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# The motivations of scientists as drivers of international mobility decisions

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## Abstract

Recent research has explored the influence of the motivations and preferences of scientists (their 'taste for science', or preference for basic research, independence, publishing and peer recognition) on career decisions such as selection in industry versus academia. This paper continues this stream of research by examining the role played by the motivations of academic scientists in the international mobility decision. We hypothesize that the motivations of scientists affect the outcome of the international mobility decision since they determine the impact of the incentives for moving faced by the scientist. We test this hypothesis with a sample of Belgian academic scientists in all academic fields using the Belgian Career of Doctorate Holders survey. We find that those who are motivated by a desire for independent research are more likely to leave Belgium, and those who are motivated by salary are less likely to do so. More generally, we find a positive relationship between a higher taste for science and international mobility. However, these effects are not present in the social sciences and humanities. While motivations appear to play a role in the outcome of the scientist's migration decision, descriptive analyses indicate that they have less impact on the behavior of mobile scientists, as we observe little correlation between the motivations of mobile scientists and the reason for leaving Belgium or their destination.

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## 1. Introduction

This paper examines how differences in the motivations of academic scientists can determine their international mobility decisions. The motivations of scientists are often assumed to be homogeneous – e.g. scientists share a desire for independence, publishing, peer recognition, and interest in basic research, also called a 'taste for science' (Roach & Sauermann, 2010; Aghion, Dewatripont, & Stein, 2008; Stern, 2004). However, recent research has found these to be heterogeneous, and differences in motivations drive certain career decisions of scientists (Roach & Sauermann, 2010; Stern, 2004; Sauermann & Roach, 2011; Sauermann & Cohen, 2010). This contributes to the further understanding of the determinants of scientist behavior, but the impact of differences in scientist motivations has not been taken into account in the international mobility decisions of scientists. This paper aims to fill this gap by explicitly considering the role of heterogeneous motivations in the scientist's international mobility decision. The international mobility of scientists has been studied extensively, finding them to be more internationally mobile than the general population (Auriol, 2010; Bekhradnia & Sastry, 2005; Hunter, Oswald, & Charlton, 2007; Martinelle, 2002; Moguérou P. , 2006). The United States attracts many scientists, but European scientists still travel mainly within Europe (Cervantes & Guellec, 2002; Bekhradnia & Sastry, 2005; Auriol, 2010; Ioannidis, 2004).

The remained of this paper is structured as follows. The next part defines the motivations of scientists. Part 3 shows how the motivations of scientists will influence the migration decision, since they affect the impact of the incentives to move offered to the scientist. In part 4 we describe our data, followed by descriptive analysis and methodology in part 5 and 6. Part 7 describes the results of the estimations. We find, other factors equal, that scientists who chose to become a scientist for reasons related to independence are more likely to leave Belgium, but scientists with motivations related to salary are less likely to move. More generally, we find that those who leave Belgium have a higher taste for science (which we define as an index for motivations related to the nature of scientific work itself or independence), but no different taste for business (which we define as motivations related to salary, job security, or career progression). When we compare "hard sciences" (natural sciences, engineering, medical sciences, and agricultural sciences) with social sciences and humanities, we find no effects of motivation on mobility in the latter. Within the former, we find positive effects of motivations

related to independence and contribution to society. These findings are limited due to the construction of our dataset: since we have only cross-section data, we cannot assess the direction of causality between motivations and mobility. We only consider the motivations of scientists in this analysis, and do not possess information about the incentives offered to them, limiting the degree up to which we can assess whether motivations were the critical factor in these decisions. We find only weak evidence of differences in mobility behavior due to differences in motivations in terms of reason for leaving Belgium or country of destination, although this analysis in descriptive in nature.

## 2. Motivations

We define the motivations of a scientist as the driver of his engagement in scientific activity. A scientist's motivations shows in which of the rewards of science he is interested (Sauermann, Cohen, & Stephan, 2010). Previous work on the motivations of scientists has identified a range of possible motivations, such as intellectual challenge, peer recognition, income, general career progress, and contribution to society. Out of these, intellectual challenge, money, and peer recognition have been studied the most, as the classical rewards of science (the gold, ribbon, and puzzle) (Sauermann & Cohen, 2010; Stephan & Levin, 1992; Sauermann H. , 2008).

Motivations can be extrinsic or intrinsic in nature. A scientist is extrinsically motivated if he values rewards that come from an outside source, such as wage or peer recognition. These rewards are either completely separable from the work itself or indirect outcomes. A scientist is intrinsically motivated if the rewards for the work come from within the scientist or are direct outcomes of the activity. Independence fuels intrinsic motivation in the sense that it allows individuals to select those problems or activities which result in the highest levels of satisfaction, and to attribute as much of their success as possible to their own actions (Amabile, Hill, Hennessey, & Tighe, 2004; Sauermann & Cohen, 2010; Ryan & Deci, 2000). The motivations of scientists have also been classified using the concept of a 'taste for science', which represents the scientist's preference for independence, publishing, peer recognition, and basic research (Sauermann & Cohen, 2010; Sauermann H. , 2008).

Many works in the economics of science assume that scientists have a preference for freedom in research, a desire to publish their findings, are intrinsically motivated, and are interested in basic

research (Aghion, Dewatripont, & Stein, 2008; Gans, Murray, & Stern, 2010; Shapin, 2008). However, scientists are heterogeneous in their motivations (Sauermann H. , 2008). This heterogeneity can explain certain career decisions: scientists tend to self-select into careers where the incentives offered to them match their motivations. Ph.D. students who prefer a career in industrial research above a career in academia tend to have lower preferences for freedom, publishing, collaboration with other scientists, and peer recognition, have higher preferences for salary and access to resources, and are more interested in applied work than those who prefer to go to academia (Roach & Sauermann, 2010). Industrial scientists differ in their preference for publishing, and are highly heterogeneous in the wage premium they require in order to accept a position in which they are not allowed to publish research findings (Stern, 2004; Sauermann & Roach, 2011). Differences in motivations correlate with differences in innovative performance: industrial Ph.D. scientists who have motivations related to intellectual challenge, money, and independence tend to perform better than industrial researchers with motives related to job security and personal responsibility in terms of patent applications, granted patents, and salary (Sauermann & Cohen, 2010).

## 3. How motivations affect international mobility

To explore how motivations could affect scientist's international mobility decision, we draw on the neoclassical economics of migration literature[1]. It finds that individuals migrate when the expected net benefits of migration (usually expressed in terms of real earnings) exceed the expected costs of moving (Borjas G. , 1994; Sjaastad, 1962). We adapt this model to include heterogeneous motivations of scientist.

Scientists can have many incentives to move, citing both salary and career progression, as the quality of their research environment, availability of funding, or the opportunity to work with "star scientists" as relevant factors in their international mobility decisions. However, reasons related to the scientist's research environment are generally considered to be more important than financial motivations or general career-related considerations (Kannankutty & Burelli, 2007; Auriol, 2007; MORE, 2010). This is also shown in the data analyzed in this paper: of those

[1] For a review of the different models in the migration literature, see Massey et al. (1993).

who have left Belgium between 1996 and 2005, only a minority indicated that they did so for reasons related to salary, a job offer from abroad, or to look for a new job abroad, and a much larger share indicated that they left Belgium for reasons specifically to improve their scientific environment (Table 6).

We introduce this in the neoclassical economics of migration framework by extending its traditional focus on wage to that of the utility received by the scientist through his work. We define this to be a function of the extrinsic and intrinsic rewards received by the scientist and his preference for each of these rewards, as measured through his degree of intrinsic and extrinsic motivation. Motivations influence the impact of incentives: a scientist will earn more utility from a given level of extrinsic rewards if his extrinsic motivations are stronger, and vice versa. The extrinsic rewards enjoyed by the scientist are determined by a number of factors, such as his salary, job security, and social recognition. His intrinsic rewards constitute the satisfaction derived from the work itself, which is in large degree determined by the quality of his research environment, including the level freedom in choosing research topics, and access to funding, resources, and star colleagues. It then follows that scientists with higher extrinsic (intrinsic) motivations would respond more strongly to international differences in factors that affect his ability to accrue extrinsic (intrinsic) rewards. As the scientist will move when the difference in total utility between the host country and the home country is greater than the cost of moving, and since the size of this difference is partly determined by the scientist's motivations, the scientist is more likely to move when the incentives to move (e.g. increase in salary or better access to equipment) match the scientist's motivations. This means that the motivations of the scientist are an important factor in the outcome of the international mobility decision: a scientist will only move if the difference in those circumstances for which has a preference are large enough[2]. It also follows that scientists who choose to become mobile are likely to do so specifically for reasons related to improving those aspect of the utility function which match the closest to their motivations, and that scientists who choose to become mobile move to that country which offers the largest increment in that aspect of their scientific reward for which they have the greatest preference. In conclusion, this framework suggests that the motivations of

[2] Unfortunately, our analysis does as of yet not take international differences in circumstances into account, but only the motivations of scientists.

scientists can have an important impact on the outcome of the scientist's mobility decision, reason to become mobile, and destination. Different motivations can have different effects, depending on the home situation of the scientist, and the net expected gains in utility from extrinsic and intrinsic rewards. We will now investigate this empirically.

