzerland. Besides, we found that cultural distance (CULTDIST; data for Switzerland only) is positively related to RDFOR, what is not surprising given the ambiguous results of previous research. Investing abroad in R&D to adapt products to local market needs is thus an effective means to overcoming cultural distance as a barrier to serving foreign markets.

For the two variables representing *I-advantages* we got the expected sign though not for both countries. In the Austrian case, large firms (SIZE), as hypothesised, are more inclined to be active abroad in R&D, whereas for Switzerland we did not find a size effect what, however, is not very surprising given the large share of internationalised SMEs (Hollenstein 2005). High coordination costs (COORD), as predicted, deter foreign R&D investments though only in the Swiss case.

6.1.2 Mode choice

Hypothesis H2, postulating that the OLI model is able to explain why a firm chooses an equity-based rather than a non-equity governance mode (MODE), is largely confirmed for *both countries*. For Switzerland, all *categories* of OLI variables (though relatively few variables within the O- and I-category) yielded statistically significant results. For Austria, only the OL-part of the model contributes to explaining mode selection. For both countries, the results for the experience and motive variables are convincing (see Table 4, cols. 2 and 4).

More specifically, among the O-advantages, the variables resource use, market-oriented motives of R&D and international experience are crucial for explaining a firm's preference for an equity-based mode (positive sign). Human capital intensity (LHC) and market-oriented motives (RDMARK) are relevant in both countries. "Extended international experience" (captured by region-specific experience variables) is a highly important explanatory variable across the board in Austria (positive sign for ASIA, NAFTA and EAST, with the largest effect, as expected, for the most distant region, i.e. ASIA), whereas it is only a secondary factor for Swiss companies (EAST). This difference is not surprising in view of the large and regionally highly diversified FDI stock of the Swiss economy; in these conditions the benefits due to a marginal increase of experience from transactions with distant regions are small. Furthermore, we obtained the expected negative sign for RDKNOW (though statistically significant only for Austria).

Among the *L-disadvantages*, we got the expected negative effect of a "restrictive regulatory framework" (REGUL; Austria only), meaning that equity-based foreign R&D are less attractive than non-equity ventures. For CULTDIST (no data for Austria) we obtained a positive sign; Swiss companies thus select an equity-based mode as a means to internalise the risks entailed by cultural distance.

I-advantages are statistically significant only in the Swiss case. We found the expected positive sign for firm size (SIZE) and coordination costs (COORD), what again may reflect the Swiss firms' long-standing international experience enhancing their capability to internalise R&D-related transaction costs.

Table 4 (about here)

6.2 Model B: Impact of foreign R&D and its governance on firm performance

6.2.1 Model B1: Innovation output

Hypothesis H3a, stating that foreign R&D raises a parent firm's innovation output (LINNL), is confirmed for *both countries*. We found a significant positive effect of RDFOR on LINNL, having controlled for the standard determinants of innovation output and some structural firm characteristics (see Table 5, cols. 1 and 3). The positive innovation effect, which also was identified in earlier studies (see subsection 3.2.1), is larger for Swiss than for Austrian firms. With regard to the standard variables of an innovation function we got for Switzerland, with the exception of the intensity of non-price competition, the expected positive signs: resource use (LCL, LHC), knowledge protection (PAT) and foreign ownership (FOR). The estimates based on Austrian data yielded a quite similar pattern.

Hypothesis H4a, postulating that the (positive) contribution of foreign R&D to a parent firm's innovation output is larger in case of an equity-based than a non-equity governance mode, is *not supported* neither for *Switzerland* nor for *Austria*. The coefficient of MODE is statistically insignificant, having controlled for the standard variables of an innovation function (see Table 5, cols. 2 and 4). The size of the positive impact of foreign R&D on innovation performance is thus independent of the R&D mode choice.

