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Choice of Foreign R&D Entry Mode and Its Relation to Firm Performance: A Firm-level Analysis for Switzerland and Austria

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Abstract
The objective of this study is to identify the determinants of a firm's foreign entry mode choice and the relationship between mode selection and firm performance for the specific case of R&D—a topic not yet 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 invest in R&D abroad but also the related choice between an equity-based and a non-equity governance mode. Moreover, the research reveals that foreign R&D activity is positively related to firm performance and that this relationship is stronger in the case of an equity-based mode of governance, however only in the Swiss case. The differences between the two countries primarily reflect the much higher degree of internationalisation of the Swiss economy.

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1 Introduction

The internationalisation of R&D significantly progressed over the last two decades. At the same time, it has become more attractive to choose non-equity over equity-based modes of governance (Hagedoorn 1996; Dunning and Lundan 2008). Against this background, it is surprising that the extensive entry mode literature provides hardly any empirical evidence on the determinants of mode selection 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; Dunning and Lundan 2008; Morschett *et al.* 2010).

There is a need to fill this gap since the results of the *general* research about the foreign mode selection cannot necessarily be applied to the case of R&D. For example, "insufficient protection of IPR in host countries" may be more important as a determinant of entry mode choice in the case of R&D than international activity as a whole. Similarly, specific motivations for investing in R&D abroad, such as "knowledge-seeking motives", are probably more relevant in the case of R&D than foreign activities in general. Furthermore, foreign R&D engagements are often a means to get access to completely new technological fields implying higher risks and uncertainties than in the case of FDI in general. As a consequence, firms may prefer a non-equity mode of governance that involves a lower resource commitment than an equity-based organisation of control (Teece 1992; Narula and Zanfei 2005).

Against this background, first, we aim at identifying the *determinants* of a firm's choice between equity-based and non-equity governance modes of foreign R&D. Second, we analyse the relation of foreign R&D to a parent firm's domestic *performance* and postulate that the association is stronger in the case of equity-based modes of control.[1]

The *equity-based governance mode*, as defined in this paper, includes 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-operations with foreign partners without capital participation. Firms with ventures of both

[1] Deviating from the title of the paper we use in the following, in line previous studies, the expressions *"impact* or *effect"* on firm performance rather than *"relation to* or *association with"* firm performance, although a cross-section analysis, in a strict sense, precludes a causal interpretation (see Subsection 5.3.2).

types are assigned to the first category. In the case of the equity-based mode, we had preferred to further distinguish between wholly-owned affiliates and partial ownership (JVs), which, however, was not feasible considering the small number of JVs.[2]

A special feature of this paper is its *comparative* approach. We perform separate model estimates for Switzerland and Austria 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. The Swiss economy is internationalised to a much higher degree than the Austrian one (OECD 2008, 2009). For example, the share of patents based on foreign R&D amounts to about 20% of all patents in Austria, whereas it is 57% in Switzerland, which is higher than in any EU country as well as in Japan and the USA (see Wolfmayr et al. 2013: 17). 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 relation to firm performance indeed reflect, to a substantial extent, the disparities between the two countries in terms of the degree of internationalisation, which in turn underlines the relevance of a comparative approach.

The empirical analysis of the foreign R&D mode choice is based on a model consisting of two equations (Model A). The first equation serves to identify the factors that determine the general decision to invest in R&D abroad ("*propensity equation*") and the second to explain a firm's choice between the two governance modes distinguished in this paper *("mode equation*"). The propensity equation is not only relevant by itself but it also 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).

The theoretical framework for the empirical analysis of Model A is the OLI paradigm (Dunning 2000). Previous work showed that the OLI model is well-suited to explaining the *propensity* to foreign R&D as well as the *mode choice* in the case of *foreign activity in general* (see Subsection 2.2). In the present analysis,

[2] Notice that complete out-contracting of R&D activities to a foreign company or university/government lab is not considered as foreign R&D.

we find that the OLI model also succeeds to explain the *mode choice in the specific case of foreign R&D* both for Austria and Switzerland.

In Model B we analyse whether a parent firm achieves a higher performance as a result of its foreign R&D activities and whether this effect is larger in the case of equity-based governance modes than in the case of non-equity modes of control. For this purpose, we specify two alternative performance equations: one with innovation output (*model B1*) and the other with labour productivity (Model B2) as the dependent variable. In both equations, we insert *"propensity"* and, alternatively, "*mode"* of foreign R&D as explanatory variable. Moreover, we control for the standard factors determining innovation output and labour productivity, respectively. Throughout, we allow for the *potential* endogeneity of the propensity and the mode variable. The empirical analysis shows that, in line with our hypothesis, foreign R&D improves firm performance, but only in the case of Swiss companies (a result that is in line with previous work; see Subsection 3.2). This effect (a new finding) is larger in the case of an equity-based mode of governance than a non-equity mode. This result underlines the economic significance of differentiating between equity-based and non-equity governance of foreign R&D.

The study complements previous research in several respects. First, we analyse a firm's foreign mode choice and its relationship with firm performance not only for foreign activity in general but *specifically for R&D*, something that, to the best of our knowledge, has not been done to date. Second, we apply a *comparative* approach in order to identify the robustness of the explanatory pattern and the significance of the degree of internationalisation as a determinant of the differences between the two countries included in this study. Third, we account for two *econometric problems* so far hardly addressed in entry mode research, i.e. selectivity in explaining the mode choice and endogeneity of the entry mode variable in the performance equations.

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

2 Model A: Determinants of the propensity and governance of 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. Under these conditions, firm-specific capabilities yield a competitive edge independent of the economic attractiveness of different locations ("new trade theory", see, e.g., Helpman 1984). Moreover, "transaction cost theory" states 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 (Dunning 1977, 1979). 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 the most recent version (Dunning and Lundan 2008) the OLI model applies not only to international production but also to R&D. In addition, it emphasises the strategic aspects of internationalisation more explicitly by 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. Furthermore, the OLI paradigm now clearly takes into consideration the network character of international activities, which reflects the increasing attractiveness of partnerships and alliances compared to hierarchical governance modes.