## 4. Data

Our analysis is based on the Belgian part of the Careers of Doctorate Holders (CDH) survey (Federaal Wetenschapsbeleid, 2006). This survey, created in 2006 by the OECD in cooperation with Eurostat and Unesco Institute for Statistics, aims to gain more insights in the careers and international mobility of the Belgian population of doctorate holders (international results have been published in Auriol (2007,2010). The survey population was determined using the 2001 Belgian population census. We analyze a cohort of 884 academic researchers who graduated between 1991 and 2005, who are active in all scientific domains.

# 5. Measures & descriptive analysis

## 5.1. Measures

Summary statistics can be found in Table 1 and correlations can be found in Table 2.

**Table 1: summary statistics (N=884)**

| Variable | Measure type | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| mot. Creative/innovative work | binary | 0.90 | 0.29 | 0 | 1 |
| mot. Salary | binary | 0.07 | 0.25 | 0 | 1 |
| mot. Career prospects | binary | 0.17 | 0.37 | 0 | 1 |
| mot. Job security | binary | 0.05 | 0.22 | 0 | 1 |
| mot. Work circumstances | binary | 0.31 | 0.46 | 0 | 1 |
| mot. Independence | binary | 0.73 | 0.44 | 0 | 1 |
| mot. Contribution | binary | 0.25 | 0.43 | 0 | 1 |
| left Belgium | binary | 0.19 | 0.40 | 0 | 1 |
| Age (1996) | continuous | 27.76 | 6.26 | 17 | 62 |
| Female | binary | 0.33 | 0.47 | 0 | 1 |
| Born outside of Belgium | binary | 0.08 | 0.27 | 0 | 1 |
| PhD education abroad | binary | 0.13 | 0.34 | 0 | 1 |
| Postdoc | binary | 0.43 | 0.50 | 0 | 1 |
| Ability: priv./gov. Scholarship | binary | 0.37 | 0.48 | 0 | 1 |
| Ability: PhD in top 100 inst. | binary | 0.02 | 0.15 | 0 | 1 |
| Graduation year | Categorical | 1998.92 | 4.13 | 1991 | 2005 |
| field: natural sciences | binary | 0.34 | 0.47 | 0 | 1 |
| field: engineering | binary | 0.17 | 0.37 | 0 | 1 |
| field: medical sciences | binary | 0.13 | 0.33 | 0 | 1 |
| field: agricultural sciences | binary | 0.04 | 0.19 | 0 | 1 |
| field: social sciences | binary | 0.20 | 0.40 | 0 | 1 |
| field: humanities | binary | 0.12 | 0.33 | 0 | 1 |

**Table 2: Correlations between key variables (N=884)**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Left Belgium | 1.000 | | | | | | | | | | |
| 2 | Mot. Creative/innov. work | 0.043 | 1.000 | | | | | | | | | |
| 3 | Mot. Salary | -0.048 | -0.115* | 1.000 | | | | | | | | |
| 4 | Mot. Career prospects | -0.017 | -0.010 | 0.018 | 1.000 | | | | | | | |
| 5 | Mot. Job security | 0.037 | -0.077 | 0.039* | 0.207* | 1.000 | | | | | | |
| 6 | Mot. Work circumstances | 0.033 | 0.043 | 0.801* | -0.001 | 0.039 | 1.000 | | | | | |
| 7 | Mot. Independence | 0.107* | 0.143* | 0.066* | 0.054 | 0.131* | 0.190* | 1.000 | | | | |
| 8 | Mot. Contribution | 0.049 | 0.064* | -0.015 | -0.009 | 0.004 | 0.041 | 0.133* | 1.000 | | | |
| 9 | Postdoc | 0.165* | 0.078* | 0.099* | -0.034 | -0.045 | 0.102* | 0.012 | -0.041 | 1.000 | | |
| 10 | priv./gov. Scholarship | 0.083* | 0.046 | 0.040 | 0.021 | -0.062 | 0.051 | 0.037 | -0.089* | 0.093* | 1.000 | |
| 11 | PhD educ. in top 100 inst. | -0.020 | 0.026 | -0.113 | 0.051 | 0.0624 | 0.024 | -0.024 | 0.013 | -0.047 | -0.075* | 1.000 |

*: significant at 0.05

### 5.1.1. Key measures

*International mobility.* Each respondent in the survey listed all countries in which he has lived between January 1996 and December 2005. As we are studying outward mobility, we specify our dependent variable as having left Belgium at least once in this period. 19.34% of the sample (171 observations) has done so. Of these mobile scientists, 94% only left Belgium once (161 obs.), 4% left again after coming back to Belgium (7 obs.), and 2% left three times (3 obs.), which results in a total of 184 individual moves. The majority of these moves go to other countries in the European Union[3] (54%, 99 obs.). The United States and Canada attract a third of all moves (34%, 63 obs.), and the rest of the world accounts for the remaining 12% (22 obs.). Three quarters of those that leave Belgium also return to Belgium in the observation period[4]. The average stay abroad of those that returned to Belgium lasted 15 months (SD:16). The median stay takes 11 months.

*Motivations.* We measure the scientist's motivation the survey question "please indicate why you have chosen for a career as a scientist", followed by 8 possible motivations: creative and

[3] We define the European Union as the countries it included in 1995: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Switzerland, and the United Kingdom (European Union, 2011)

[4] It is important to note that our data is biased towards return mobility: the survey population was defined using the Belgian population survey of 2001, which means that the part of the population which permanently left Belgium between 1996 and 2001 and lost Belgian citizenship is not represented in the sample. Since no non-response analysis was performed, we are unable to quantify the size of this bias (Moortgat & Van Mellaert, 2010).

interesting work, good salary, extralegal benefits, career prospects, independence, contribution to society, job security, good work circumstances (multiple options were possible). We can classify these motivations according to their extrinsic or intrinsic value. Salary, extralegal benefits, career prospects, and job security are extrinsic motivations, and becoming a researcher because the work is creative and interesting or because of the opportunity to work independently are intrinsic in nature. Work circumstances and contribution to society could have intrinsic as well as extrinsic aspects (Sauermann & Cohen, 2010). One caveat of this indicator is that the survey measures motivations only in the form of a binary indicator. This implies that while we can assess whether or not the person is motivated by this factor, we do not know the strength of this motivation relative to others. Table 3 describes the answers to this question. 90% of the sample chose 'creative and interesting work' as a reason for becoming a researcher, and the majority (73%) indicated that they became a researcher because it allowed them to work independently. About a third of the sample indicated that 'good work circumstances' (31%) or the opportunity to contribute to society played a role (25%). Career prospects were chosen by 17% of the sample, and only a minority indicated that salary (5%) or job security (7%) played a role. Nobody indicated that they became a researcher because of the good extralegal benefits. Turning to differences in motivations between mobiles and not mobiles, we observe that those who have left Belgium have significantly more often chosen for a career in science because of the opportunity to work independently. This is a first indication that the outcome of the migration decision depends on the motivations of the scientist.

**Table 3: Motivations for choosing a career in science**

| Motivation for career in science | Full sample | Has left Belgium | Has not left Belgium | |
|---|---|---|---|---|
| Creative and interesting work | 90% | 93% | 90% | . |
| Opportunity to work independently | 73% | 83% | 71% | *** |
| Good work circumstances | 31% | 34% | 30% | . |
| Opportunity to contribute to society | 25% | 29% | 24% | . |
| Good career prospects | 17% | 15% | 17% | . |
| Job security | 5% | 7% | 5% | . |
| Good salary | 7% | 4% | 7% | . |
| Extralegal benefits | 0% | 0% | 0% | . |
| N | 884 | 171 | 713 | |
| Stars indicate equal-variance t-tests. ***: p<0.01, **: p<0.05, *:p<0.1 | | | | |

Some possible measurement issues arise from these indicators of motivations. The respondents might have adjusted their motivations to what they think is socially desirable (Social Desirability Bias) (Fischer & Katz, 2000), and common measurement scales might have inflated the relations between the variables (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The latter concern can be addressed with the observations that, for the indicators for motivations, no correlation exceeded a value of 0.25[5], and the factor analysis discussed below returned no factor with positive loadings on all items, suggesting that these variables show no systematic positive correlation due to common measurement method. However, the correlations between motivations might be inflated since we cannot take the relative strength of motivations into account due to the binary indicators. Although the dependent variable has the same form as the motivation indicators, it is derived from other data, making it improbable that our results are driven by common methods bias. As for the former issue, it is indeed possible that the motivation data suffers social desirability bias. The crucial issue, however, is whether the bias could also affect the correlations between the motivations and the answers to the international mobility question. The questions are asked far away from each other in the survey, and are asked in

[5] The tetrachoric correlations used for the factor analysis below had a maximum correlation of 0.47.

different contexts, which makes such correlation unlikely. Lastly, the question arises whether motivations are exogenous and stable over time. Many economists assume that preferences for work attributes are trait-like (Amabile, Hill, Hennessey, & Tighe, 2004; Sauermann & Cohen, 2010). However, preferences might be affected over time by socialization, for example in the workplace (Allen & Katz, 1992; Sauermann & Roach, 2011). Since the measurement of motivations took place after the observed mobility period, it could be the case that observed preferences have selected the scientists into mobility, but mobility might also have shaped the preferences of the scientist. Therefore, we cannot ascertain the direction of causality between motivations and mobility. Preferences could also change over the scientist's life cycle (Levin & Stephan, 1991). Since we only have access to cross-sectional data, we cannot offer any evidence regarding the stability of preferences over time. However, Sauermann & Roach (2011), based on two waves of the Survey of Doctorate Recipients, compared the evolution of motivations between 2001 and 2003, and found these to be quite stable.