Table 5 (about here)

6.2.2 Model B2: Labour Productivity

Hypothesis H3b, predicting that foreign R&D raises a parent firm's labour productivity, is confirmed *only for Switzerland* (see Table 6, cols. 1 and 3). The effect of foreign R&D activities (RDFOR) on labour productivity (LQL) is significantly positive, having controlled for the classical production inputs (positive sign of physical, human and knowledge capital intensity: LCL, HCL, LRDL) and some structural firm characteristics. The results are in line with previous studies although they partly identified such an effect only for some types of foreign R&D (see subsection 3.2.2). For *Austria*, neither RDFOR nor the production function part of the model yields significant effects.

Hypothesis H4b postulates that the contribution of foreign R&D to a parent firm's productivity is higher in case of equity-based than non-equity governance. For *Switzerland*, the findings, at least as a clear tendency, are in line with the hypothesis; the positive coefficient of MODE nearly passes the test of significance at the 10% level ($p=0.12$)[12] having controlled for the classical factor inputs and some

[12] The productivity advantage of an equity-based over a non-equity governance mode might be statistically significant if lagged productivity effects would have been accounted for (what is not possible in a cross-section analysis).

structural firm characteristics. In contrast, H4b is clearly rejected for *Austria* (see Table 6 cols. 2 and 4).

Hypothesis H4c is confirmed for *Switzerland* as can be seen from a comparison of the results for model B2 and B1: the productivity differential between choosing an equity-based rather than a non-equity governance mode (col. 2 of Table 6) is positive (at least as a strong tendency), but there is no such difference with respect to innovation output (col. 2 of Table 5). For *Austria*, a test of H4c is not feasible as H4b (model B2: productivity) and H4a (model B1: innovation) were rejected.

Table 6 (about here)

7. Summary and conclusions

The strong growth of international R&D over the last two decades was accompanied by an increasing importance of non-hierarchical governance of this type of activity. It is thus quite surprising that, to date, the extensive literature dealing with foreign market entry fully neglected the analysis of the mode choice for the specific case of foreign R&D; the more so as the findings from the general foreign entry mode research cannot be carried over unseen to R&D. To fill this gap, we analysed, *firstly*, why firms locate R&D activities abroad and, what is at the core of interest, why some of them choose an equity-based rather than a non-equity mode of governance. *Secondly*, we sought to determine the impact of foreign R&D on a parent firm's performance in terms of innovativeness and productivity, thereby asking for possible differences between governance modes.

The study is based on parallel estimations of identically specified models for Swiss and Austrian companies. The firm-level data stem from similar surveys conducted in the business sector of Switzerland and Austria in 2010. The comparative approach allows to identify country-specific patterns of explanation from which we may gain insight into the relationship between mode choice (and its performance effects) and the degree of internationalisation (which is much higher in the Swiss economy).

The synopsis of the empirical results (see Table 7) shows that the OLI model as specified in this study succeeds to explaining for both countries why a firm performs R&D abroad and in what conditions it chooses an equity-based rather than a non-equity governance mode. We found many similarities of the pattern of explanation (what could not be taken for granted) but also some important divergences, in particular with respect to the mode choice. The differences to a substantial extent reflect the disparities between the two countries with respect to the level of internationalisation. International experience of a more complex nature, particularly from transactions with distant regions, is highly relevant as a factor determining R&D mode choice of Austrian firms, but the same is not true for Swiss companies as

many of them since long are accustomed to interact with partners from all over the world. Long-standing international experience may also explain why only Swiss firms are able to internalise the uncertainties of foreign R&D investments arising from large cultural distance, weak IPR protection in target countries or high coordination costs.

Table 7 (about here)

Larger are the differences between the two countries with regard to the impact of foreign R&D on a firm's innovation output and productivity. For Switzerland, we obtained the hypothesised positive effect of foreign R&D on innovation and productivity, whereas in the Austrian case only the innovation effect was significant. Moreover, we found, though only for Switzerland, that the impact on productivity, as expected, is larger in case of an equity-based than a non-equity mode of governance, whereas the effect on innovation does not depend on the mode choice. The divergences between the two countries with regard to the performance effects of foreign R&D again might be due to the more widespread and long-standing presence of Swiss firms at foreign locations. In these circumstances, foreign R&D, particularly in case of equity-based governance, is highly integrated in the value creating process of parent firms implying strong performance feedbacks.