We postulate that the *OLI paradigm* is an appropriate theoretical framework for explaining the foreign R&D *propensity* (yes/no decision) and the related *mode choice* (equity-based vs. non-equity governance). Previous work more or less confirms this approach in the case of R&D propensity (see Subsection 2.2.1). The OLI model is also quite successful in explaining the mode selection *in general* (see Subsection 2.2.2). We use Model A to test the hypothesis that the OLI model can

also explain the mode choice in the *specific case of R&D*, which, as argued in the introductory section, cannot be taken for granted.

The OLI model basically accounts for three groups of variables: 1)"*Ownership-specific (O) advantages*", which arise mainly from the availability of firm-specific knowledge, human capital, managerial skills, property rights, marketing outlets, access to finance or international experience. 2) *"Location-specific (L) advantages"*, which root in differences between foreign and domestic locations with respect to factors favouring or impeding knowledge creation and use: degree of protection of IPR, knowledge infrastructure, availability of R&D personnel, general regulatory framework or cultural proximity. 3) *"Internalisation (I) advantages"*, which primarily allow to avoiding uncertainties of (unstable) market relations (entailing high transaction costs or weak appropriability of knowledge) by setting up foreign subsidiaries and, to a lesser extent, by engaging in *equity*-based co-operations (JVs) with foreign partners.

We include some other variables that complement the basic ingredients of the OLI model: First, *firm size*, which, in addition to being a structural control variable, captures I-advantages (e.g. superiority in monitoring foreign activities) and size-related elements of O-advantages (e.g. privileged access to capital markets). Second, specific strategic goals of foreign R&D *("motives"*) stand for L-advantages of host countries (knowledge-seeking motives) or a mix of O- and L-advantages (market-oriented motives). Third, *competitive pressure* may induce (or force) a firm to extend its R&D activities to foreign locations.

The OLI model incorporates the "transaction cost approach" of explaining foreign *mode choice*. In this regard, Anderson and Gatignon (1986) postulate 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.

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

[3] We formulate H1 and H2 in terms of locational *dis*advantages rather than advantages of *host* countries. In so doing, we get a clear correspondence to the specification of the empirical model, in which locational variables are represented by *obstacles* to engaging abroad in R&D.

H1: A firm's *propensity* to perform R&D in 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 choosing 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, it is necessary 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, the less productive ones export and the least productive companies exclusively serve domestic markets, is widely supported by recent empirical research (for a review, see, e.g., Greenaway and Kneller 2007; Wagner 2011).[4] Notwithstanding these results, we do not insert productivity as an additional explanatory variable because the O-variables we use in our model already account for productivity differences.[5] Adding the variable "productivity" would thus lead to biased estimates (multicollinearity).

2.2 Evidence from previous research related to H1 and H2

2.2.1 Propensity to foreign R&D

There are quite a few empirical studies that use the OLI model to analyse the determinants of foreign R&D. According to Arvanitis and Hollenstein (2007), all three components of the OLI model positively affect the foreign R&D propensity of Swiss firms, with O- and I-advantages as dominant drivers. Rammer and Schmiele (2008) and Schmiele (2012) get similar results for Germany. Studies based on Japanese (or Japanese and Swedish) data, even though they do not explicitly apply the OLI model, confirm the relevance of OLI-related variables (Zejan 1990; Belderbos *et al.* 2009) or find evidence for O- and L-advantages

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

[5] A regression analysis shows that the O-variables of our model are strongly related to labour productivity.

(Odagiri and Yasuda 1996; Ito and Wakasugi 2007; Shimizutani and Todo 2008). Swedish studies (Hakanson and Nobel 1993; Andersson 1998) identify international experience (representing O-advantages) and pre-existence of production facilities as the most important determinants of foreign R&D, a result that is in line with the "stages view of internationalisation" (Johanson and Vahlne 1977). All in all, the evidence is quite consistent with *hypothesis H1*.

2.2.2 Mode of foreign R&D

To our knowledge, Brouthers *et al.* (2001) is the only study that aims at explaining the mode choice specifically for foreign R&D. However, the very small database of this OLI-based analysis precludes an effective evaluation of *hypothesis H2*.

Therefore, we report some results of the extensive research dealing with foreign entry mode *in general*. We concentrate on contributions that *explicitly* use the OLI paradigm as framework of analysis. The majority of these studies confirm 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 cannot necessarily be applied to the *specific case of R&D* (see Section 1) at least they do not prevent an OLI-based explanation of the foreign R&D mode choice right from the beginning.

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

3.1 Approach and hypotheses

Model B seeks to identify the impact of foreign R&D and the related mode choice on a parent firm's domestic performance. Model B1 explains a firm's *innovation output* by the foreign R&D propensity and, *alternatively*, the foreign R&D governance mode – the two variables we are interested in. To get reliable estimates of their effect we also account for the main explanatory variables of an innovation output equation, that is, the resource base of a firm (physical and human capital), the appropriability of knowledge, the market conditions and some structural firm

characteristics such as size and age of a firm and its industry affiliation. In this approach, foreign R&D is an additional element of a firm's resource base.

In Model B2, we estimate a production function with *labour productivity* used as dependent variable. We again consider foreign R&D or, *alternatively*, foreign R&D governance as the explanatory variables of interest. To ensure unbiased estimates of the respective coefficients, we control for three production factors, i.e. physical, human and knowledge capital (created by a parent firm's domestic R&D), and the same structural firm characteristics we use in Model B1. In Model B2, foreign R&D is a specific production factor that complements the three above-mentioned production inputs.