We employ exploratory factor analysis on these indicators in order to discern the common factors underlying these variables (see Appendix 1 for more details and further discussion), and find two uncorrelated factors, which can be described as the scientist's motivation by science-related factors and by general career-related factors (Table 4). We name these factors respectively taste for science and taste for business, congruent with the previous literature (Sauermann, Cohen, & Stephan, 2010; Sauermann & Roach, 2011; Sauermann, Cohen, & Stephan, 2010). The first factor, which we name 'taste for business', is positively correlated with having started a career in science because of good salary, career prospects or job security, which are all extrinsic rewards of doing science. The second factor, which we name taste for science, is positively correlated being a scientist because the work itself is creative and interesting, or because it offers the opportunity to do independent work, both intrinsic rewards. Note that the motivations by the opportunity to contribute to society and good work circumstances are only weakly captured in the analysis.

**Table 4: Summary of rotated exploratory factor analysis results for motivations of sample (n=1164)**

| | Factor Loadings | |
|---|---|---|
| Item | Taste for Business | Taste for Science |
| Creative and interesting work | -0.30 | **0.52** |
| Good salary | **0.43** | 0.08 |
| Good career prospects | **0.50** | -0.04 |
| Job security | **0.73** | 0.24 |
| Work circumstances | 0.13 | 0.33 |
| Opportunity to do independent work | 0.30 | **0.75** |
| Opportunity to contribute to society | 0.00 | 0.35 |

*Note:* Factor loadings over .40 appear in bold.

We can now preliminarily assess whether there are differences in the 'taste for science' and 'taste for business' between scientists who have left Belgium and who did not. We find that those who have left Belgium score significantly higher on the taste for science index (Mean(SD) mobile vs. not mobile: 0.20(0.65) vs -0.02(0.74), $t(882)= -3.51$, $p < 0.0001$), but do not score differently on taste for business (Mean(SD) mobile vs. not mobile: -0.01(0.69) vs -0.02(0.67), $t(882) = -0.14$, $p=0.89$). This provides additional preliminary evidence that the migration decision might result in a net gain more often for those with a higher taste for science, leading to more international mobility.

### 5.1.2. Important controls

*Ability.* The international mobility of skilled workers selects positively on ability: the highly skilled have more opportunities to valorize their work, leading to a lower opportunity cost of moving and hence more mobility (Borjas G. , 1987; Chiswick, 1999). This has been verified empirically in the case of general migration in several studies. Highly-educated people show much more willingness to move to another country in order to improve their work or living conditions (Liebig & Sousa-Poza, 2004; Chiquiar & Hanson, 2002), and migrant workers tend to be more skilled than the native population (Saint-Paul, 2004). This has also been investigated in the specific case of scientist migration: migrating Ph.D. holders who move to the US to complete a postdoc were more productive during their Ph.D. than others (Moguérou P. , 2006), and the foreign-born and foreign-educated scientists contribute disproportionally more to exceptional

works of science and engineering (Guellec & Cervantes, 2001). Moreover, highly cited academics are more mobile than the rest of the scientist population (Bekhradnia & Sastry, 2005; Hunter, Oswald, & Charlton, 2007). It is therefore crucial to control for the scientist's ability in the empirical analysis. This selection can also lead to a possible endogeneity issue: it could be the case that those with a higher taste for science put more effort into their scientific careers, leading to higher ability later on in life[6]. In order to control for ability, we employ a two of possible measures[7]. The first concerns the quality of the ranking of the scientist's PhD institute. The world's top institutes are able to select the best students, so attending a top school, especially internationally, might be a sign of higher inherent ability. We define a top school as a school that is in the top 100 of the 2005 ARWU ranking, and include a dummy that takes value '1' if the scientist did so[8]. The second concerns the source of the scientist's funding for his Ph.D. studies. Government and private grants for Ph.D. mandates tend to select heavily on the ability of the applicant in terms of his previous academic performance. This means that the group of scientists which did receive such a scholarship might be of higher ability than those who did not. This is recorded in the survey, and we include it in the form of a binary indicator.

*Postdocs.* Postdoctoral positions are an important driver of international mobility flows of young researchers (Melin, 2004; Bekhradnia & Sastry, 2005). Since our sample consists of recently graduated PhD holders, many engage in a postdoc in the observation period (33%), and 60% of the mobile sample does so specifically to complete a postdoc abroad (Table 6). To take this into account, we include a dummy variable in the analysis which takes value one if the scientist indicates that he is currently holding a position as a postdoc or has held a post-doctoral position between 1996 and 2005[9].

[6] We tested this in some sense using our preliminary indicator of ability (obtaining private or government scholarships to fund PhD. We found no systematic differences in motivations or taste between those that did obtain a scholarship and those that did not.

[7] We also propose a number of additional measures in the discussion section of the paper, which were unfortunately not available at time of writing.

[8] A issue with this measure is that most of the 'top schools' in the sample lie outside of Belgium. This means that this measure of ability might be related to a scientists innate propensity to migrate: taken skill as a given, the scientist with the highest propensity to move will be more likely to attend the top school.

[9] A possible issue here is that engaging in a postdoc might select on certain motivations itself. Table 2 does indeed show significant correlations between having done a postdoc and becoming a scientist because of creative work, good salary, or agreeable work circumstances. Removing this variable from the analysis, however, does not critically influence our results (Table 5, column 7).

### 5.1.3. Additional controls

*Gender*. Female scientists are less likely to migrate than males. Women are also less mobile when in a relationship, while this is not the case for men (Dumont, Martin, & Spielvogel, 2007; Moguérou P. , 2004). In order to account for this, we include a dummy variable "gender", which takes value one if the scientist is female.

*Age.* Young scientists make up a disproportionate part of scientist mobility flows (Auriol, 2010). The human capital theory (Becker, 1962) states in this regard that the reward for human capital investments decreases as the time left to profit from this investment grows shorter, which makes international mobility the most attractive as an investment early on in one's career. On the other hand, older researcher might receive more offers to travel, due to seniority and reputation effects. In order to account for this effect, we include age as a quadratic function in the analyses. The cross-section nature of our data does not allow us to include the age of the scientist when he leaves the country, since this is not observed for those who do not move. Instead, we include the age of the scientist at the beginning of the observation period (1996). The career decisions of scientists are also affected by general fluctuations in the scientific labor market, creating a need to control for cohort effects (Stephan & Levin, 1992). In order to take this into account, we include 15 graduation year dummies, ranging from 1991 to 2005.

*Scientific domain.* The international mobility of scientists is related to their field of research. The migration rate of highly cited scientists varies from less than 20% to over 50%, depending on the scientific field (Ioannidis, 2004). This can be explained by the notion that some fields contain knowledge that is more globally applicable than others: While a science degree carries a comparable connotation around the world, a law degree will often only be relevant for the country in which it has been obtained (Hunt & Gauthier-Loiselle, 2009). Additionally, a scientist's preferred country of destination depends on his fields of expertise, since countries vary in their 'national expertise' across fields. In order to account for this, we include dummies for the 36 scientific fields in the survey.

*Previous migration experience.* Previous migration experiences during and after education lead to more international mobility later on (De Grip, Fouarge, & Sauermann, 2009; King, Ruiz-Gelices, & Findlay, 2004; Parey & Waldinger, 2007). We take this account in the analysis through two binary variables, which take value 1 when the scientist was born outside of Belgium and whether the scientist obtained his Ph.D. outside of his country of birth.