Considering scope and findings of the analysis and the complete lack of studies dealing with foreign mode choice with respect to R&D, we add to previous research in several respects. Firstly, the analysis showed that the OLI model is a robust framework not only for explaining why firms invest abroad in R&D (what is in line with the literature) but also (what is new) why they choose an equity-based rather than a non-equity governance mode. Secondly, it turned out, though only for Switzerland, that the impact of foreign R&D on a parent firm's performance depends on the mode choice (a topic not analysed in previous research). Thirdly, we identified similarities and divergences of the patterns of explanation for the two countries, with the discrepancies primarily reflecting different levels of internationalisation. Finally, we accounted for selectivity and endogeneity problems, which were completely neglected in entry mode research.

Although the study substantially extends previous research, it has its limitations which primarily are due to the cross-section nature of the data. As a consequence, it is impossible to analyse dynamic aspects of internationalisation such as the path-dependence of mode choice or time lags of performance effects. For the same reason, the results, rather than indicating causal relationships, have to be interpreted as partial correlations, what, however, still allows to assess whether the findings are consistent with the hypotheses. Furthermore, the results of the comparison between the Swiss and the Austrian economy cannot be generalised. It would thus be worthwhile to investigate whether the

results for Switzerland are characteristic for other countries that are very active in R&D at foreign locations, and whether the findings for Austria are representative for economies only weakly internationalised in this respect.

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Table 1: **Data structure and incidence of foreign R&D by industry/sector (NACE codes) and firm size class**

	Switzerland				Austria			
	Sectoral and size distribution of firms with		Share of firms with		Sectoral and size distribution of firms with		Share of firms with	
	only domestic R&D	*foreign (*and domestic) R&D	*foreign* (and domestic) R&D	*equity-based foreign* R&D	*only domestic* R&D	*foreign (*and domestic) *R&D*	*foreign* (and domestic) R&D	*equity-based foreign* R&D
	%	%	(% of *all* firms with R&D)	(% of firms with *foreign* R&D)	%	%	(% of *all* firms with R&D)	(% of firms with *foreign* R&D)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry / Sector								
High-tech manufacturing	*49.6*	*67.1*	*31.2*	*68.6*	*40.9*	*40.0*	*48.3*	*49.9*
- Chemicals / Pharma (20, 21)	8.3	9.9	27.3	46.5	7.4	7.1	47.6	50.0
- Electronics (26, 27)	17.3	27.6	36.8	66.8	14.8	17.9	59.5	64.0
- Machinery (28)	17.1	24.3	32.7	78.6	13.7	10.7	38.5	26.8
- Other (22, 29, 30)	6.8	5.3	17.8	74.7	4.9	4.3	42.9	49.9
Low-tech manufacturing	*31.1*	*15.8*	*11.7*	*79.5*	*21.1*	*23.6*	*55.0*	*57.6*
- Metalworking (24, 25)	9.9	6.6	15.4	59.7	6.3	7.1	55.6	50.0
- Other (10-19, 23, 31, 32, 33)	21.2	9.2	10.0	93.0	14.8	16.4	54.8	60.8
Knowledge-intensive services	*12.3*	*11.8*	*22.2*	*61.3*	*31.0*	*31.4*	*50.0*	*0*
- ICT / R&D (61, 62, 63,74, 85)	3.8	3.9	24.0	16.7	12.7	12.9	50.0	0
- Finance / HQ (64, 65, 70)	2.9	3.3	26.3	100	3.5	3.6	50.0	0
- Business services. (71, 72)	5.6	4.6	18.9	71.4	14.8	15.0	50.0	0
Other industries [a]	*7.0*	*5.3*	*17.4*	*74.7*	*7.0*	*5.0*	*35.0*	*57.1*
Firm Size (number of employees)								
5 to 49	25.9	15.8	14.0	37.9	47.9	42.1	43.4	18.7
50-249	44.2	36.2	18.9	74.6	26.4	21.4	40.0	53.3
250 and more	29.9	48.0	37.1	76.5	25.7	36.4	69.9	64.7
Total	100	100	23.1	69.7	100	100	49.3	42.8

[a] Agriculture; Electricity; Water supply; Construction; Wholesale and retail trade; Transportation and storage; Accommodation and food services; Real estate; Administrative and support service activities.