Foreign R&D *propensity* should be positively related to innovation output and productivity as it increases a firm's knowledge base and/or market position. The impact of the *mode choice*, however, is not so evident. We argue that the performance effect of foreign R&D is larger in the case of an equity-based mode of governance since, under these conditions, foreign activities are integrated more strongly in the innovation and production process of the parent company than in the case of a non-equity arrangement of control. The decisive role of the within-group integration is emphasised, for example, by Ambos *et al.* (2006). Similarly, Gassmann and von Zedtwitz (1999) stress that insufficient trust among R&D co-operation partners adversely affects a parent firm's benefits gained from foreign R&D co-operation. The same holds true if the headquarter and its foreign partners pursue different objectives. The empirical literature which specifically deals with the factors influencing the intra-firm transfer of knowledge shows that problems in this respect are easier to keep under control if intra-group (technology-related) information flows are adequately organised and managed (Rabbiosi 2011), and if the capacity to absorb external knowledge of the parent firm (Penner-Hahn and Shaver 2005) as well as the foreign unit is high (Minbaeva *et al.* 2003). As these conditions are easier to fulfil if foreign R&D activities are equity-based, we expect that the performance effect of foreign R&D is particularly large for this type of governance.

Furthermore, the advantage of an equity-based mode of control over a non-equity governance mode might be larger with respect to productivity than to innovation output. We argue that market-oriented foreign R&D activities, which mostly rest on an equity-based governance, primarily increase 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). The opposite is the case for 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 gain access to completely new fields of technology, tends to involve high risks and uncertainties and is thus frequently organised as a non-equity co-operation (Teece 1992). 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 output.

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

H3: *Foreign R&D* raises a parent firm's innovation output (H3a) and labour productivity (H3b).

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

3.2 Evidence from previous research related to H3 and H4

3.2.1 Impact on innovation output

The results of previous studies dealing with the impact of foreign R&D on a parent firm's innovation output are quite consistent. Peters and Schmiele (2010) show that German firms having invested in R&D abroad are particularly innovative. Other researchers also obtain a positive innovation effect which, however, is only due to specific types of foreign R&D. For example, Iwasa and Odagiri (2004) find that "research-oriented" foreign R&D activities raise the patent output of Japanese companies, but that the same is not true for "application-oriented" R&D. Similarly, Piscitello and Rabbiosi (2007) come across a positive effect on the innovativeness of Italian parent firms only in the case of "competence-creating" foreign R&D. For Swiss companies, Arvanitis and Hollenstein (2011) show that knowledge-seeking foreign R&D activities positively affect a parent company's

sales of innovative products, whereas market- or efficiency-oriented R&D do not have such an effect. For European multinationals, Ambos *et al.* (2006) find 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 find that the positive innovation effect is primarily due to knowledge-related types of foreign R&D.

Finally, we notice that, to the best of our knowledge, there is no empirical research which deals with the relationship between foreign *R&D mode choice* and innovation output (*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) obtain a positive output effect of foreign R&D in the case of UK multinationals. Other studies also find a positive effect, which, however, is only due to specific categories of foreign R&D. For example, Todo and Shimizutani (2008) show, for Japanese companies, that overseas R&D which aims at the acquisition of new knowledge increases the growth of total factor productivity (TFP), but that this is not the case for R&D which focuses on the adaptation of products to foreign market needs. In contrast to Japan, in the case of Switzerland the positive impact on labour productivity is the result of market- and efficiency-seeking foreign R&D, while knowledge-seeking R&D does not have such an effect (Arvanitis and Hollenstein 2011). Another study for Switzerland (Ben Hamida and Piscitello 2013) does not find a positive relationship between foreign R&D and productivity growth, but obtains such an effect when only knowledge-seeking R&D is considered. Griffith *et al.* (2006) identify positive effects on TFP growth in the case of UK multinationals which have invested in technology-sourcing R&D in US locations. In contrast to these studies, Fors (1997), who uses Swedish data, does not find any significant productivity effect. To sum up, the majority of empirical studies indeed obtain the expected positive impact of foreign R&D on productivity, which, however, primarily is due to specific categories of foreign R&D. Nevertheless, the findings are largely in line with *hypothesis H3b*.

As far as we know, Brouthers *et al.* (2001) is the only analysis of the influence 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 H4* as it relies on very few observations.

4 Data and incidence of foreign R&D

The model estimates are based on cross-section firm data. In the *Swiss* case, these stem from a survey conducted in 2010 by the KOF Swiss Economic Institute among a random sample of 4533 firms (5 or more employees) drawn from the official enterprise census of 2008.[6] The sample covers the whole business sector and is stratified by 29 industries and 3 firm size classes. 1921 companies provided valid information (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 an equity-based governance mode. 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 varying according to 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.

In the same year, a similar survey was conducted in the Austrian business sector. In contrast to Switzerland, the questionnaire[7] did not address a representative sample of firms but was sent to all companies whose innovation activities were supported by the Austrian Research Promotion Agency (FFG) at least once in the period 2005-2009. Only 410 of the 5702 firms which received the questionnaire provided valid information. The low response rate (7%) is partly due to the fact that in many instances the subsidised innovation projects were based on engineering, consultancy and similar activities rather than on R&D. As this is the

[6] The questionnaire of the Swiss survey is available on:
http://www.kof.ethz.ch/de/umfragen/strukturumfragen/andere-umfragen/internat2010/

[7] The questionnaire of the Austrian survey provided by Berger *et al.* (2011: 191-197) can be downloaded from:
http://www.joanneum.at/uploads/tx_publicationlibrary/RR110_Internationalisierung_FuE.pdf.