## 6. Specification

As our main hypothesis concerns the influence of motivations on the outcome of the migration decision, we first regress whether or not the scientist has left Belgium on his preferences and control measures, using probit regression:

$$\Pr(LEFT\_BELGIUM_i = 1) = \Phi(\beta_0 + \alpha MOTIVATIONS_i + \beta CONTROLS_i + \varepsilon_i)$$

$MOTIVATIONS_i$ represents a vector of motivations, and $CONTROLS_i$ represents a vector of control variables. We are especially interested in the efficacy of the non-bibliometric measures of ability. Therefore, we add them to the model one by one:

$$\Pr(LEFT\_BELGIUM_i = 1) = \Phi(\beta_0 + \alpha MOTIVATIONS_i + \beta CONTROLS_i + \gamma ABILITY_i + \varepsilon_i)$$

Additionally, we perform these regressions using the indices for taste for science and taste for business in order to assess the presence of aggregate effects:

$$\Pr(LEFT\_BELGIUM_i = 1) = \Phi(\beta_0 + \omega TASTE_i + \beta CONTROLS_i + \gamma ABILITY_i + \varepsilon_i)$$

## 7. Results

### 7.1. The mobility decision

Table 5 presents the results for the probability of having left Belgium between 1996 and 2005. In the baseline model (column 1), age is not significant, which might be due to the inclusion of graduation-year fixed effects[10]. Women are less likely to have moved than men. Those who engaged in a postdoc between 1996 and 2005 are more likely to have left Belgium, and nationality and past studies abroad do not make a significant difference. When we introduce the

[10] When we omit these from the regression, age follows an inverse-u shape, with the maximal probability of moving at 28 years.

motivation-related variables (column 2), these are jointly significant ($\chi_2(7) = 14.34, p = 0.045$). The pseudo-$R^2$ of the models lies around 0.15. We observe a significant positive coefficient for motivation by independence, and a significant negative coefficient for motivation by salary. Adding our non-bibliometric measures for ability (columns 3, 4 and 5), the coefficients of the motivations variables remain stable. The controls for ability are positive but not significant, which might call into question the adequacy of these indicators. When we estimate the model using the aggregate taste-for-science and taste-for-business indices (column 6), these are only weakly jointly significant ($\chi_2(2) = 5.38, p = 0.0678$). We find a positive effect for taste for science but no negative effect for taste for business.

When we split the sample in "hard sciences" (natural sciences, medical sciences, agricultural sciences and engineering) and "soft sciences" (social sciences and humanities), we observe major differences between the two. In the first, both the indicators for motivations as tastes are jointly highly significant ($(\chi_2(7) = 19.70, p = 0.0063)$ and $(\chi_2(2) = 9.15, p = 0.0103)$, respectively), while in the latter they are not ($(\chi_2(7) = 8.19, p = 0.3165)$ and $(\chi_2(2) = 3.78, p = 0.1513)$). In the "hard sciences" we observe positive effects for independence, contribution to society, and taste for science. This leads to the conclusion that, first, motivations play a role in the migration decision in the hard sciences, but not in the soft sciences, and second, that in the hard sciences those with a higher desire for independence or need to contribute to society migrate more often than others.

In conclusion, we find in the full sample that those doctorate holders employed in academia who are motivated by a desire for independence are more likely to leave Belgium at least once. Those who are motivated by salary have a lower probability of having done so. More in general, we find a positive effect of having a higher taste for science on the probability of moving abroad. The role of motivations seems to differ across fields: we find significant differences in the natural sciences, medical sciences, agricultural sciences, and engineering, but not in the social sciences or humanities. A possible cause for this could be that the size of the incentives to move differ between groups: if these differences are smaller for the 'soft sciences' other factors in the mobility decision (such as the cost of moving) would gain more importance relative to the scientist's motivations.

**Table 5: Probit regression of having left Belgium at least once**

| Dep: left Belgium | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Hard sciences | | Soft sciences | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M: creative/innovative | | -0.008 | -0.009 | -0.008 | -0.009 | | 0.018 | -0.187 | | 0.302 | |
| | | (0.206) | (0.206) | (0.206) | (0.206) | | (0.190) | (0.254) | | (0.412) | |
| M: salary | | -0.589** | -0.590** | -0.587** | -0.587** | | -0.505** | -0.458 | | -0.772 | |
| | | (0.264) | (0.264) | (0.264) | (0.264) | | (0.254) | (0.352) | | (0.473) | |
| M: career prospects | | -0.150 | -0.150 | -0.152 | -0.153 | | -0.161 | -0.145 | | -0.152 | |
| | | (0.157) | (0.157) | (0.157) | (0.157) | | (0.146) | (0.198) | | (0.312) | |
| M: job security | | 0.165 | 0.162 | 0.166 | 0.163 | | 0.061 | 0.203 | | -0.263 | |
| | | (0.240) | (0.241) | (0.240) | (0.241) | | (0.226) | (0.300) | | (0.533) | |
| M: work circumstances | | -0.014 | -0.016 | -0.017 | -0.018 | | -0.014 | -0.026 | | -0.116 | |
| | | (0.121) | (0.121) | (0.121) | (0.121) | | (0.115) | (0.152) | | (0.233) | |
| M: independence | | 0.286** | 0.287** | 0.286** | 0.287** | | 0.268** | 0.487*** | | 0.082 | |
| | | (0.138) | (0.138) | (0.138) | (0.138) | | (0.129) | (0.172) | | (0.284) | |
| M: contribution to society | | 0.158 | 0.157 | 0.160 | 0.160 | | 0.154 | 0.363** | | -0.261 | |
| | | (0.127) | (0.127) | (0.127) | (0.127) | | (0.118) | (0.165) | | (0.227) | |
| Taste for science | | | | | | 0.190** | | | 0.297*** | | -0.022 |
| | | | | | | (0.080) | | | (0.100) | | (0.152) |
| Taste for business | | | | | | -0.025 | | | 0.053 | | -0.260 |
| | | | | | | (0.082) | | | (0.101) | | (0.170) |
| Ab: PhD at top 100 inst. | | | 0.086 | | 0.091 | 0.084 | 0.249 | 0.752 | 0.750 | | |
| | | | (0.399) | | (0.399) | (0.393) | (0.358) | (0.511) | (0.498) | | |
| Ab:Priv/gov. Funds | | | | 0.030 | 0.031 | 0.020 | 0.060 | 0.059 | 0.037 | -0.057 | -0.066 |
| | | | | (0.119) | (0.120) | (0.118) | (0.113) | (0.144) | (0.141) | (0.250) | (0.242) |
| Age | -0.113 | -0.133 | -0.133 | -0.131 | -0.130 | -0.111 | -0.152 | 0.061 | 0.086 | -0.119 | -0.116 |
| | (0.115) | (0.114) | (0.114) | (0.114) | (0.114) | (0.114) | (0.109) | (0.202) | (0.197) | (0.188) | (0.192) |
| Age² | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 | -0.003 | -0.003 | 0.000 | 0.000 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.004) | (0.003) | (0.003) | (0.003) |
| Female | -0.281** | -0.256** | -0.256** | -0.255** | -0.255** | -0.261** | -0.195* | -0.349** | -0.341** | -0.155 | -0.205 |
| | (0.122) | (0.125) | (0.125) | (0.125) | (0.125) | (0.123) | (0.117) | (0.159) | (0.156) | (0.234) | (0.231) |
| Born outside Belgium | 0.135 | 0.134 | 0.129 | 0.137 | 0.133 | 0.125 | 0.161 | -0.124 | -0.097 | 0.346 | 0.345 |
| | (0.212) | (0.214) | (0.215) | (0.214) | (0.215) | (0.214) | (0.204) | (0.303) | (0.293) | (0.365) | (0.358) |
| Postdoc | 0.466*** | 0.477*** | 0.478*** | 0.477*** | 0.478*** | 0.463*** | | 0.637*** | 0.611*** | 0.108 | 0.089 |
| | (0.118) | (0.120) | (0.120) | (0.120) | (0.120) | (0.118) | | (0.152) | (0.149) | (0.232) | (0.225) |
| PhD abroad | -0.236 | -0.227 | -0.235 | -0.223 | -0.232 | -0.238 | -0.093 | -0.106 | -0.188 | -0.377 | -0.336 |
| | (0.191) | (0.194) | (0.198) | (0.194) | (0.198) | (0.197) | (0.178) | (0.270) | (0.264) | (0.340) | (0.333) |
| Constant | 2.873 | 2.975 | 2.959 | 2.897 | 2.878 | 2.651 | 3.571** | 0.231 | -0.087 | 2.936 | 3.232 |
| | (1.826) | (1.865) | (1.866) | (1.885) | (1.886) | (1.846) | (1.815) | (3.004) | (2.872) | (3.108) | (3.085) |
| All estimations include scientific domain and graduation year fixed effects | | | | | | | | | | | |
| N | 884 | 884 | 884 | 884 | 884 | 884 | 884 | 595 | 595 | 259 | 259 |
| Pseudo R-squared | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.13 | 0.19 | 0.18 | 0.13 | 0.12 |

*: p<0.10, **:p<0.05, ***:p<0.01

### 7.2. Estimation issues

A number of issues persist throughout these estimations. The first issue concerns the interpretation of differences in motivations. Mobility flows depend on the combination of the incentive offered to scientists to move and the preference for the incentives. While we do observe the preferences of the scientist, we do not observe the size of the incentives on which the mobility decision was based. It could be the case that the incentives to move are of such size that any combination of preferences could not change the outcome of the mobility decision. In that case, there would be no causal link between the different motivations of scientists and the international mobility decision. Since we do not have data on the incentives to move, we cannot exclude this possibility. We hope to these factors in future research in order to ameliorate this.

Another causality issue arises from the cross-sectional nature of our dataset, as stated above. Since the measurement of motivations takes place after the mobility decision, we cannot exclude the possibility that mobility affected the motivations of those who move instead of the other way around.