Source: KOF Swiss Economic Institute; Joanneum Research, POLICIES, Centre for Economic and Innovation Research.

Table 2: **Specification of the explanatory variables in model A: *Foreign R&D*** [a]

Explanatory variables	Description	Foreign R&D yes/no RDFOR	Equity-based vs. non-equity mode of foreign R&D yes/no MODE
O-advantages			
LRDS	R&D expenditures, % of sales (logarithm)	+	+
LHC	Personnel with tertiary degrees, % of total employment (logarithm)	+	+
LCL	Investment in physical capital per employee (logarithm) (Switzerland: firm level; Austria: industry level)	+	+
Knowledge protection (Dummy variables with value 1 if the specific protection instrument is used (Austria) or is highly effective (Switzerland); otherwise 0)			
PAT	Patents	+	+
BRANDCOPY	Brands, copyrights	+	+
Basic international experience (Dummy variables with value 1 for a specific range of the sales to export ratio; otherwise 0)			
X1, X2	Share of exports: 26-70% and 71-100%; reference group: 0-25%	+	/
Extended international experience (Dummy variables (based on exports and/or FDI yes/no) with EU/EFTA as reference group)			
EAST	Eastern Europe	/	+
ASIA	China, India, other Asian countries	/	+
NAFTA	USA, Canada, Mexico	/	+
ROW	Rest of the World (excl. Western Europe)	/	+
L-*dis*advantages of *host* locations *Obstacles* to foreign R&D activities in (potential) host countries (Dummy variables with 1 for high relevance of a specific obstacle (values 4 or 5 on a 5-point Likert scale); otherwise 0)			
REGUL	Excessive regulation of economic activity	-	-
IPR	Insufficient protection of intellectual property rights	-	-
STAFF	Lack of R&D personnel	-	-
CULTDIST	Large cultural distance (Switzerland only)	?	?
I-advantages / Firm size			
SIZE	Number of employees (logarithm)	+	+
COORD	High/low coordination costs (values 4 or 5 on a 5-point Likert scale) as an obstacle to foreign R&D	-	+
Market environment			
COMP	*Market* structure: number of principal competitors *Switzerland*: Share of firms with more than 15 principal competitors on the world market (3-digit industry level); *Austria*: Dummy variable with value 1 for more than 15 principal competitors; otherwise 0 (firm level)	+	/
Motives of foreign R&D (Dummy variables with value 1 for high relevance of a *motive* (value 4 or 5 on a 5-point Likert scale); otherwise 0)			
RDMARK	Market-oriented foreign R&D (as a means to supporting local production and sales)	/	+
RDCOST	Cost-oriented foreign R&D (lower R&D costs; higher R&D-related subsidies and tax allowances)	/	?
RDKNOW	Knowledge-seeking foreign R&D (proximity to top universities; proximity to highly innovative firms; relevance of reverse technology transfer)	/	-

Control variables			
FOR	Foreign-owned firm (yes/no; dummy variable)	-	-
LAGE	Firm age (number of years; logarithm)	+	+
IND_1, …, IND_9	Industry dummy variables (reference group: ”other industries”; for definition see Table 1	yes	/
S1, …, S3	Sector dummy variables: (S1: high-tech manufacturing, S2: knowledge-intensive services, S3: other industries, with low-tech manufacturing as reference group; for definition see Table 1)	/	yes

[a] Variables not used in the one or the other equation are marked with /.