case for about 50% of all innovative firms (Statistik Austria 2012), the response rate *effectively* may be about 14%. As the size and industry composition of our dataset is similar to that of the official R&D statistics (Berger *et al.* 2011: 80), we conclude that the low response rate does not imply a strongly biased sample *per se*. To get a sample comparable to the Swiss one, we excluded 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 an equity-based governance mode. Varying according to the specific equation to be estimated, the final dataset (after deletion of observations with missing values) comprises 200 to 237 *R&D performing firms*. In models including only the companies that, *additionally*, undertook *R&D abroad*, the number of observations is in the range of 95 to 107. All in all, we conclude 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 final sample of firms that invested in R&D only at home and of those that did so also abroad. Moreover, it 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: First (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; this is the case for firms investing in R&D only at home as well as for those also active abroad. In the Swiss economy, high-tech manufacturing stands out, particularly with respect to firms undertaking R&D also abroad. Second (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, large firms are very strongly represented among the firms that are active in R&D also abroad. Third (Col. 4 vs. 8), equity-based governance modes of foreign R&D are more prevalent than non-equity arrangements in the Swiss economy, whereas the opposite is the case 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 surprising at first sight, is not inconsistent with the fact that Switzerland's outward FDI *flows* are much higher than those of Austria (see Section 1), as Swiss firms that engage in R&D abroad are larger and more frequently equity-based than their Austrian counterparts (see above).

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*

Table 1 continued

Table 1 continued

	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)
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.

We complete the data section by indicating that many variables we use in model estimation are dummies (yes/no; high/low). The *high/low* dummies pertain to specific *obstacles* and *motives* for investing in R&D abroad as well as to *co-ordination costs*. These variables, originally measured on a five-point Likert scale, reflect a firm's *qualitative* judgment of the relevance of certain factors for deciding on internationalisation. For model estimation, we convert the ordinal measures of relevance (from "very high" (5) to "very low" (1)) throughout into dummies with value 1 (originally 4 or 5) and zero (originally 1, 2 or 3); for details see Table 2 in Subsection 5.1.2.

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 of two probit equations. The "propensity equation" determines the likelihood of a firm to investing in foreign R&D (variable RDFOR). Provided a firm is active abroad in R&D, the "mode equation" explains why it chooses an equity-based rather than a non-equity governance mode (variable MODE with value 1 for equity-based mode and zero otherwise; for a precise definition of MODE see Section 1). 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

The model explains RDFOR and MODE by three sets of variables capturing O-, L- and I-advantages complemented by some general controls (age and foreign ownership of the firm as well as industry affiliation). Additionally, the mode equation 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 RDFOR equation we insert two variables (not contained in the MODE equation) to ensure the identification of the Heckman

model: “export intensity” (X1, X2) and “degree of competition” (COMP); for justification of the two variables, see Subsection 5.3.1.

We specify the explanatory part of the empirical model as follows (see Table 2 for exact definition, measurement and sign expectation of the variables):

O-advantages: O-advantages of parent companies are supposed to be positively related to RDFOR and MODE. We consider R&D (LRDS), human capital (LHC) and physical capital intensity (LCL) as O-variables representing strategic asset availability. Furthermore, we insert dummies standing for the availability of patents (PAT) and brands/copyrights (BRANDCOPY), which, in addition to being firm-specific assets, are important instruments for protecting a firm’s knowledge.

International experience: As emphasised by the stages view of internationalisation, experience at the international level is an important factor determining foreign activities (O-advantage). Therefore, we use an indicator of “basic international experience” (“export intensity”: dummies X1 and X2, reflecting different levels of export shares; see below, Subsection 5.3.1) as an explanatory variable in the RDFOR equation. In the MODE equation, however, we apply a more “demanding” measure of international experience. We presume that “*extended international experience*” (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 and exports in regions that differ in their distance from Switzerland/Austria: Asian countries (ASIA), Eastern Europe (EAST), North America (NAFTA) and ”Rest of the world” (ROW), with EU/EFTA serving as reference region. The dummies should be positively associated with MODE as almost all firms are active in EU/EFTA, with the largest coefficient expected for the most distant region (ASIA).

L-disadvantages: The model contains four dummy variables (high/low) reflecting a firm’s assessment of the relevance of specific *obstacles* for investing abroad in R&D. As these stand for *dis*advantages of host countries, they should be negatively related to RDFOR. The L-disadvantages we consider are “insufficient protection of intellectual property rights” (IPR), “lack of R&D personnel”

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 **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)	?	?

Table 2 continued

Table 2 continued

Explanatory variables	Description	Foreign R&D yes/no **RDFOR**	Equity-based vs. non-equity mode of foreign R&D **MODE**
I-advantages / Firm size			
SIZE	Number of employees (logarithm)	+	+
COORD	High/low co-ordination 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 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 /.

(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 a larger resource commitment than non-equity engagements (Anderson and Gatignon 1986).

However, CULTDIST is a special case among the L-variables, as the literature *in part* provides arguments for a *positive* sign, contrary to the other obstacle variables. 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 exports based on R&D in the country of origin. With respect to MODE, some authors argue, for example, that an equity-based mode of governance is superior to a non-equity mode if a foreign unit, due to cultural differences, is not able to absorb knowledge stemming from the parent company sufficiently (Morschett *et al.* 2010). It is therefore not surprising that the empirical evidence with regard to the influence of cultural distance on mode choice is inconclusive (Tihanyi *et al.* 2005). Thus, we do not postulate a priori a specific sign for variable CULTDIST.

I-advantages: To account for I-advantages, we use firm size (SIZE) and the costs of co-ordinating foreign and domestic R&D activities (COORD: high/low). SIZE stands for I-advantages reflecting, for example, the superiority of large firms in managing international R&D (positive relationship between SIZE, and RDFOR and MODE, respectively).[8] Furthermore, we presume that high co-ordination costs deter firms from investing abroad in R&D (negative association between COORD and RDFOR). In contrast, we expect a positive sign for COORD in the MODE equation because a firm, given it is active abroad in R&D, can reduce co-ordination costs by selecting a high-control mode (Anderson and Gatignon 1986; Brouthers and Hennart 2007).