In order to check for heteroskedasticity issues, we specified a number of heteroskedastic probit models (Appendix 2), using both broad scientific fields as graduation cohorts for heteroskedasticity terms[11]. We find that, while the likelihood-ratio tests are significant, the interpretation of our results remains unchanged. In the 'soft sciences', we now observe a significant negative effect for work circumstances and contribution to society, but the motivation indicators still are not jointly significant.

The last issue concerns our measurement of ability. The binary non-bibliometric measures for ability allow us only to distinguish a higher skilled-subgroup in the sample. These measures do not capture any positive selection in the estimations, which might indicate that they are not adequate as controls for the individual ability of the scientist. The use of more sensitive measures of scientist ability might be called for, which will be included in our future research in the form of bibliometric measures for ability (which are discussed in more detail below).

[11] In order to specify this, we had to group social sciences and humanities together ('soft sciences').

### 7.3. Behavior of mobile scientists

We will now go into more detail about the behavior of mobile scientists. Both the reason for leaving Belgium as the country of destination of mobile scientists should be determined partly by the scientist's motivations. Since the limited number of observations (N=184) does not leave much scope for rigorous empirical analysis, we will keep to describing differences in differences in motivations across these factors.

We will first discuss the reasons why mobile scientists left Belgium (Table 6). All scientists who left Belgium at least once in the observed period were asked to indicate why they did so (multiple options were possible). The majority of those who left Belgium indicated that they did so in order to complete a postdoc abroad (60%). Other important reasons were related to continuing research in general (41%) and better publication opportunities (34%). A quarter of the respondents indicated that they went abroad because they were sent by their current employer (23%). A fifth left Belgium because they were offered a job abroad (21%) or because they had the opportunity to create a new research domain (20%). A smaller share of the scientists who left Belgium did so because their research domain did not exist in Belgium (11%), because they could earn a higher salary abroad (11%), could more easily find a job (10%), or because of personal or familial reasons (5%).

**Table 6: Reasons for leaving Belgium**

| Reason for leaving Belgium | Share |
|---|---|
| Postdoc abroad | 59.57% |
| Continue research | 41.49% |
| Better publication opportunities | 33.51% |
| Sent by current employer | 22.87% |
| Received job offer | 21.28% |
| Create new research domain | 19.68% |
| Better salary | 11.17% |
| Research domain does not exist in Belgium | 11.11% |
| Easier to find a job | 9.58% |
| Personal or familial reasons | 4.79% |
| N | 184 |

Table 7 shows the correlations between taste for science and business and the reasons for leaving Belgium. We observe only one significant correlation, between taste for business and leaving Belgium because it is easier to find a job abroad. T-tests on the scores for taste for science and business by reason for leaving Belgium indicate the same: the only significant difference is in taste for business by leaving Belgium because of better publication opportunities (see Appendix 3). The correlations between the individual motivations and reasons for leaving Belgium (not shown) also show a single significant correlation: those who indicate that they became a researchers for reasons related to job security tend to leave Belgium more often because it is easier to get a job there. On the whole, there appears to be a weak relation between the motivations of the scientist and his reasons for leaving Belgium, but the descriptive nature of our analysis limits the scope of the conclusions that can be draw from this.

**Table 7: Correlations between taste for science and business and reasons for leaving Belgium**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.Taste for science | 1 | | | | | | | | | | | |
| 2.Taste for business | 0.01 | 1 | | | | | | | | | | |
| 3.RL: Postdoc abroad | 0.04 | -0.01 | 1 | | | | | | | | | |
| 4.RL: Continue research | 0.10 | 0.03 | 0.12 | 1 | | | | | | | | |
| 5.RL: Better pub. Opp. | -0.04 | -0.01 | 0.08 | 0.36* | 1 | | | | | | | |
| 6.RL:Sent by curr. Emp. | -0.00 | -0.03 | -0.13 | 0.20* | 0.13 | 1 | | | | | | |
| 7.RL: Received job offer | -0.09 | 0.02 | 0.14* | 0.11 | -0.03 | 0.07 | 1 | | | | | |
| 8.RL Create new research domain | -0.02 | 0.1 | 0.04 | 0.24* | 0.39* | 0.16* | 0.017 | 1 | | | | |
| 9.RL: Better salary | -0.10 | 0.11 | -0.02 | 0.08 | -0.01 | 0.12 | 0.43* | 0.23* | 1 | | | |
| 10.RL: Research domain not in Belgium | -0.05 | 0.02 | 0.08 | 0.23* | 0.20* | 0.06 | 0.05 | 0.32* | 0.13 | 1 | | |
| 11.RL: Easier to find a job | 0.03 | 0.19* | 0.04 | -0.02 | -0.03 | 0.01 | 0.17* | 0.13 | 0.11 | 0.15* | 1 | |
| 12.RL: personal | 0.07 | -0.05 | -0.02 | 0.11 | -0.05 | 0.00 | 0.19* | 0.07 | 0.00 | 0.00 | 0.18* | 1 |

*: significant at p<0.05

Table 8 shows the destinations of scientists that have left Belgium. The United States is the most popular destination, with 30% of all moves. Although it is the largest single destination, Western Europe attracts more researchers combined: 54% of all of those who leave Belgium travel to another Western European country. Other top destinations include the United Kingdom, France, the Netherlands, and Germany. These countries share a border and/or a language with Belgium, and are, since they are inside the European Union, easy destinations to reach. In total, 35% of all who leave Belgium go towards countries adjacent to Belgium.

**Table 8: Top ten countries of destination of those leaving Belgium**

| Rank | country | Freq. | Percent | Cum. |
|---|---|---|---|---|
| 1 | UNITED STATES | 55 | 29.95% | 29.95% |
| 2 | UNITED KINGDOM | 27 | 14.72% | 44.67% |
| 3 | FRANCE | 23 | 12.69% | 57.36% |
| 4 | NETHERLANDS | 12 | 6.60% | 63.96% |
| 5 | GERMANY | 10 | 5.58% | 69.54% |
| 6 | CANADA | 7 | 3.55% | 73.10% |
| 7 | ITALY | 6 | 3.05% | 76.14% |
| 8 | DENMARK | 5 | 2.54% | 78.68% |
| 9 | SWITZERLAND | 5 | 2.54% | 81.22% |
| 10 | AUSTRALIA | 4 | 2.03% | 83.25% |
| 11 | ISRAEL | 4 | 2.03% | 85.28% |
| 12 | SWEDEN | 4 | 2.03% | 87.31% |
| 13 | SPAIN | 3 | 1.52% | 88.83% |
| 14 | IRELAND | 2 | 1.02% | 89.85% |
| 15 | JAPAN | 2 | 1.02% | 90.86% |
| 16 | LUXEMBOURG | 2 | 1.02% | 91.88% |
| 17 | POLAND | 2 | 1.02% | 92.89% |
| 18 | SOUTH AFRICA | 2 | 1.02% | 93.91% |
| 19 | AUSTRIA | 1 | 0.51% | 94.42% |
| 20 | CAMBODIA | 1 | 0.51% | 94.92% |
| 21 | CHILE | 1 | 0.51% | 95.43% |
| 22 | CONGO | 1 | 0.51% | 95.94% |
| 23 | FINLAND | 1 | 0.51% | 96.45% |
| 24 | GREECE | 1 | 0.51% | 96.95% |
| 25 | HUNGARY | 1 | 0.51% | 97.46% |
| 26 | NEW ZEALAND | 1 | 0.51% | 97.97% |
| 27 | NORWAY | 1 | 0.51% | 98.48% |
| 28 | PORTUGAL | 1 | 0.51% | 98.98% |
| 29 | UNITED ARAB EMIRATES | 1 | 0.51% | 99.49% |
| 30 | WALLIS AND FUTUNA | 1 | 0.51% | 100.00% |
| | Total | 184 | 100.00% | |

Now we assess whether the region of destination of the scientist is related to his motivations. Figure 1 shows the deviation from the mean of the share of scientists going to each destination by his motivations (Appendix 3 shows a more detailed table)[12]. Those that indicated that they became a scientists because of good career prospects go to the United States in 18% more of the cases than average. Those motivated by doing independent work or by the opportunity to contribute to society appear to move to countries bordering with Belgium in slightly less of the cases (8% and 6%, respectively). However, we find no significant correlations between taste for science or business and the scientist's region of destination (Table 9). In sum, while we find some differences in terms of destination between some of the motivations, there are no

[12] Note that in this and the following figure, motivation by salary and job security were omitted due to the small number of observations per region in these categories.

significant correlations between taste for business or science and region of destination. However, since this is only a descriptive analysis, the conclusions drawn here should be interpreted with care.