Table 3: **Specification of the explanatory variables in model B: *Firm performance*** [a]

		Innovation equation	Productivity equation
Explanatory variables	Description	Sales of innovative products per employee (logarithm) LINNL	Value added per employee (logarithm) LQL
Foreign R&D			
RDFOR *or* ***alternatively***	Foreign R&D (dummy variable yes/no)	+	+
MODE	Equity-based mode of foreign R&D (value1) vs. non-equity mode of foreign R&D (value 0)	+	+
Resource use			
LCL	Investment in physical capital per employee (logarithm) (Switzerland: firm level; Austria: industry level)	+	+
LHC	Personnel with tertiary degrees, % of total employment (logarithm)	+	+
LRDL	R&D expenditures per employee (logarithm)	/	+
Knowledge protection (Dummy variables with value 1 if the specific protection instrument is used (Austria) or is highly effective (Switzerland); otherwise 0)			
PAT	Patents	+	/
BRANDCOPY	Brands, copyrights	+	/
Market environment			
Marktet structure (Number of principal competitors on the world market)			
COMP	*Switzerland*: Share of firms with more than 15 principal competitors on the world market (3-digit industry level); *Austria*: Dummy variable with value 1 for more than 15 principal competitors; otherwise 0 (firm level)	?	/
Intensity of competition (Dummy variables with value 1 for high intensity of competition on the firm's principal markets worldwide; otherwise 0; *Switzerland*: 3-digit industry-level; *Austria*: firm level)			
IPC	Intensity of price competition	?	/
INPC	Intensity of non-price competition	+	/
Control variables			
SIZE	Number of employees (logarithm)	?	?
FOR	Foreign-owned firm (yes/no; dummy variable)	+	+
LAGE	Firm age (number of years; logarithm)	?	?
IND_1, …, IND_9	Industry dummy variables (reference group: "other industries"; for definition see Table 1	yes	/
S1, …, S3	Sector dummy variables: (S1: high-tech manufacturing, S2: knowledge-intensive services, S3: other industries, with low-tech manufacturing as reference group; for definition see Table 1)	/	yes

[a] Variables not used in the one or the other equation are marked with /.

Table 4: **Results for model A:** ***Determinants of propensity and governance of foreign R&D*** [a]

	SWITZERLAND		AUSTRIA	
Explanatory Variables [b]	Foreign R&D yes / no (RDFOR)	Equity-based vs. non-equity-mode of R&D governance (MODE)	Foreign R&D yes / no (RDFOR)	Equity-based vs. non-equity-mode of R&D governance (MODE)
	Probit	Probit	Probit	Probit
O-advantages				
LRDS	.125*	-.063	.151**	-.193
	(.068)	(.125)	(.064)	(.140)
LHC	.242**	.601*	.064*	.489**
	(.123)	(.337)	(.036)	(.233)
LCL	.096	-.115	.145	-.290
	(.090)	(.123)	(.200)	(.343)
PAT	.085	-.337	.082	-.257
	(.184)	(.358)	(.217)	(.447)
BRANDCOPY	.120	-.226	.578***	1.24***
	(.178)	(.415)	(.207)	(.471)
X1	.581**	/	.589**	/
	(.264)		(.288)	
X2	.684***	/	.655**	/
	(.251)		(.311)	
EAST	/	1.29***	/	.878**
		(.480)		(.396)
ASIA	/	.598	/	2.41***
		(.426)		(.748)
NAFTA	/	.109	/	1.13**
		(.452)		(.511)
ROW	/	-.007	/	-1.36**
		(.376)		(.542)
L-disadvantages				
REGUL	-.097	.430	-.192	-2.87**
	(.188)	(.388)	(.380)	(1.208)
IPR	.694***	-.681	-.596***	-.649
	(.210)	(.441)	(.221)	(.452)
STAFF	-.211	.501	-.132	-.521
	(.225)	(.438)	(.289)	(.426)
CULTDIST	.514**	2.08***	na	na
	(.215)	(.499)		
I-advantages / Firm size				
SIZE	.081	.363***	.183**	.115
	(.070)	(.139)	(.087)	(.144)
COORD	-.494**	.936*	.064	-.402
	(.223)	(.548)	(.203)	(.459)
Market environment				
COMP	.020*	/	.480*	/
	(.011)		(.246)	