Motives of foreign R&D: The OLI model implies that the motivation for investing abroad in R&D is another factor influencing MODE (no data for firms without foreign R&D). Empirical studies dealing with the mode choice *in general* find a positive association between market-oriented motives and high-control modes of

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

governance (Tsai and Cheng 2002; Gil *et al.* 2006). The results are ambiguous in the case of cost-reducing motives (Shan 1991; Shi *et al.* 2001; Gil *et al.* 2006). As our model deals with *R&D activities*, we include *three* motive variables (dummies: high/low relevance): In addition to market- and cost-oriented motives (RDMARK, RDCOST), we account for knowledge-seeking foreign R&D (RDKNOW). RDMARK should positively correlate with MODE (O-advantages of parent companies, L-advantages of host countries). In the 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, in accordance with the inconclusive results of the general entry mode literature, we have no *a priori* sign expectation for variable RDCOST.

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. Moreover, if foreign-owned firms are active in R&D abroad, they probably seek highly specific knowledge, which can be accessed most effectively through R&D co-operations. We thus expect a negative sign of FOR in the RDFOR as well as the MODE equation. In contrast, firm age (LAGE), an indicator of market experience, should be positively related to RDFOR and MODE. Finally, we account for industry-specific effects representing diverging business conditions in the reference period, for example. Industry dummies also control for an "omitted variable bias".

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

5.2.1 Innovation equation (Model B1)

The (logarithm of) "sales of new or significantly improved products per employee" (LINNL) is the dependent variable we use in the *innovation output* equation. The explanatory variables we are interested in are RDFOR and MODE, respectively, for which we expect a positive sign. In order to get reliable estimates of the innovation effect of the two variables, we control for a set of explanatory variables regularly used in the empirical innovation literature: resource endowment of the firm (human and physical capital: LCL, LHC), appropriability (PAT, BRANDCOPY), market structure (COMP) and intensity of price and non-price

competition (IPC, INPC), firm size (SIZE), foreign ownership (FOR), firm age (LAGE) and industry affiliation (dummies). Based on the standard findings of empirical innovation research, we expect a positive influence of resource endowment, appropriability, intensity of non-price competition and foreign ownership. A positive effect of price competition, if it actually exists, usually is 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.

5.2.2 Productivity equation (Model B2)

The (logarithm of) value added per employee (LQL) is the dependent variable we use in the *productivity* equation. Again we expect a positive sign for the two explanatory variables we are interested in, i.e. RDFOR and MODE, respectively. [9] In order to get reliable estimates of the productivity effect of the two variables, we control for the effect of the input factors of a standard production function (physical, human and knowledge capital intensity: LCL, LHC and LRDL; positive sign). Moreover, we insert the same general control variables we apply in the innovation equation (SIZE, FOR, LAGE, industry affiliation). In accordance with the literature, we expect a positive sign for variable FOR but have no *a priori* sign expectation for SIZE and LAGE. Table 3 shows the exact definition, the measurement and the sign expectations of the variables used in Models B1 and B2.

[9] Firms investing in foreign R&D often are also involved in other activities abroad (e.g. manufacturing). Unfortunately, we cannot control for this aspect due to missing data. As a consequence, the estimates may exhibit a certain bias. We note, however, that previous research suffers from the same problem.

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 *Market 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 a 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	+	/

Table 3 continued

Table 3 continued

		Innovation equation	Productivity equation
Explanatory variables	Description	Sales of innovative products per employee (logarithm) LINNL	Value added per employee (logarithm) LQL
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 /.

5.3 Methodological problems

5.3.1 Sample selection bias

MODE is measured only for firms that are active in R&D abroad, which, as mentioned above, may give rise to a selection bias in estimating the mode equation (Model A). We account for this problem never dealt with in entry mode research by applying a *two-stage* Heckman correction (Heckman 1979). In order to identify the Heckman model, we include two variables in the propensity equation that we drop in the mode equation, i.e. "export intensity" (dummies X1, X2) and "degree of competition" (COMP: number of principal competitors on the world market). We justify the use of these instruments by arguing, first, 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. The "*degree of competition*" (COMP) can be used as an instrument, based on the

view that intensive competition may force firms to invest in R&D abroad in order to escape the competitive pressure.[10] In contrast, we do not see why COMP should significantly influence mode selection.

Our estimates of the *two-stage* Heckman model show that selectivity is not a real problem. The identifying variables X1, X2 and COMP are statistically significant in the propensity equation, but the "inverse mills ratio" inserted in the mode equation is statistically not significant in the Swiss (p=.597) nor the Austrian case (p=.767). Therefore, we may estimate the propensity and the mode equation of Model A independently (two separate equations).

5.3.2 Endogeneity and causality

The analysis of Model A and B are based on cross-section data, which is common practice in entry mode research.[11] Consequently, all explanatory variables, in principle, could be endogenous.[12] Therefore, rather than making causal claims we interpret the estimated coefficients as *partial correlations* what, however, does not preclude an evaluation of our hypotheses.

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 identifies "*lagged* productivity" as the main factor for determining why a company self-selects into FDI. Accordingly, contrary to our Model B, causality runs from productivity to FDI. However, there also is evidence for the reverse causality running from FDI to productivity (learning effects), even if it is controlled for self-selection. The same holds true for R&D- and innovation-related FDI (see Pfaffermayr and Wolfmayr 2013). Against this background, we estimate the two performance equations (Models B1 and B2) in a way that accounts for a (possible) two-way relationship between RDFOR and MODE, respectively, and firm performance. Accordingly, we instrument RDFOR and

[10] In addition, intensive competition may be an incentive to invest in R&D abroad in an attempt to benefit from (potential) first mover advantages.