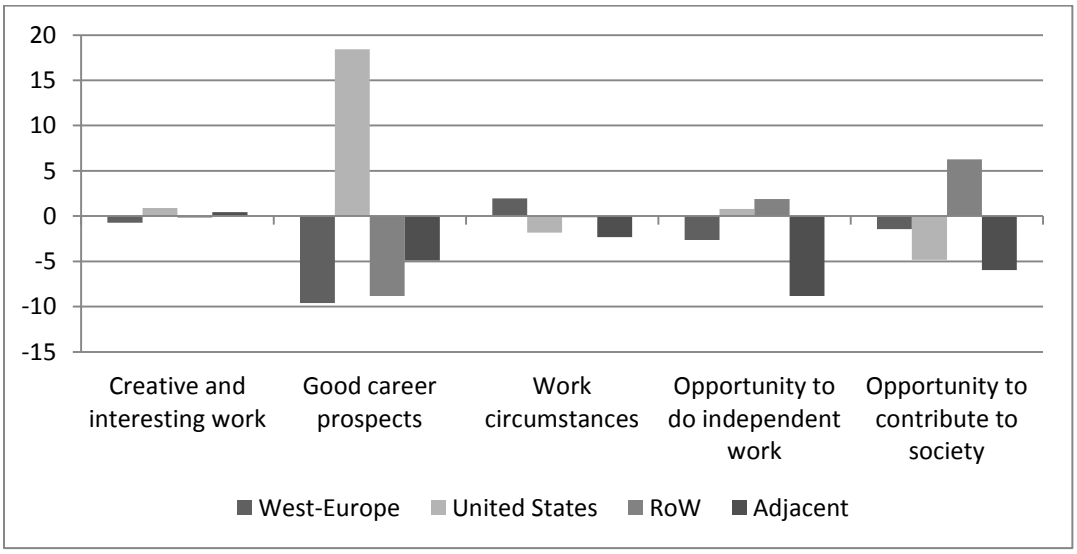


**Figure 1: Region of destination by motivation, deviation from mean, in percentage points (note: motivation by salary and job security omitted due to small sample size)**

**Table 9: Correlations between taste for science and region of destination**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Taste for science | 1 | | | | | |
| 2. Taste for business | 0.0096 | 1 | | | | |
| 3. Rest of World | 0.1146 | 0.0077 | 1 | | | |
| 4. US/Canada | 0.0382 | 0.0406 | -0.2609* | 1 | | |
| 5. Western Europe | -0.1114 | -0.0434 | -0.4075* | -0.7752* | 1 | |
| 6. Adjacent | -0.0337 | -0.0035 | -0.2579* | -0.4906* | 0.6329* | 1 |
| *: significant at p<0.05 | | | | | | |

## 8. Discussion

A growing body of research considers the role of motivations in the career decisions of scientists. Motivations might play an important role in the outcome of the individual's international mobility decision, since these determine the impact of the scientist's incentives to migrate. We investigate this empirically by analyzing whether differences in motivations lead to different outcomes for a sample of Belgian academic scientists. Our results indicate a relation between the motivations of scientists and the decision to become internationally mobile: scientists who are motivated by a need for independence choose more often to leave Belgium than others, and those who are motivated by salary do so less often. More generally, those with a higher taste for

science have a higher chance of becoming mobile than others, but a higher taste for business does not appear to negatively affect international mobility rates. This differs across fields: differentiating between 'hard' sciences (natural sciences, engineering, medical sciences, agricultural sciences) and 'soft' sciences (social sciences and humanities), we find that those in hard sciences are more likely to move when they are motivated by a desire for independence or want to contribute to society, while in the soft sciences motivations do not appear to play a role in this decision process. One possible interpretation for these findings could be that, in the hard sciences, the scientific environment in Belgium offers high wages compared to other countries but less in terms of opportunities for independence research. However, as we do not observe these international differences, we are limited in the conclusions we can draw from this. We hope to ameliorate this in future research by including these factors in the analysis, but the highly domain-specific nature of many of these factors makes this a challenging task.

Analyzing the specific reason for moving and destination of those who chose to move yields little in terms of relation to motivation, although this analysis is only descriptive in nature and limited in the number of cases observed. Future research should include more rigorous investigation of the effect of motivations on the behavior of mobile scientists.

This study is not without limitations. The binary indicators of motivations only register the existence of a given motivation without the possibility to assess its strength. This limits the analysis in the level of detail at which we can compare motivations among scientists. Second, the cross-sectional nature of our data does not allow us to establish the direction of causality between motivations and mobility, since mobility might also influence the motivations of the scientist. Last, our measure for ability only allows us to separate a low-skilled group of scientists from a high-skilled group, limiting the estimation of and control for ability effects on mobility. Therefore, our future research should include the establishment of more advanced indicators of scientist ability. We propose the use of bibliometric measures. In order to minimize the risk of endogeneity issues, it is essential to create a measure that is influenced as least as possible by the scientist's career, to minimize the risk of endogeneity issues. Therefore, we propose two measures: the number of citations received by and the impact factor of the journal of the scientist's first paper (or of papers published in the first year of his scientific career). Since these

both take place either during the scientist's Ph.D. education or shortly after graduation, these should be minimally influenced by earlier career choices.

## Appendix 1: Exploratory Factor analysis

Here we will describe, in more detail, our factor analysis. Initially we examined the factorability of the 8 motivation items, using several criteria. Due to the minimal number of positive responses on 'motivation by extralegal benefits', this motivation was removed from the items. All of the other 7 items correlate significantly with at least one other item, using tetrachoric correlations[13] (Table 10). The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.55, which is only justly acceptable, but Bartlett's test of sphericity was significant ($\chi^2(21) = 225, p < 0.0001$). 6 of the 8 items on the diagonal of the anti-image correlation matrix were greater than 0.5, with the other values being close (0.46 and 0.49). The communalities indicate that the items share some common variance, except motivation through work circumstances and the opportunity to contribute to society (Table 11). Nevertheless, since we have no other item to represent the scientist's preference for agreeable work circumstances and since the second item is part of the classical rewards for science (in the form of peer recognition (Stephan & Levin, 1992)), we keep all seven items in the analysis.

**Table 10: Tetrachoric correlations of motivations**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. creative and interesting work | 1.00 | | | | | | |
| 2. salary | -0.20* | 1.00 | | | | | |
| 3. career prospects | -0.07 | 0.14 | 1.00 | | | | |
| 4. Job security | -0.13 | 0.29* | 0.47* | 1.00 | | | |
| 5. work circumstances | 0.08 | 0.17* | -0.01 | 0.13 | 1.00 | | |
| 6. independence | 0.36* | 0.27* | 0.06 | 0.47* | 0.35* | 1.00 | |
| 7. contribution to society | 0.20* | -0.01 | -0.00 | 0.11 | 0.07 | 0.28* | 1.00 |

*: significant at p<0.05

Even though the main goal of this analysis is to identify and compute composite scores for the factors underlying these motivation indicators, we chose to do the analysis using principal factor estimation instead of principal component analysis, since the assumption made in principal component analysis that the communalities are all equal to one is clearly violated. The initial

[13] Tetrachoric correlations assume that an indicator takes value 1 when an underlying latent variable (normally distributed) crosses a certain threshold (Uebersax J. , 2006). Since this assumption appears to be conceptually valid in this case, we believe that the use of tetrachoric correlations is appropriate. Uebersax (2000) suggests the use of the tetrachoric correlation matrix when applying factor analysis to binary variables, which can then be analyzed like a matrix of Pearson correlations when the tetrachoric correlation matrix is positive semidefinite.

estimation returned three factors with a positive eigenvalue. Of these, the first explains 56% of the common variance, the second 32%, and the third 11%. We preferred the two-factor solution (explaining 88% of the common variance) because of its match to previous findings, interpretability, and the fact that the third factor contained no primary loadings. Regarding rotations, varimax, quartimax and oblimin rotation yielded little difference, and it was decided to settle on varimax rotation for the final solution. In this solution, all items (except opportunity to contribute to society and work circumstances, which both have low communality) have a primary factor loading larger than 0.4, and no items have a cross-correlation larger than 0.3 (Table 11).

**Table 11: Factor loadings and communalities based on a principal components analysis with oblimin rotation (N=884)**

| | Factor Loadings | | |
|---|---|---|---|
| Item | Taste for Business | Taste for Science | Communality |
| Creative and interesting work | -0.30 | **0.52** | 0.41 |
| Good salary | **0.43** | 0.08 | 0.27 |
| Good career prospects | **0.50** | -0.04 | 0.33 |
| Job security | **0.73** | 0.24 | 0.61 |
| Work circumstances | 0.13 | 0.33 | 0.19 |
| Opportunity to do independent work | 0.30 | **0.75** | 0.67 |
| Opportunity to contribute to society | 0.00 | 0.35 | 0.14 |
| Eigenvalue | 0.84 | 0.84 | |
| % of variance | 56% | 32% | |

*Note:* Factor loadings over .40 appear in bold.