Motives of foreign R&D				
RDMARK	/	1.09** (.436)	/	.895** (.443)
RDCOST	/	-.309 (.400)	/	.256 (.353)
RDKNOW	/	-.472 (.344)	/	-3.26*** (.794)
Control variables				
FOR	-.037 (.198)	-.302 (.438)	-.047 (.285)	-.110 (.411)
LAGE	.045 (.118)	-.346 (.301)	.079 (.106)	.552** (.219)
IND_1, …, IND_9	significant	/	not significant	/
S1, S2, S3	/	significant	/	significant
Constant	-4.40*** (1.154)	-1.75 (1.78)	-3.30 (2.01)	-.152 (2.79)
Statistics				
N	478	110	223	107
Wald χ^2	166.9***	54.9***	58.0***	38.3**
Pseudo R^2	.412	.413	.229	.563
Correctly assigned (%)	86	82	73	88

[a] Heteroskedasticity-robust standard errors in brackets (White procedure). The statistical significance of the parameters is indicated with ***, ** and * representing the 1%, 5% and 10% test level respectively. For the industry/sector dummies we only indicate the joint significance. Variables not used in the one or the other equation are marked with /.

[b] For variable definition see Table 2.

Table 5: **Results for model B1: Impact of foreign R&D on *innovation output* (LINNL) [a, b]**

	SWITZERLAND		AUSTRIA	
Explanatory variables [c]	Impact on LINNL of RDFOR [3] (TSLS IV-Tobit)	Impact on LINNL of MODE (Tobit)	Impact on LINNL of RDFOR (Tobit)	Impact on LINNL of MODE (Tobit)
Foreign R&D				
RDFOR	.939***	/	.343**	/
	(.288)		(.162)	
MODE	/	-.037	/	.100
		(.261)		(.200)
Resource use				
LCL	.106**	.180	-.086	-.358*
	(.043)	(.156)	(.165)	(.198)
LHC	.086**	.448**	.046**	-.010
	(.044)	(.197)	(.019)	(.025)
Knowledge protection				
PAT	.245*	-.084	.435***	.601**
	(.131)	(.238)	(.164)	(.265)
BRANDCOPY	.085	.024	.233	.218
	(.115)	(.276)	(.157)	(.218)
Market environment				
COMP	-.005	-.044***	-.081	-.223
	(.008)	(.015)	(.183)	(.312)
IPC	-.002	.034**	.053	-.006
	(.008)	(.017)	(.171)	(.226)
INPC	-.012*	-.035***	.256	.170
	(.007)	(.010)	(.175)	(.304)
Control variables				
SIZE	-.115**	.123	-.105*	-.021
	(.049)	(.097)	(.055)	(.085)
FOR	.449***	.571**	.698***	.741***
	(.141)	(.225)	(.200)	(.264)
LAGE	-.184**	-.381**	.130	.142
	(.086)	(.165)	(.093)	(.149)
IND_1, …, IND_9	significant	/	significant	/
S1, S2, S3	/	not significant	/	significant
Constant	1.58***	8.328***	3.015*	5.569***
	(.980)	(2.307)	(1.595)	(2.083)
Statistics				
N	415	100	237	102
F-Value		3.17***	5.39***	4.91***
Wald [2]	81.3***			
Pseudo R^2		.093	.084	.093

[a] Heteroskedasticity–robust standard errors in brackets (White procedure). The statistical significance of the parameters is indicated with ***, ** and * representing the 1%, 5% and 10% test level respectively. For the industry/sector dummies we only indicate the joint significance. Variables not used in the one or the other equation are marked with /.

[b] In this equation we had to correct for the endogeneity of RDFOR. To do so we used as instrument a dummy variable indicating several kinds of activity at foreign locations (distribution, production, sourcing). In the other equations endogeneity of RDFOR and MODE was rejected.

[c] For variable definition see Table 2 and 3.