[11] Exceptions are Barkema *et al.* (1996) as well as Chen and Chang (2011).

[12] To our knowledge, Shaver (1998) is the only entry mode study that deals with endogeneity.

MODE in order to test for endogeneity of the two variables by applying the procedure of Rivers and Vuong (1988).

For *Austria*, the tests do not yield any evidence for endogeneity of RDFOR and MODE, irrespective of whether we use innovation output or labour productivity as the dependent variable. The coefficients of the residuals (predicted value of the instrumented variables minus value of the original variables) are not significant at the 10% test level. In the *Swiss* case, we can reject endogeneity of RDFOR and MODE in all equations with the exception of RDFOR in the innovation equation (Model B1). Given these results, we proceed as follows: In the *only* case for which endogeneity cannot be excluded we perform a two-stage IV-Tobit estimation where the predicted value of RDFOR is used as an explanatory variable in the second stage equation (see Wooldridge 2002). This procedure yields the final estimate of the coefficient of RDFOR in the innovation equation for Switzerland (Table 5, Col. 1 in Subsection 6.2). If there is no indication of endogeneity, we use the equations based on the original variables (Table 5, Cols. 2 to 4 and Table 6, Cols. 1 to 4 in Subsection 6.2).

6 Empirical results

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

6.1.1 Propensity to foreign R&D

For *both countries*, all *categories* of OLI variables help explain the propensity to invest abroad in R&D (RDFOR). Differences exist only for a few *individual* variables (see Table 4, Cols. 1 and 3). The estimates confirm *hypothesis H1* and are in line with the findings of previous research we reported in Subsection 2.2.1.

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

We also find a significant effect for two variables representing *L-disadvantages* of host locations, that is "insufficient protection of intellectual property rights" (IPR) and "large cultural distance" (CULTDIST). The other two L-variables, i.e. "excessive regulation of economic activity" (REGUL) and "lack

of R&D personnel" (STAFF), do not influence the decision to locate R&D in foreign countries. The insignificance of REGUL may indicate that only some clearly *knowledge-related* dimensions of regulation are relevant (e.g. enforced

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) Probit	Equity-based vs. non-equity-mode of foreign R&D (MODE) Probit	Foreign R&D yes / no (RDFOR) Probit	Equity-based vs. non-equity-mode of foreign R&D (MODE) 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)

Table 4 continued

Table 4 continued

	SWITZERLAND		AUSTRIA	
Explanatory Variables [b]	Foreign R&D yes / no (RDFOR) Probit	Equity-based vs. non-equity-mode of foreign R&D (MODE) Probit	Foreign R&D yes / no (RDFOR) Probit	Equity-based vs. non-equity-mode of foreign R&D (MODE) Probit
L-disadvantages				
REGUL	-.097 (.188)	.430 (.388)	-.192 (.380)	-2.87** (1.208)
IPR	.694*** (.210)	-.681 (.441)	-.596*** (.221)	-.649 (.452)
STAFF	-.211 (.225)	.501 (.438)	-.132 (.289)	-.521 (.426)
CULTDIST	.514** (.215)	2.08*** (.499)	na	na
I-advantages / Firm size				
SIZE	.081 (.070)	.363*** (.139)	.183** (.087)	.115 (.144)
COORD	-.494** (.223)	.936* (.548)	.064 (.203)	-.402 (.459)
Market environment				
COMP	.020* (.011)	/	.480* (.246)	/
Motives of foreign R&D				
RDMARK	/	1.09** (.436)	/	.895** (.443)
RDCOST	/	-.309 (.400)	/	.256 (.353)
RDKNOW	/	-.472 (.344)	/	-3.26*** (.794)

Table 4 continued

Table 4 continued

	SWITZERLAND		AUSTRIA	
Explanatory Variables [b]	Foreign R&D yes / no (RDFOR) Probit	Equity-based vs. non-equity-mode of foreign R&D (MODE) Probit	Foreign R&D yes / no (RDFOR) Probit	Equity-based vs. non-equity-mode of foreign R&D (MODE) Probit
Control variables				
FOR	-.037	-.302	-.047	-.110
	(.198)	(.438)	(.285)	(.411)
LAGE	.045	-.346	.079	.552**
	(.118)	(.301)	(.106)	(.219)
IND_1, …, IND_9	significant	/	not significant	/
S1, S2, S3	/	significant	/	significant
Constant	-4.40***	-1.75	-3.30	-.152
	(1.15)	(1.78)	(2.01)	(2.79)
Statistics				
N	478	110	223	107
Wald □2	166.9***	54.9***	58.0***	38.3**
Pseudo R2	.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.

transfer of technology to local firms), whereas regulation *in general* is not effectively considered as an obstacle to foreign R&D.

"Insufficient protection of intellectual property rights" (IPR) in host regions affects foreign R&D of Austrian and Swiss companies differently. In case of Austria, weak regulation of IPR, in line with expectations, deters firms from investing in R&D abroad. The opposite is true for Swiss companies, for which insufficient protection of IPR is not an impediment. This may be due to the fact that the majority of foreign R&D projects are extensions of manufacturing facilities (see the data presented by Pfaffermayr and Wolfmayr 2013) that originally were esta-

blished regardless of the local R&D regime. This argument is particularly relevant in the case of economies with a long-standing tradition of internationalisation such as Switzerland. Furthermore, we find that cultural distance (CULTDIST; data for Switzerland only) is positively related to RDFOR. Investing in R&D abroad in order to adapt products to local market needs is thus an effective means to overcome cultural distance as a barrier to serving foreign markets.