The first factor is positively correlated with being motivated by becoming a scientist because of its good salary, good career prospects, or job security. Therefore, we name this factor the scientist's 'taste for business': these items represent general career-related reasons for becoming a scientist. The second factor is positively correlated by becoming a scientist for the creative and interesting work, and the opportunity to do independent work. These motivations are related to the nature of the scientific profession, and capture the scientist's scientific motivation. Therefore, we name this factor the scientist's taste for science, in line with previous research (Sauermann,

Cohen, & Stephan, 2010; Sauermann & Cohen, 2010; Sauermann, Cohen, & Stephan, 2010). We calculated Cronbach's alpha to check the scales for internal consistence, and found these to be low (Table 12), even though our findings match those of previous authors. The factors appear to be uncorrelated[14] (-0.02). This supports the notion that a scientist's motivations for science and business are multidimensional constructs rather than a one-dimensional scale (Sauermann H. , 2008).

We calculated composite scores for each of the two factors. Both have means equal to zero, and the standard deviations are comparable. The kurthosis and skewness of the indices indicate that these factors are not normally distributed, as is also shown by the histograms in Figure 2and Figure 3. Observe that, while both indicators have means equal to zero, taste for science has the highest density around 0.5 and taste for business has the highest density around -0.5.

In sum, this analysis indicated that two factors that are underlying the motivations of scientists, in line with previous investigations. However, our data is limited in the number of items representing each of these factors, and the factors are only measured in binary variables, which limits the variance available for this analysis. Furthermore, these factors fail to capture two of the motivations (work circumstances and the opportunity to contribute to society).

**Table 12: Descripitive statistics for the two motivation factors**

| | No. of items | M(SD) | Skewness | Kurtosis | Alpha |
|---|---|---|---|---|---|
| Taste for Science | 2 | 0.00(0.70) | 2.60 | 9.90 | 0.29 |
| Taste for Business | 3 | 0.00(0.75) | -0.95 | 2.60 | 0.28 |

[14] This remained the case when we used other rotations.

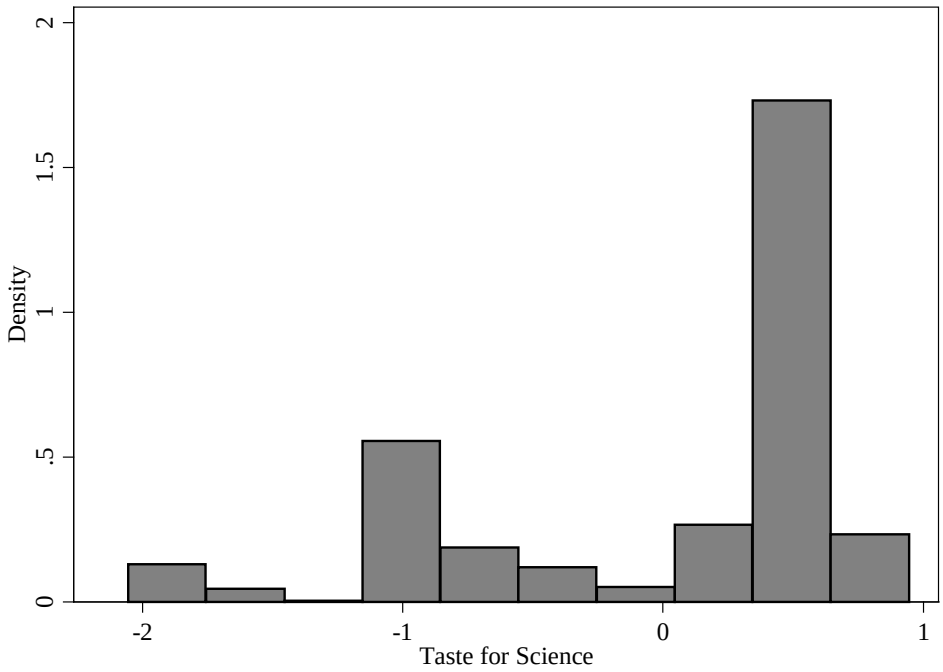


**Figure 2: histogram of taste for science**

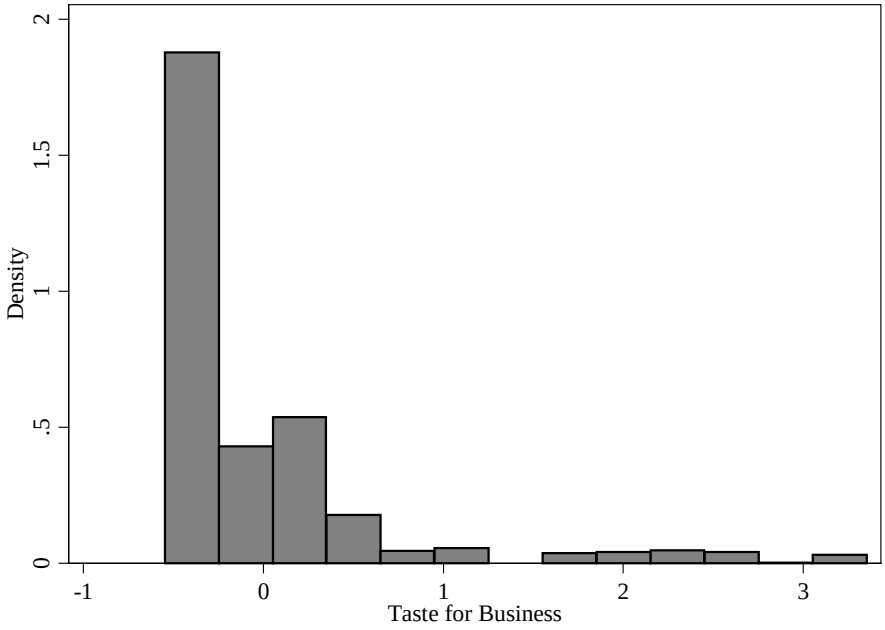


**Figure 3: histogram of taste for business**

# Appendix 2: heteroskedastic probit regressions

| Dep.: has left Belgium | **Full sample** | | | | | |
|---|---|---|---|---|---|---|
| M: creative/innovative work | -0.133 | -0.084 | | | -0.104 | |
| | (0.330) | (0.376) | | | (0.426) | |
| M: salary | -0.872* | -1.079* | | | -0.697 | |
| | (0.508) | (0.655) | | | (0.442) | |
| M: career prospects | -0.276 | -0.414 | | | -0.188 | |
| | (0.256) | (0.340) | | | (0.299) | |
| M: job security | 0.169 | 0.320 | | | 0.294 | |
| | (0.405) | (0.473) | | | (0.671) | |
| M: work circumstances | 0.036 | 0.010 | | | -0.374 | |
| | (0.195) | (0.221) | | | (0.236) | |
| M: independence | 0.567* | 0.581** | | | 0.624** | |
| | (0.315) | (0.265) | | | (0.285) | |
| M: contribution to society | 0.306 | 0.379 | | | 0.531** | |
| | (0.216) | (0.263) | | | (0.265) | |
| Taste for science | | | 0.399** | 0.370** | | -0.107 |
| | | | (0.193) | (0.151) | | (0.192) |
| Taste for business | | | -0.050 | -0.048 | | 0.335** |
| | | | (0.153) | (0.151) | | (0.159) |
| Ab: PhD at top 100 inst. | 0.146 | 0.083 | 0.081 | 0.042 | 0.873 | 1.169 |
| | (0.771) | (0.860) | (0.872) | (0.858) | (0.785) | (0.726) |
| Ab:Priv/gov. Funds | 0.107 | 0.055 | 0.098 | 0.042 | -0.034 | -0.063 |
| | (0.199) | (0.218) | (0.211) | (0.205) | (0.250) | (0.240) |
| Age | -0.106 | -0.076 | -0.097 | -0.081 | 1.141* | 1.309* |
| | (0.223) | (0.266) | (0.231) | (0.238) | (0.651) | (0.688) |
| Age² | -0.001 | -0.002 | -0.001 | -0.001 | -0.028** | -0.031** |
| | (0.004) | (0.005) | (0.004) | (0.004) | (0.014) | (0.015) |
| Postdoc | 0.899*** | 1.058*** | 0.959*** | 0.974*** | 0.846*** | 0.772*** |
| | (0.336) | (0.343) | (0.330) | (0.313) | (0.264) | (0.246) |
| Female | -0.546** | -0.601** | -0.600** | -0.586** | -0.236 | -0.261 |
| | (0.273) | (0.279) | (0.284) | (0.263) | (0.248) | (0.241) |
| Immigrant | 0.061 | 0.041 | 0.050 | -0.001 | -0.044 | 0.106 |
| | (0.379) | (0.419) | (0.412) | (0.402) | (0.469) | (0.449) |
| Phd abroad | -0.164 | -0.106 | -0.232 | -0.172 | -0.170 | -0.288 |
| | (0.364) | (0.409) | (0.391) | (0.375) | (0.395) | (0.377) |
| Constant | 2.766 | 2.933 | 2.553 | 2.650 | -18.329 | -21.533 |
| | (3.474) | (4.039) | (3.577) | (3.662) | (12.899) | (14.157) |
| Estimations include scientific domain and graduation year fixed effects | | | | | | |
| **Heteroskedasticity terms** | | | | | | |
| natural sciences | 0.596 | 0.734** | 0.774* | 0.768** | 0.066 | 0.073 |
| | (0.412) | (0.359) | (0.413) | (0.377) | (0.202) | (0.204) |
| engineering | 0.065 | | 0.173 | | | |
| | (0.466) | | (0.442) | | | |
| medical sciences | | 0.476 | | 0.229 | | |
| | | (0.514) | | (0.446) | | |
| soft sciences | 0.976** | 1.149*** | 1.012*** | 1.037*** | 0.217 | 0.167 |
| | (0.407) | (0.407) | (0.388) | (0.394) | (0.217) | (0.204) |
| Graduation year <1996 | | | | | 2.258*** | 2.376*** |
| | | | | | (0.637) | (0.642) |
| Graduation year 1996-2001 | | | | | 1.601*** | 1.654*** |
| | | | | | (0.494) | (0.514) |
| P-value LR-test of het. Terms = 0 | 0.0378 | 0.0254 | 0.0280 | 0.0266 | 0.0004 | 0.0016 |
| N | 884 | 884 | 884 | 884 | 884 | 884 |