Table 6: **Results for model B2: Impact of foreign R&D on *labour productivity* (LQL) [a, b]**

	SWITZERLAND		AUSTRIA	
	Impact on LQL of		Impact on LQL of	
Explanatory Variables [c]	RDFOR (OLS)	MODE (OLS)	RDFOR (OLS)	MODE (OLS)
Foreign R&D				
RDFOR	.121*	/	-.069	/
	(.066)		(.096)	
MODE	/	.248	/	.165
		(.162)		(.141)
Resource use				
LCL	.044**	.080	.125	.144
	(.019)	(.105)	(.078)	(.119)
LHC	.046***	.252**	.019	.022
	(.016)	(.101)	(.013)	(.021)
LRDL	.095***	.135	-.058	-.142*
	(.027)	(.106)	(.042)	(.083)
Control variables				
SIZE	-.006	-.043	-.009	-.091
	(.020)	(.075)	(.062)	(.099)
FOR	.198***	.220	.307***	.576***
	(.057)	(.140)	(.111)	(.146)
LAGE	-.047	-.047	.039	-.134
	(.035)	(.140)	(.055)	(.088)
INDUSTRY	significant	/	not significant	/
SECTOR	/	not significant	/	not significant
Constant	11.14***	9.587***	2.427***	2.852***
	(.325)	(2.044)	(.833)	(1.054)
Statistics				
N	525	106	200	95
F-value	5.39***	2.49**	3.06***	3.56***
R^2	.212	.229	.203	.301

[a] Heteroskedasticity–robust standard errors in brackets (White procedure). The statistical significance of the parameters is indicated with ***, ** and * representing the 1%, 5% and 10% test level respectively. For the industry/sector dummies we only indicate the joint significance. Variables not used in the one or the other equation are marked with /.

[b] Endogeneity of RDFOR and MODE was rejected in all equations.

[c] For variable definition see Table 2 and 3.

Table 7: **Results for model estimates at a glance**

Hypothesis	Switzerland	Austria
Model A: Determinants of foreign R&D		
H1: Foreign R&D yes/no	yes	yes
H2: Governance mode (equity vs. non-equity)	yes	yes
Model B: Impact on firm performance		
Innovation output		
H3a: Foreign R&D yes/no	yes	yes
H4a: Governance mode (equity vs. non-equity)	no	no
Productivity		
H3b: Foreign R&D yes/no	yes	no
H4b: Governance mode (equity vs. non-equity)	(yes)	no
H4c: Productivity advantage of equity- over non-equity mode larger than innovation advantage (H4b vs. H4a)	yes	no

Appendix: Data availability

The data used in this paper stem from two surveys conducted in parallel in Switzerland and Austria in spring 2010. The samples cover the whole business sector of the two countries (firms with at least five employees). Model estimations exclusively are based on survey data at firm level.

The questionnaire used in the Swiss survey can be downloaded from http://www.kof.ethz.ch/de/umfragen/strukturumfragen/andere-umfragen/internat2010/. This link also allows to downloading a German, French and Italian version of the questionnaire. In the Austrian case, the questionnaire (German only) is downloadable from http://www.joanneum.at/uploads/tx_publicationlibrary/RR59_02.pdf.

The two questionnaires are not fully identical but the questions used for variable construction are highly comparable. The (very) few differences do not hamper reliable estimates (as some additional model estimations have shown). The precise specifications of the variables used in model estimation for the two countries are listed in detail in Table 2 (model A) and Table 3 (model B) of the paper. Using these tables it is very easy to identify the correspondence between the variables and the underlying questions of the two questionnaires.

The firm-level data are highly confidential (as promised to the firms participating in the surveys conducted in Switzerland and Austria respectively. Nevertheless they can be made available on request, though only under certain conditions:

1. The user of the data must be a researcher (PhD student; staff member of a research institution).
2. The user has to provide a short description of the planned research.
3. The descriptive and/or econometric analysis of the data has to take place at the premises of the corresponding author of the present paper, i.e. at the KOF Swiss Economic Institute, Zurich. A specifically configurated PC is available for data access and analysis.

Applications for the use of the data should be addressed to the corresponding author:

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