The results for I-advantages differ between the two countries. As hypothesised, in Austria, large firms (SIZE) are more inclined to be active in R&D abroad. For Switzerland, we do not find a size effect, which is not very surprising given that foreign presence is widespread also among small and, even more so, among medium-sized companies (see Hollenstein 2005). As predicted, high co-ordination costs (COORD) deter foreign R&D investments, but only in the Swiss case.

Finally, as postulated, we find for both countries that a high "degree of competition on world markets" (COMP) forces firms to invest in R&D abroad or is an incentive to do so.

6.1.2 Mode choice

For both countries, the empirical results largely confirm hypothesis H2, which postulates that the OLI model is able to explain why a firm chooses an equity-based rather than a non-equity governance mode (MODE). For Switzerland, all groups of OLI variables (though relatively few individual variables within the O- and I-category) yield 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).

Resource use, market-oriented motives of R&D and international experience (O-advantages) 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. As expected, we get a positive sign for ASIA, NAFTA and EAST, with the largest effect for ASIA, the most distant region. In contrast, it is a secondary factor for Swiss companies (only EAST is significant). This difference is not surprising in view of the large and regionally highly

diversified stock of FDI of the Swiss economy as under these conditions the benefits arising from a marginal increase of experience from transactions with distant regions are small.

Among the *motive variables*, we obtain the predicted positive sign of RDMARK, whereas, again in line with expectations, the sign of RDKNOW is negative but statistically significant only for Austria. RDCOST does not influence the R&D mode choice, which corresponds to the ambiguous results for this variable in the general entry mode literature.

Furthermore, we find significant effects of some L-*disadvantages*. The sign of REGUL is negative (Austria only), meaning that equity-based foreign R&D is less attractive than non-equity ventures in case of an excessive regulation of economic activity. In line with part of the literature, we obtain a positive sign for CULTDIST (*no data for Austria*). Swiss companies seem to 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. As postulated, we find positive effects of firm size (SIZE) and co-ordination costs (COORD). This result may again reflect the long-standing international experience of Swiss firms, which enhances their capability to internalise R&D-related transaction costs.

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

6.2.1 Model B1: Innovation output

For *both countries*, the empirical estimates are in line with *hypothesis H3a*, which states that foreign R&D raises a parent firm's innovation output (LINNL). We obtain 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 effect on innovation, which has been identified in earlier studies also (see Subsection 3.2.1), is larger for Swiss than for Austrian firms. With regard to the standard variables of an innovation output equation, we get the expected positive signs: resource use (LCL, LHC), knowledge protection (PAT) and foreign ownership (FOR). The only exception is the intensity of non-price competition (INPC). The estimates based on Austrian data yield a rather similar pattern.

We do not find any evidence for hypothesis H4a postulating that the (positive) contribution of foreign R&D to a parent firm's innovation output is larger in the case of an equity-based than a non-equity mode of governance. This result holds

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

	SWITZERLAND		AUSTRIA	
	Impact on LINNL of		Impact on LINNL of	
Explanatory variables [c]	RDFOR [3] (TSLS IV-Tobit)	MODE (Tobit)	RDFOR (Tobit)	MODE (Tobit)
Foreign R&D				
RDFOR	.939*** (.288)	/	.343** (.162)	/
MODE	/	-.037 (.261)	/	.100 (.200)
Resource use				
LCL	.106** (.043)	.180 (.156)	-.086 (.165)	-.358* (.198)
LHC	.086** (.044)	.448** (.197)	.046** (.019)	-.010 (.025)
Knowledge protection				
PAT	.245* (.131)	-.084 (.238)	.435*** (.164)	.601** (.265)
BRANDCOPY	.085 (.115)	.024 (.276)	.233 (.157)	.218 (.218)
Market environment				
COMP	-.005 (.008)	-.044*** (.015)	-.081 (.183)	-.223 (.312)
IPC	-.002 (.008)	.034** (.017)	.053 (.171)	-.006 (.226)
INPC	-.012* (.007)	-.035*** (.010)	.256 (.175)	.170 (.304)

Table 5 continued

Table 5 continued

	SWITZERLAND		AUSTRIA	
Explanatory variables [c]	Impact on LINNL of RDFOR [3] (TSLS IV-Tobit)	MODE (Tobit)	Impact on LINNL of RDFOR (Tobit)	MODE (Tobit)
Control variables				
SIZE	-.115** (.049)	.123 (.097)	-.105* (.055)	-.021 (.085)
FOR	.449*** (.141)	.571** (.225)	.698*** (.200)	.741*** (.264)
LAGE	-.184** (.086)	-.381** (.165)	.130 (.093)	.142 (.149)
IND_1, …, IND_9	significant	/	significant	/
S1, S2, S3	/	not significant	/	significant
Constant	1.58*** (.980)	8.33*** (2.31)	3.02* (1.59)	5.57*** (2.08)
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. 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.

true for Switzerland as well as for Austria. The coefficient of MODE is statistically insignificant, having controlled for the standard variables of an innovation output function (see Table 5, cols. 2 and 4). The positive impact of foreign R&D on innovation performance is thus independent of the mode choice.

6.2.2 Model B2: Labour productivity

The empirical analysis confirms hypothesis H3b, which predicts that foreign R&D raises a parent firm's labour productivity. However, this is the case 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 know¬ledge capital intensity: LCL, HCL, LRDL) and some structural firm character¬istics. The results are in line with previous studies, although in part these identify such an effect only for specific types of foreign R&D (see Subsection 3.2.2). In the case of Austria, RDFOR does not exert a significant influence onlabour productivity, and the same holds true for the classical elements of the underlying production function.

Hypothesis H4b postulates that the contribution of foreign R&D to a parent firm's productivity is higher in the case of an equity-based than a non-equity mode of governance. For Switzerland, the findings, at least as a clear tendency, are in line with this hypothesis. The positive coefficient of MODE nearly passes the test of significance at the 10% level (p=0.12), having controlled for the classical factor inputs and some structural firm characteristics. In contrast, there is no evidence for H4b in the case of Austria (see Table 6, Cols. 2 and 4).