note: *** p<0.01, ** p<0.05, * p<0.1

| Dep: has left Belgium | | | **Hard sciences** | | | **soft sciences** | |
|---|---|---|---|---|---|---|---|
| M: creative/innovative work | -0.202 | -0.154 | -0.013 | | | 0.711 | |
| | (0.351) | (0.412) | (0.475) | | | (1.004) | |
| M: salary | -0.580 | -0.733 | -0.562 | | | 1.376 | |
| | (0.530) | (0.693) | (0.516) | | | (1.025) | |
| M: career prospects | -0.215 | -0.385 | -0.378 | | | -0.374 | |
| | (0.262) | (0.378) | (0.332) | | | (0.700) | |
| M: job security | 0.238 | 0.414 | 0.300 | | | -1.501 | |
| | (0.415) | (0.527) | (0.684) | | | (1.952) | |
| M: work circumstances | 0.014 | -0.017 | -0.314 | | | -0.980* | |
| | (0.200) | (0.243) | (0.250) | | | (0.585) | |
| M: independence | 0.623* | 0.714** | 0.707** | | | 0.771 | |
| | (0.347) | (0.291) | (0.347) | | | (0.621) | |
| M: contribution to society | 0.438* | 0.583* | 0.774** | | | -1.506*** | |
| | (0.230) | (0.310) | (0.320) | | | (0.584) | |
| Taste for science | | | | 0.435** | 0.437*** | | -0.031 |
| | | | | (0.215) | (0.164) | | (0.255) |
| Taste for business | | | | 0.035 | 0.037 | | -0.122 |
| | | | | (0.152) | (0.158) | | (0.328) |
| Ab: PhD at top 100 inst. | 0.726 | 0.699 | 1.659 | 0.806 | 0.763 | | |
| | (0.807) | (0.871) | (1.040) | (0.871) | (0.839) | | |
| Ab:Priv/gov. Funds | 0.121 | 0.088 | 0.117 | 0.095 | 0.051 | 0.028 | 0.055 |
| | (0.205) | (0.236) | (0.250) | (0.218) | (0.221) | (0.534) | (0.462) |
| Age | 0.027 | 0.144 | 0.740 | 0.026 | 0.072 | -0.924* | -0.631 |
| | (0.276) | (0.363) | (0.620) | (0.282) | (0.313) | (0.488) | (0.509) |
| Age² | -0.003 | -0.005 | -0.018 | -0.002 | -0.004 | 0.012* | 0.008 |
| | (0.005) | (0.007) | (0.013) | (0.005) | (0.006) | (0.007) | (0.008) |
| Postdoc | 0.909** | 1.148*** | 0.869*** | 0.985*** | 1.043*** | 1.022** | 0.916** |
| | (0.368) | (0.376) | (0.317) | (0.376) | (0.336) | (0.463) | (0.411) |
| Female | -0.554* | -0.648** | -0.369 | -0.627** | -0.639** | 0.265 | 0.227 |
| | (0.292) | (0.305) | (0.274) | (0.313) | (0.287) | (0.555) | (0.457) |
| Immigrant | -0.220 | -0.270 | -0.222 | -0.242 | -0.297 | 1.132 | 1.110 |
| | (0.408) | (0.485) | (0.537) | (0.445) | (0.469) | (0.860) | (0.711) |
| Phd abroad | 0.068 | 0.167 | 0.313 | -0.021 | 0.031 | 0.747 | 0.364 |
| | (0.383) | (0.486) | (0.485) | (0.416) | (0.436) | (0.773) | (0.663) |
| Constant | 0.489 | -0.480 | -9.432 | 0.374 | 0.167 | 14.630* | 11.541 |
| | (4.065) | (5.079) | (9.421) | (4.128) | (4.404) | (7.995) | (8.502) |
| | Estimations include scientific domain and graduation year fixed effects | | | | | | |
| **Heteroskedasticity terms** | | | | | | | |
| natural sciences | 0.551 | 0.771** | 0.003 | 0.740* | 0.785** | | |
| | (0.422) | (0.369) | (0.291) | (0.429) | (0.376) | | |
| engineering | -0.031 | | -0.326 | 0.078 | | | |
| | (0.526) | | (0.331) | (0.500) | | | |
| medical sciences | | 0.539 | | | 0.245 | | |
| | | (0.571) | | | (0.503) | | |
| social sciences | | | | | | 10.796 | 9.364 |
| | | | | | | (10.764) | (10.055) |
| Graduation year <1996 | | | 1.684** | | | | |
| | | | (0.691) | | | | |
| Graduation year 1996-2001 | | | 1.263*** | | | | |
| | | | (0.480) | | | | |
| LR-test of het. Terms = 0: prob>chi²= | 0.1765 | 0.1128 | 0.0030 | 0.0912 | 0.0817 | 0.0004 | 0.0436 |
| N | 595 | 595 | 595 | 595 | 595 | 259 | 259 |

note: *** p<0.01, ** p<0.05, * p<0.1

## Appendix 3: taste for science versus reason for leaving

| | Share | | Taste for Science | | | Taste for business | | |
|---|---|---|---|---|---|---|---|---|
| | | Cases | Mean | St.Dev | p-value* | Mean | St.Dev | p-value* |
| Postdoc abroad | 1 | 107 | 0.24 | 0.61 | 0.5629 | -0.02 | 0.75 | 0.8886 |
| | 0 | 77 | 0.17 | 0.66 | | 0 | 0.64 | |
| Continue research | 1 | 78 | 0.29 | 0.57 | 0.1764 | 0.01 | 0.74 | 0.7086 |
| | 0 | 106 | 0.16 | 0.67 | | -0.02 | 0.68 | |
| Better publication opportunities | 1 | 62 | 0.18 | 0.65 | 0.6028 | -0.02 | 0.65 | 0.9202 |
| | 0 | 122 | 0.22 | 0.62 | | 0 | 0.73 | |
| Sent by current employer | 1 | 43 | 0.2 | 0.67 | 0.9622 | -0.04 | 0.6 | 0.7146 |
| | 0 | 141 | 0.21 | 0.62 | | 0.02 | 0.74 | |
| Was offered job | 1 | 38 | 0.12 | 0.76 | 0.2288 | 0.01 | 0.72 | 0.8306 |
| | 0 | 146 | 0.24 | 0.59 | | -0.01 | 0.7 | |
| Research domain does not exist in Belgium | 1 | 21 | 0.14 | 0.69 | 0.4875 | 0.03 | 0.77 | 0.7603 |
| | 0 | 163 | 0.22 | 0.69 | | -0.01 | 0.7 | |
| Create new research domain | 1 | 37 | 0.2 | 0.66 | 0.8125 | 0.13 | 0.86 | 0.1501 |
| | 0 | 147 | 0.22 | 0.63 | | -0.04 | 0.66 | |
| Better salary | 1 | 20 | 0.03 | 0.82 | 0.1805 | 0.22 | 0.82 | 0.1179 |
| | 0 | 164 | 0.23 | 0.60 | | -0.03 | 0.69 | |
| Easier to find a job | 1 | 17 | 0.26 | 0.45 | 0.7331 | 0.38 | 1.01 | **0.0118** |
| | 0 | 146 | 0.21 | 0.65 | | -0.06 | 0.64 | |
| Personal or familial reasons | 1 | 8 | 0.43 | 0.64 | 0.3165 | -0.17 | 0.35 | 0.4645 |
| | 0 | 176 | 0.43 | 0.29 | | 0.01 | 0.71 | |
| N | | | | | 184 | | | |

*: of two sample t-test

## Appendix 4: Motivation versus region of destination

| | Adjacent to Belgium | United States | Rest of World |
|---|---|---|---|
| Creative and interesting work | 32.62 | 34.05 | 11.89 |
| Good career prospects | 27.27 | 51.61 | 3.23 |
| Work circumstances | 29.85 | 31.34 | 11.94 |
| Opportunity to do independent work | 23.34 | 33.94 | 13.94 |
| Opportunity to contribute to society | 26.23 | 28.33 | 18.33 |
| Total | 32.18 | 33.17 | 12.06 |

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