For Switzerland, the empirical results also confirm hypothesis H4c, as can be seen from a comparison of the estimates of Models B2 and B1. The productivity differential between choosing an equity-based rather than a non-equity governance mode is positive (Col. 2 of Table 6), as postulated, whereas the two modes of governance do not differ in terms of innovation output (Col. 2 of Table 5). In the case of Austria, a test of hypothesis H4c is not feasible as the empirical results reject both H4b (related to productivity) and H4a (related to innovation).

6.3 1.1 Synopsis of the findings

Table 7 presents a synopsis of the empirical tests of the hypotheses put forward in this paper for Switzerland and Austria. At a glance, it shows that the estimates for Switzerland largely confirm the hypotheses postulated by Model A (determinants of foreign R&D and R&D mode choice) and Model B (impact of foreign R&D and

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	11.1***	9.59***	2.43***	2.85***
	(.325)	(2.04)	(.833)	(1.05)
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 Tables 2 and 3.

the related mode choice on firm performance). In the case of Austria, the evidence is much weaker and more or less confined to Model A.

The empirical results with respect to the drivers and impact of foreign R&D propensity are in line with the findings of previous studies we reviewed in Subsections 2.2 and 3.2 (H1 and H3a and, only for Switzerland, also H3b). The analysis of the hypotheses related to the determinants of foreign R&D mode choice and its effect on firm performance (H2, H4a, H4b and H4c) cannot be compared with the literature, as, to date, it has not dealt with this topic for the *specific case of foreign R&D*. Our model estimates confirm three out of the four hypotheses in the case of Switzerland (H2, H4b and H4c) but only one for Austria (H2).

In the concluding section, we shall highlight the similarities and divergences of the *patterns* of explanation we find for the two countries. As will be seen, the differences primarily reflect the much higher degree of internationalisation of the Swiss economy in general and even more so with respect to R&D.

Table 7: Results for the 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 is larger than innovation advantage (H4b vs. H4a)	yes	no

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 has fully neglected the analysis of the mode choice in the specific case of foreign R&D; the more so as the findings from the general foreign entry mode research cannot necessarily be transferred to R&D. To fill this gap, we first aimed at identifying the factors determining why firms locate R&D abroad and asked (what is at the core of our interest) why some of them choose an equity-based rather than a non-equity mode of governance of this type of activity. Second, we analysed the effect of foreign R&D on a parent firm's performance in terms of innovativeness and productivity, thereby seeking possible differences between the two 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 the two countries 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).

As hypothesised, it turns out that the OLI model is able to provide an explanation for both countries as to why a firm performs R&D abroad and under which kind of conditions it chooses an equity-based rather than a non-equity governance mode. For the two economies, we find many similarities in the pattern of explanation (something that 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 a highly relevant factor for determining the R&D mode choice of Austrian firms. This is not the case for Swiss companies as many of them have been accustomed to interacting with partners from all over the world for a long time. 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 protection of IPR in host countries or high costs of co-ordinating foreign and domestic R&D activities.

The differences between the two economies with regard to the impact of foreign R&D and the related mode choice on a firm's innovation output and productivity are larger. For Switzerland, we obtain the hypothesised positive effect of foreign R&D on both dimensions of firm performance, whereas in the case of Austria only the innovation effect is significantly positive. Moreover, as expected, we find, though only for Switzerland, that the impact on productivity is larger in the 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 in foreign locations. In these circumstances, foreign R&D, particularly in the case of equity-based governance, is highly integrated in the value creating process of parent firms, implying strong performance feedbacks.

Considering the scope and findings of the analysis and the complete lack of studies dealing with the mode choice in case of foreign R&D, we complement previous research in several respects. First, we show that the OLI model is a robust framework, not only for explaining under which conditions firms invest in R&D abroad (these results are in line with the literature) but also (and this is new) why they choose an equity-based rather than a non-equity mode of governance. Second, it turns 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. Third, we identify several similarities and divergences of the patterns of explanation for the two countries, with the discrepancies primarily reflecting different levels of internationalisation. Finally, the analysis accounts for selectivity and endogeneity problems, which, so far, are 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 choices or time lags of performance effects. For the same reason, the results have to be interpreted as partial correlations rather than as causal relationships; however, it is still possible to assess whether the findings are consistent with the hypotheses. Furthermore, the study does not allow

to generalising the results. Therefore, it would make sense to investigate whether the findings we get for Switzerland are characteristic for other countries that are highly active abroad in R&D, and whether those for Austria are representative for economies which are only weakly internationalised in this respect.

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Data availability

The data used in this paper stem from two surveys, which we 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). All model estimations are based on the firm-level data collected in these surveys.

The German, French and Italian version of the questionnaire used in the Swiss survey can be downloaded from: http://www.kof.ethz.ch/de/umfragen/strukturumfragen/andere-umfragen/internat2010/

The questionnaire used in Austria (German version only) can be downloaded from: http://www.joanneum.at/uploads/tx_publicationlibrary/RR59_02.pdf

The two questionnaires are not fully identical but the questions used for the construction of the variables are highly comparable. The (very) few differences do not hamper reliable estimates (as shown by some additional model estimates). The precise specifications of the variables we 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. These tables provide an easy way to identify the correspondence between the variables and the underlying questions of the two questionnaires.

The firm-level data are highly confidential (as we promised the firms participating in the surveys conducted in Switzerland and Austria, respectively). However, they can be made available upon request, though only under the following conditions:

1. The user of the data must be a PhD student or a staff member of a research institution.
2. The user has to provide a short description of the planned research.
3. The analysis of the data has to take place at the author's workplace, i.e. at the KOF Swiss Economic Institute, Zurich.

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